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NASA Space Flight Program and Project Management Handbook

National Aeronautics and Space Administration
Headquarters
Washington, D.C. 20546

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Preface

This handbook is the companion document to *NPR 7120.5F*, *NASA Space Flight Program and Project Management Requirements*. It represents the accumulation of knowledge on managing program and projects derived from NASA's human, robotic, and scientific missions. It incorporates the "corporate knowledge" for existing and future NASA space flight programs and projects, including NASA's Artemis missions to establish a sustainable human presence on the Moon through collaboration with commercial and international partners, NASA's James Webb Space Telescope (JWST) mission, and NASA's robotic missions on Mars. The practices discussed have evolved as a function of NASA's core values of safety, integrity, teamwork, excellence, and inclusion, and may also prove a resource for other agencies, the private sector, and academia. The knowledge gained from the Agency's victories and defeats, including the checks and balances and initiatives to better control cost and risk, provides a foundation for continuing an exciting and healthy space program.

This handbook provides implementation guidance for NPR 7120.5F and includes the changes and updates to key procedural requirements in NPR 7120.5F since NPR 7120.5E. The goal of the NPR requirements is to ensure programs and projects are developed and successfully executed in the most cost-effective and efficient manner possible. This handbook provides context, rationale, and explanation to facilitate the application of requirements and to pass on some of the hard-won best practices and lessons learned.

While thoughtful planning and execution is important in all phases of a program or project life cycle, NASA places particular emphasis on activities during the Formulation Phase to:

- Accurately characterize the complexity and scope of the program or project.
- Increase understanding of programmatic requirements.
- Better identify and mitigate high safety, technical, acquisition, cost, and schedule risks.
- Improve the fidelity and realism of cost and schedule commitments made when the program or project is approved to transition from Formulation to Implementation.

Key changes in NPR 7120.5F include updating the requirements for establishing Agency Baseline Commitments (ABC) and for performing Joint Cost and Schedule Confidence Level (JCL) analyses for tightly coupled programs; adding additional requirements for doing a JCL analysis for single-project programs and projects over $1B Life-Cycle Cost (LCC); and using initial capability cost estimates instead of LCC estimates in certain instances for single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point.

The NPR includes continued emphasis on the ability and need to properly tailor requirements to fit the size, complexity, cost, and risk of the program or project. Tailoring guidance has been added to Appendix C of NPR 7120.5F along with a reference to resources to facilitate tailoring available on the Agency Tailoring Website.[1] Changes to tailoring guidance include clarifying the process for assigning "non-applicable" to requirements and modifying stand-alone requirements for program and project control plans; flexibility for programs using innovative acquisition approaches; clarification of delegation of tailoring authority; and pre-customization of the NPR 7120.5 Compliance Matrix.[2]

With the release of the *NASA-STD-1006, Space System Protection Standard* and *NPR 1058.1, NASA Enterprise Protection Program*, Space Asset Protection is now the Mission Resiliency and Protection Program. Programs are no longer required to do a Threat Summary, and Project Protection Plans need to address the new standard and NPR.

Changes related to governance include updates to program and project acquisition strategy and planning aligned with *NPD 1000.5, Policy for NASA Acquisition*; shifted responsibility for management of independent reviews from the Independent Program Assessment Office to Mission Directorates; and added program and project consideration for management and utilization of Agency-level capability components through capability portfolios per *NPR 8600.1, NASA Capability Portfolio Management Requirements*. The Dissenting Opinion process is now the Formal Dissent process, which retains the current process.

Changes to the life cycle include clarification of the criteria triggering a Program Implementation Review (PIR); adding emphasis to the use of leading indicators in Life-Cycle Reviews (LCRs) and Key Decision Points (KDPs); and providing additional guidance in the *NASA Common Leading Indicators Detailed Reference Guide*.[3]

Updates to program and project documentation and guidance include changes to the Appendix I table documentation and products in NPR 7120.5F, including the addition of the Human Systems Integration Plan, System Security Plan, Quality Assurance Surveillance Plan, Orbital Collision Avoidance Plan (OCAP), and Performance Measurement Baseline (PMB) and the deletion of the Education Plan, Information Technology Plan, and Product Data and Life Cycle Management Plan.

The information, techniques, methodologies, and practices described in this handbook are the compilation of best practices and lessons learned from some of the best program and project managers, systems engineers, technical teams, procurement specialists, scientists, financial managers, and leadership within the Agency, academia, commercial organizations, and other government agencies. The authors of this handbook are grateful for their dedication and insight.

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[1] https://appel.nasa.gov/npr-7120-5-tailoring-resources
[2] Pre-customized Compliance Matrix templates eliminate non-applicable requirements for specific types of programs and projects. See Section 3.1.5 for more information on the full Compliance Matrix and pre-customized templates.
[3] https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_52.pdf

1 Introduction

1.1 Purpose

This handbook is a companion to *NPR 7120.5F, NASA Space Flight Program and Project Management Requirements* and supports the implementation of the requirements by which NASA formulates and implements space flight programs and projects. Its focus is on what the program or project manager needs to know to accomplish the mission, but it also contains guidance that enhances the understanding of high-level procedural requirements. (See Appendix C for NPR 7120.5F requirements with rationale.) As such, it starts with the same basic concepts but provides context, rationale, guidance, and a greater depth of detail for the fundamental principles of program and project management. This handbook also explores some of the nuances and implications of applying the procedural requirements, for example, how the Agency Baseline Commitment (ABC) agreement evolves over time as a program or project moves through its life cycle.

1.2 Document Structure

Guidance begins in Chapter 2 with a high-level overview of NASA's space flight program and project management structure and references to specific topics elsewhere in the document that provide greater levels of detail. The overview also includes NASA's Governance structure and a description of the program and project life cycles and management decision points.

Details of the activities in the phases of the life cycle begin in Chapter 3 with programs and continue in Chapter 4 with projects. These chapters capture the flow of program and project activities and give a perspective on what needs to be accomplished while progressing through the phases of the program and project life cycles. Chapter 3 describes the four different program types, their common activities, and how they differ. Chapter 4 covers activities for all categories of projects with a greater focus on Category 1 projects. All the activities to meet the requirements of a Category 1 project are detailed, including activities that may not be applicable to Category 2 or 3 projects.

The special topics in Chapter 5 explain important concepts from NPR 7120.5F in more detail. They explain the nuances and implications of Governance, Technical Authority, tailoring principles, and the Formal Dissent process and how they are implemented in specific situations such as a project being developed in a multi-Center environment. Key program and project documentation is explored in more detail in the section on maturing, approving, and maintaining baselines that include the ABC and the Management Agreement. Other special topics include:

- Earned Value Management (EVM).

- Analyses and work supporting decisions, including Joint Cost and Schedule Confidence Level (JCL) analysis.
- The Federal budgeting process.
- The independent Standing Review Boards (SRBs) and Life-Cycle Reviews (LCRs).
- Other reviews such as the Termination Review.
- Requirements for external reporting.
- Program or project management selection and certification.
- Leading indicator guidance.
- The Work Breakdown Structure (WBS) and its relationship to Agency financial processes.

1.3 How to Use This Handbook

This handbook is structured as a reference document to make it useful for the practitioner. The focus is on the activities a program or project manager needs to perform with context and explanation for the requirements. Rather than reading the handbook as a chronological narrative, the program or project manager can go to a specific section to learn about a particular area of interest, e.g., Section 5.3 on Formal Dissent. Chapter 3 on programs and Chapter 4 on projects stand on their own, so a project manager can go to Chapter 4 and determine what is required in one place. That means that some of the material that is common between chapters and phases is duplicated to be complete. When a particular topic such as the WBS is introduced, it is defined in *italicized blue font text*. If the topic is discussed in greater depth in this handbook, the reader is referred to that location. On occasion, the reader will be referred to another handbook or a community of practice for more in-depth knowledge.

Additional blue font text contains content about key concepts, including points of elucidation or emphasis on best practices as well as rationales or principles behind some of the requirements. In addition, required products are **bolded** in the text, so content about them can be more easily located.

This handbook is available in print format on the NASA Technical Reports Server (NTRS) at <link to be provided>. Though the content of this handbook is intended to stand the test of time, the electronic Word version of the handbook is subject to revision as NPR 7120.5 evolves. However, dynamic content is reserved for online forums. For example, information supplemental to policy documents can be found in the Office of the Chief Engineer (OCE) listing under the "Other Policy Documents" tab in the NASA Online Directives Information System (NODIS) library. NASA personnel can also access the NASA Engineering Network (NEN) Program and Project Management community of practice.[4] While the handbook

[4] https://www.nasa.gov/open/nen-ntrs.html

presents core information, it also references extended content with pointers to various NASA communities of practice that contain additional guidance, best practices, and templates that are updated to be current with latest practice. Also, additional information in other handbooks, websites, and policy documents is liberally referenced rather than duplicated.

2 High-Level Overview of Program and Project Management

Space flight programs and projects are often the most visible and complex of NASA's strategic investments. These programs and projects flow from the implementation of national priorities, defined in the Agency's Strategic Plan,[5] through the Agency's Mission Directorates as part of the Agency's programmatic organizational hierarchy shown in Figure 2-1.

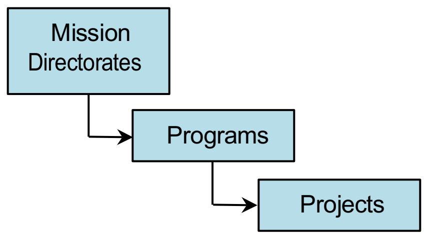


Figure 2-1 Programmatic Authority Organizational Hierarchy

This hierarchical relationship of programs to projects shows that programs and projects are different and their management involves different activities and focus. Programs and projects are distinguished by the following characteristics:

- **Program**. A strategic investment by a Mission Directorate or mission support offices with a defined architecture and/or technical approach, requirements, funding level, and a management structure that initiates and directs one or more projects. A program implements a strategic direction that the Agency has identified as needed to accomplish Agency goals and objectives.

  Architecture is the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.

- **Project**. A space flight project is a specific investment identified in a Program Plan having defined requirements, a Life-Cycle Cost (LCC), [6] a beginning, and an end[7]. A project also has a management structure and may have interfaces to other projects, agencies, and international partners. A project yields new or revised products that directly address NASA's strategic goals.

[5] Currently, *NPD 1001.0, 2022 NASA Strategic Plan.*
[6] The LCC is the total cost of the program or project over its planned life cycle from Formulation (excluding Pre-Phase A) through Implementation (excluding extended operations).
[7] Single-project programs and projects with continuing operations and production, including integration of capability upgrades, have an unspecified Phase E end point.

All NASA space flight programs and projects are subject to NPR 7120.5 requirements including spacecraft, launch vehicles, instruments developed for space flight programs and projects; some Research and Technology (R&T) developments[8] funded by and to be incorporated into space flight or aeronautics programs and projects; technical facilities specifically developed or significantly modified for space flight systems; Information Technology (IT) acquired as a part of space flight programs and projects; and ground systems that are in direct support of space flight operations. NPR 7120.5 requirements also apply to reimbursable space flight programs and projects performed for non-NASA sponsors and to NASA contributions to space flight programs and projects performed with international and interagency partners. NPR 7120.5 requirements apply to the Jet Propulsion Laboratory (JPL) (a Federally Funded Research and Development Center(FFRDC)), other contractors, and recipients of grants, cooperative agreements, or other agreements only to the extent specified or referenced in the applicable contracts, grants, or agreements.

2.1 Overview of Program and Project Life Cycles

NASA manages programs and projects to life cycles that include the systems engineering processes described in *NPR 7123.1, NASA Systems Engineering Processes and Requirements*. These life cycles are divided into defined phases that correspond to specific activities and increasing levels of expected maturity of information and products. A program or project moves through the life-cycle phases as it progresses from concept to operations, and ultimately to decommissioning. Programs and projects are periodically evaluated at specific points to gain formal approval to progress through their life cycle.

At the top level, program and project life cycles are divided into two phases: Formulation and Implementation. (See Section 2.6 and Figure 2-4 for a description of the activities of these phases.) The activities and work to be accomplished in these phases are as follows:

- **Formulation**. Identifying how the program or project supports the Agency's strategic goals; developing and allocating program requirements to initial projects; performing trade studies; assessing feasibility, technology, and concepts; deriving a technical approach from an analysis of alternatives; assessing and possibly mitigating risks based on risk-informed decision making (RIDM) and continuous risk management (CRM) processes; conducting engineering and technology risk reduction activities; maturing technologies; developing organizational structures and building teams; developing concepts and acquisition strategies; developing preliminary cost and schedule estimates and budget submissions; establishing high-level requirements, requirements flow down, and success criteria; developing system-level preliminary designs; assessing

[8] R&T programs and projects that are directly funded by a space flight program or project should decide whether they are subject to NPR 7120.5, *NPR 7120.8, NASA Research and Technology Program and Project Management Requirements,* or will be a hybrid between those two per Mission Directorate policy and Decision Authority approval. R&T projects that directly tie to the space flight mission's success and schedule are normally managed under NPR 7120.5.

the relevant industrial base and supply chain to ensure program or project success; preparing plans essential to the success of a program or project; and establishing control systems to ensure performance of those plans and alignment with current Agency strategies.

- **Implementation**. Executing approved plans for the development and operation of the program and/or project; using control systems to ensure performance to approved plans and requirements and continued alignment with the Agency's strategic goals; performing acquisition, detailed design, manufacturing, integration, and test; conducting operations; and implementing sustainment; for programs, initiating constituent projects and monitoring their formulation, approval, implementation, integration, operation, and ultimate decommissioning (tightly coupled programs may also initiate projects during Formulation); and adjusting the program and/or project as resources and requirements change.

NASA defines acquisition as the process for obtaining the systems, research, services, construction, and supplies that the Agency needs to fulfill its mission. Acquisition, which may include procurement (contracting for products and services), begins with an idea or proposal that aligns with the NASA Strategic Plan and fulfills an identified need and ends with the completion of the program or project or the final disposition of the product or service. (The definition of acquisition in accordance with NPD 1000.5, Policy for NASA Acquisition is used in a broader context than the Federal Acquisition Regulation (FAR)[9] definition to encompass strategic acquisition planning and the full spectrum of various NASA acquisition authorities and approaches to achieve the Agency's mission and activities.)

There are three different life cycles for four different types of programs (see Chapter 3) and one life cycle for three categories of projects (see Chapter 4). The life cycles are divided into phases. Transition from one phase to another requires management approval at Key Decision Points (KDPs). (See Section 2.2.3.) The phases in program and project life cycles include one or more Life-Cycle Reviews (LCRs), which are considered major milestone events. A LCR is designed to provide the program or project with an opportunity to ensure that it has completed the work of that phase and an independent assessment of a program or project's technical and programmatic status and health. The final LCR in a life-cycle phase provides essential information for the KDP that marks the end of that life-cycle phase and transition to the next phase if successfully passed. As such, KDPs serve as gates through which programs and projects must pass to continue.

KDPs for projects are designated with capital letters, e.g., KDP A. The letter corresponds to the project phase that will be entered after successfully passing through the gate. Program KDPs and LCRs are analogous to project KDPs and LCRs. KDPs for single-project programs are designated with letters as are projects, i.e., KDP A, KDP B, etc. KDPs associated with

[9] https://www.acquisition.gov/browse/index/far

other types of programs (i.e., uncoupled, loosely coupled, and tightly coupled) are designated with Roman numerals and zero. The first KDP is KDP 0, the second is KDP I, etc.

LCRs are essential elements of conducting, managing, evaluating, and approving space flight programs and projects and are an important part of NASA's system of checks and balances. Life-cycle reviews are conducted by the program and project and often an independent Standing Review Board (SRB). (SRBs are defined and discussed further in Section 3.1.1, Section 4.1.1 and Section 5.10.) NASA accords special importance to maintaining the integrity of its independent review process. LCRs provide the program or project and NASA senior management with a credible, objective assessment of how the program or project is progressing. The independent review also provides vital assurance to external stakeholders that NASA's basis for proceeding is sound.

The KDP decision to authorize a program or project's transition to the next life-cycle phase is made by the program or project's Decision Authority. (See Section 2.2.1.) The decision is based on a number of factors, including technical maturity; continued relevance to Agency strategic goals; adequacy of cost and schedule estimates; associated probabilities of meeting those estimates (confidence levels); continued affordability with respect to the Agency's resources; maturity and the readiness to proceed to the next phase; and remaining program or project risk (safety, cost, schedule, technical, management, and programmatic). At the KDP, the key program or project cost, schedule, and content parameters that govern the remaining life-cycle activities are established.

Figure 2-2 shows a simplified, high-level version of the NASA project life cycle to illustrate the relationship between the phases, gates, and major events, including KDPs and major LCRs. Note that the program life cycles (discussed in Chapter 3) vary from this simplified life cycle depending on the program type.

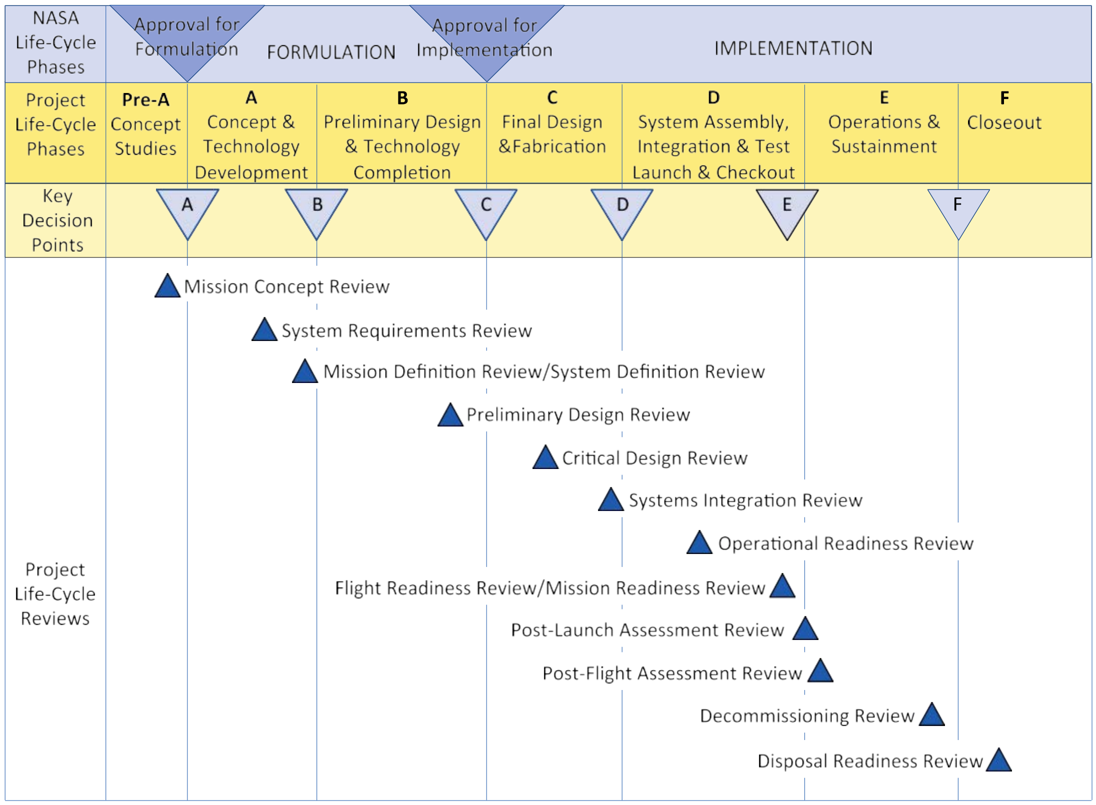


Figure 2-2 Simplified Project Life Cycle

2.2 Oversight and Approval

NASA has established a program and project management oversight process to ensure that the experience, diverse perspectives, and thoughtful programmatic and technical judgment at all levels are accessible, available, and applied to program and project activities. The Agency employs management councils and independent review boards, including the SRB, to provide the Decision Authority and upper management with insight on the status and progress of programs and projects and their alignment with Agency goals. This process enables a disciplined approach for developing the Agency's assessment, which informs the Decision Authority's KDP determination of program or project readiness to proceed to the next life-cycle phase.

This section describes NASA's oversight approach and the process by which programs and projects are approved to move forward through their life cycle. It defines and describes NASA's Decision Authority, management councils, and KDPs. (See Sections 3.2 and 4.2 for more detailed information on these topics.)

2.2.1 Decision Authority

The Decision Authority is the Agency individual who makes the KDP determination on whether and how a program or project proceeds through the life cycle and authorizes the key program cost, schedule, and content parameters that govern the remaining life-cycle activities.

For programs and Category 1 projects, the Decision Authority is the NASA Associate Administrator (AA). For Category 1 projects, the NASA AA may delegate this authority to the Mission Directorate Associate Administrator (MDAA). For Category 2 and 3 projects, the Decision Authority is the MDAA. (See Sections 2.4 and 2.5 for more information on program and project categories.)

The MDAA may delegate to a Center Director the Decision Authority to determine whether Category 2 and 3 projects may proceed through KDPs into the next phase of the life cycle. However, the MDAA will retain authority for all program-level requirements, funding limits, launch dates, and any external commitments.

The limitation on the scope of an MDAA's delegation is needed to preserve the separation of Programmatic and Institutional Authority roles as required by NASA Governance. (See Section 2.3.)

All delegations are documented and approved in either the Program Commitment Agreement (PCA), Formulation Agreement, Program Plan (NPR 7120.5F, Appendix G), or Project Plan (NPR 7120.5F, Appendix H) depending on which Decision Authority is delegating.

The PCA (NPR 7120.5, Appendix D) is an agreement between the MDAA and the NASA AA (the Decision Authority) that authorizes program transition from Formulation to Implementation. The PCA is prepared by the Mission Directorate and documents Agency and Mission Directorate requirements that flow down to the program; program objectives, management, and technical approach and associated architecture; program technical performance, schedule, time-phased cost plans, and safety and risk factors; internal and external agreements; life-cycle reviews; and all attendant top-level program requirements.

The Decision Authority's role during the life cycle of a program and project is covered in more detail in NPR 7120.5F, Section 2.3 Program and Project Oversight and Approval, and in Chapters 3 and 4 of this handbook.

2.2.2 Management Councils

At the Agency level, NASA Headquarters (HQ) has two levels of Program Management Councils (PMCs): the Agency PMC (APMC) and the Mission Directorate PMC (DPMC). The PMCs evaluate the safety, technical, and programmatic performance and content of a program or project under their purview for the entire life cycle. These evaluations focus on whether the program or project is meeting its commitments to the Agency and on ensuring successful achievement of NASA strategic goals. For all programs and Category 1 projects, the governing PMC is the APMC. The NASA AA chairs the APMC. For all Category 2 and 3 projects, the governing PMC is the DPMC. The MDAA chairs the DPMC.

The governing PMC conducts reviews to evaluate programs and projects in support of KDPs; makes a recommendation to the Decision Authority on a program or project's readiness to progress in its life cycle; and provides an assessment of the program or project's proposed cost, schedule, and content parameters. A KDP normally occurs at the governing PMC review. Prior to the governing PMC review, the program or project is reviewed by the responsible Center Director and/or Center Management Council (CMC), which provides its findings and recommendations to the MDAA and DPMC. In cases where the governing PMC is the APMC, the responsible MDAA and/or DPMC also conduct an in-depth assessment of the program or project. The Center Director/CMC and MDAA/DPMC provide their findings and recommendations to the APMC.

2.2.3 Key Decision Points

At KDPs, the Decision Authority reviews all the materials and briefings at hand, determines the program or project's maturity and readiness to progress through the life cycle, and authorizes the content, cost, and schedule parameters for the ensuing phase(s). The materials and briefings include findings and recommendations from the program manager, the project manager, if applicable, the SRB, the CMC, the DPMC, the MDAA, if applicable, and the governing PMC. KDPs conclude the life-cycle review at the end of a life-cycle phase. A KDP is a mandatory gate through which a program or project must pass to proceed to the next life-cycle phase.

A life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment and sign the Decision Memorandum.

The potential outcomes at a KDP include approval or disapproval to enter the next program or project phase, with or without actions for follow-up activities.

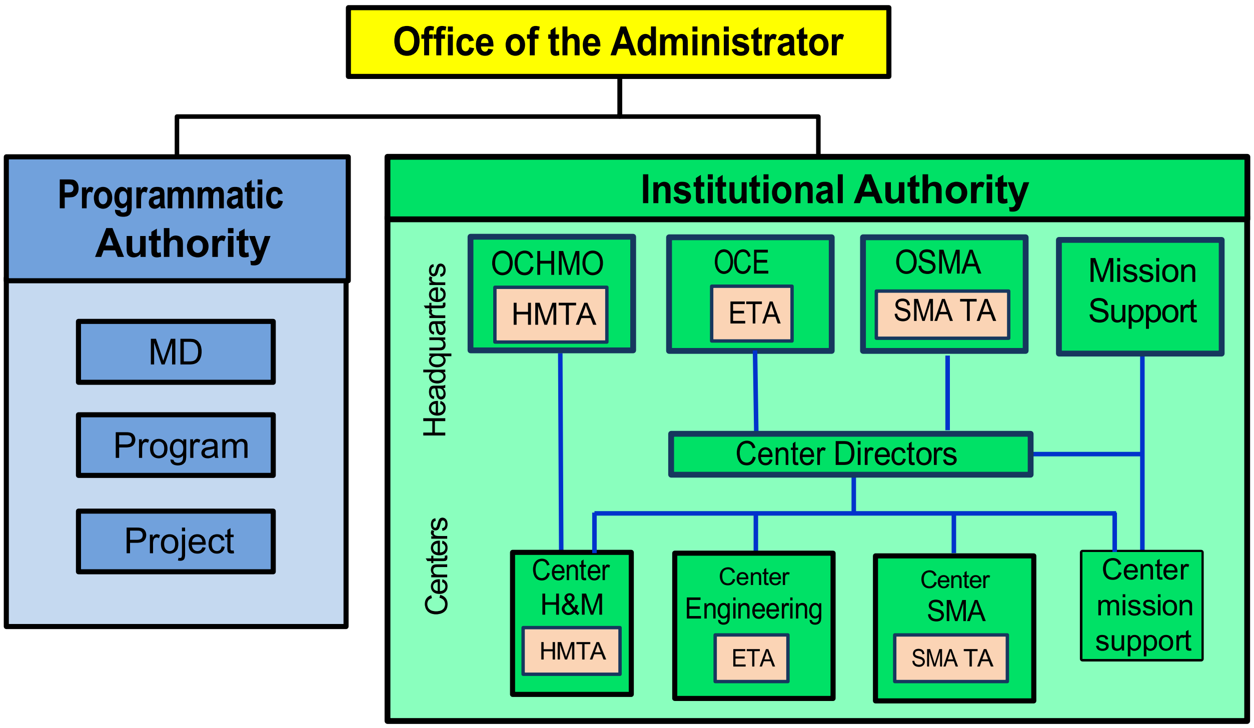
The KDP decision is summarized and recorded in the Decision Memorandum. The Decision Authority completes the KDP process by signing the Decision Memorandum. The expectation is to have the Decision Memorandum signed by concurring members as well as the Decision Authority at the conclusion of the governing PMC KDP meeting. (For more information on the Decision Memorandum, including signatories and their respective responsibilities, see Section 5.5.6, Decision Memorandum.)

2.3 Governance

To successfully implement space flight programs and projects, NASA's management focuses on mission success across a challenging portfolio of high-risk, complex endeavors, many of which are executed over long periods of time. *NPD 1000.0, NASA Governance and Strategic*

Management Handbook sets forth the Governance framework through which the Agency manages its missions and executes its responsibilities. The Governance model provides for mission success by balancing different perspectives from different elements of the organization and is also fundamental to NASA's system of checks and balances.

The cornerstone of this organizational structure is the separation of the Programmatic and Institutional Authorities. The separation of authorities is illustrated in Figure 2-3.



TA - Technical Authority
OSMA – Office of Safety and Mission Assurance
OCE – Office of the Chief Engineer
OCHMO – Office of the Chief Health and Medical Officer

Figure 2-3 Separation of Programmatic and Institutional Authorities

Programmatic Authority resides within the Mission Directorates and their respective programs and projects. (Appendix D provides a summary of the roles and responsibilities for key program and project management officials.)

Institutional Authority encompasses all organizations and authorities not in Programmatic Authority. This includes the Mission Support Directorate (MSD) and mission support offices at Headquarters and associated organizations at the Centers; other mission support organizations; Center Directors; and the Technical Authorities, who are individuals with specifically delegated authority in Engineering, Safety and Mission Assurance, and Health and Medical.

The Engineering, Safety and Mission Assurance, and Health and Medical organizations are a unique segment of the Institutional Authority. They support programs and projects in two ways:

1. They provide technical personnel and support and oversee the technical work of personnel who provide the technical expertise to accomplish the program or project mission.
2. They provide Technical Authorities, who independently oversee programs and projects. These individuals have a formally delegated Technical Authority role traceable to the Administrator and are funded independent of programs and projects.

(See Section 5.2 for more detail on the Technical Authorities.)

Each of these authorities plays a unique role in the execution of programs and projects. For example, with respect to requirements:

- Programmatic Authorities are responsible for "programmatic requirements" and focus on the products to be developed and delivered that specifically relate to the goals and objectives of a particular NASA program or project. These programmatic requirements flow down from the Agency's strategic planning process.
- Institutional Authorities are responsible for "institutional requirements" and focus on how NASA does business. "Institutional requirements" are independent of any program or project. These requirements are issued by NASA Headquarters (including the Office of the Administrator and mission support offices) and by Center organizations. Institutional requirements may respond to Federal statute, regulation, treaty, or Executive order.

(For more information on the Programmatic and Institutional Authorities and the roles and responsibilities of these authorities, see Section 5.1, NASA Governance and Appendix D.)

The "Types of Requirements" box provides definitions for some basic types of requirements. See Appendix A for definitions of these and other types of requirements.

Types of Requirements

Programmatic Requirements. Focus on space flight products to be developed and delivered that specifically relate to the goals and objectives of a particular program or project. They are the responsibility of the Programmatic Authority.

Institutional Requirements. Focus on how NASA does business independent of a particular program or project. They are the responsibility of the applicable Institutional Authority.

Allocated Requirements. Established by dividing or otherwise allocating a high-level requirement into lower-level requirements.

Derived Requirements. Arise from:

- Constraints or consideration of issues implied but not explicitly stated in the higher-level direction originating in Headquarters and Center institutional requirements or
- Factors introduced by the architecture and/or the design.

These requirements are finalized through requirements analysis as part of the overall systems engineering process and become part of the program/project requirements baseline.

Technical Authority Requirements. A subset of institutional requirements invoked by the Office of the Chief Engineer (OCE), the Office of Safety and Mission Assurance (OSMA), and the Office of the Chief Health and Medical Officer (OCHMO) documents (e.g., NASA Procedural Requirements (NPRs) or technical standards cited as program or project requirements or contained in Center documents). These requirements are the responsibility of the office or organization that established the requirement unless delegated elsewhere.

Additional types of requirements are defined in Appendix A.

2.4 NASA Programs

As a strategic management structure, the program construct is extremely important within NASA. Programs provide the critically important linkage between the Agency's strategic goals and the projects that are the specific means for achieving them.

NASA space flight programs are initiated and implemented to accomplish scientific or exploration goals that generally require a collection of mutually supporting projects. Programs integrate and manage these projects over time and provide ongoing enabling systems, activities, methods, technology developments, and feedback to projects and stakeholders. Programs are generally created by a Mission Directorate with a long-term time horizon in mind. Programs are generally executed at NASA Centers under the direction of the Mission Directorate and are assigned to Centers based on decisions made by Agency senior management consistent with the results of the Agency's strategic acquisition process.

The strategic acquisition process is the Agency process for ensuring that NASA's strategic vision, programs, projects, and resources are properly developed and aligned throughout the mission and life cycle. (See NPD 1000.0, NASA Governance and Strategic Management Handbook, and NPD 1000.5, Policy for NASA Acquisition, for additional information on the strategic acquisition process.)

(For additional information on the strategic acquisition process, refer to Sections 3.3.1 and 4.3.1.1.)

Because the scientific and exploration goals of programs vary significantly in scope, complexity, cost, and criticality, different program management strategies are required ranging from simple to complex. To accommodate this variety, the Agency has developed three different life cycles for four different program types: uncoupled, loosely coupled, tightly coupled, and single-project programs. These life cycles are illustrated in figures in Chapter 3 and show the program life-cycle phases; program life-cycle gates and major events, including KDPs; major program LCRs; and the process of recycling through Formulation when program changes warrant such action.

All types of NASA programs have a common life-cycle management process:

- **Program Formulation** is designed to establish a cost-effective program that is demonstrably capable of meeting Agency and Mission Directorate goals and objectives. During Formulation, the program team derives a technical approach, develops and allocates program requirements to initiate project activities, develops preliminary designs (when applicable), develops organizational structures and management systems, defines the program acquisition strategies, establishes required annual funding levels, and develops preliminary cost and schedule estimates.
- **Program Implementation** begins when the program receives approval to proceed to Implementation with the successful completion of KDP I (KDP C for single-project programs). Implementation encompasses program acquisition, operations, and sustainment, during which constituent projects are initiated. Constituent projects' formulation, approval, implementation, integration, operation, and ultimate decommissioning are constantly monitored. The program is adjusted to respond as needs, risks, opportunities, constraints, resources, and requirements change, managing technical and programmatic margins and resources to ensure successful completion of Implementation.

Independent evaluation activities occur throughout all phases.

2.5 NASA Projects

Like programs, projects vary in scope and complexity and thus have varying levels of management requirements and Agency attention and oversight. Projects are assigned to a category that defines the Agency expectations for the project manager and determines the project's oversight council and the specific approval requirements that apply.

Projects are assigned to Category 1, 2, or 3 based initially on:

- The project Life-Cycle Cost Estimate (LCCE), the inclusion of significant radioactive material,[10] and whether the system being developed is for Human Space Flight (HSF); and
- The priority level, which is related to the importance of the activity to NASA, the extent of international participation (or joint effort with other government agencies), the degree of uncertainty surrounding the application of new or untested technologies, and spacecraft and/or payload development risk classification.

Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point are assigned to Category 1 unless otherwise agreed to by the Decision Authority. (See *NPR 7120.5F, NASA Space Flight Program and Project Management Requirements*, Section 2.1 and Table 2-1, and Table 4-1 in this handbook for a table of project categorization guidelines and *NPR 8705.4, Risk Classification for NASA Payloads* for payload risk classification guidelines.)

The Life-Cycle Cost (LCC) of the project includes all costs, including all Unallocated Future Expenses (UFE) and funded schedule margins for formulation and development through prime mission operations (the mission operations as defined to accomplish the prime mission objectives) to disposal, excluding extended operations.

Tightly coupled programs document their LCCE in accordance with the life-cycle scope defined in the Formulation Authorization Document (FAD) or Program Commitment Agreement (PCA). Projects that are part of these programs document their LCCE in accordance with the life-cycle scope defined in their program's Program Plan, FAD or PCA, or the project's FAD.

Single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, define an initial capability during Phase A and document the initial capability scope by KDP B. Initial capability is the first operational mission flight (or as defined in the KDP B Review Plan) and is documented in the KDP B Decision Memorandum. The scope of the initial capability is also documented in the PCA, the Program Plan, and the Project Plan.

All categories of NASA projects have a common life cycle. (See Chapter 4 for a detailed explanation of the project life cycle.) The common life cycle includes the following:

- Although not part of the project life cycle, a Mission Directorate, typically supported by a program office, provides resources for concept studies (i.e., Pre-Phase A Concept Studies) prior to initiating a new project. These **pre-Formulation activities** involve Design Reference Mission (DRM) analysis, feasibility studies, technology needs

[10] Significant radioactive material is defined as levels of radioactive material onboard the spacecraft and/or launch vehicle that require nuclear launch authorization by the NASA Administrator or Executive Office of the President as described in *NPR 8715.26, Nuclear Flight Safety*. See also Section 4.4.3.3 in this handbook.

analyses, engineering systems assessments, and analyses of alternatives that typically are performed before a specific project concept emerges. Pre-Formulation activities include identifying risks that are likely to drive the project's cost and schedule and developing mitigation plans for those risks. Note that pre-Formulation costs are not included in LCCEs.

- **Project Formulation** comprises two sequential phases: Phase A (Concept and Technology Development) and Phase B (Preliminary Design and Technology Completion). NASA places significant emphasis on project pre-Formulation and Formulation to ensure adequate preparation of project concepts and plans and mitigation of high-risk aspects of the project essential to position the project for the highest probability of mission success. During Formulation, the project explores the full range of implementation options, defines an affordable project concept to meet requirements, and develops needed technologies. The activities in these phases include developing the system architecture; completing mission and preliminary system designs; planning acquisitions; conducting safety, technical, cost, and schedule risk trades; developing time-phased cost and schedule estimates and documenting the basis of these estimates; and preparing the Project Plan for Implementation. For projects with a LCC greater than $250 million, these activities allow the Agency to present to external stakeholders time-phased cost plans and schedule range estimates at KDP B and high-confidence cost and schedule commitments at KDP C.
- At KDP C, **Project Approval for Implementation**, the Decision Authority approves or disapproves the transition to Implementation and the technical scope, cost estimate, and schedule estimate.
- **Project Implementation** comprises Phases C, D, E, and F. During Phase C (Final Design and Fabrication) and Phase D (System Assembly, Integration and Test, Launch and Checkout), the primary activities are developmental in nature, including acquisition contract execution. Phase C includes completion of final system design and the fabrication, assembly, and test of components, assemblies, and subsystems. Phase D includes system assembly, integration, and test; prelaunch activities; launch; and on-orbit checkout (robotic projects) or initial operations (human space flight projects). All activities are executed according to the Project Plan developed during Formulation. KDP E marks approval to launch. After successful on-orbit checkout or initial operations, the project transitions to Phase E. The start of Phase E (Operations and Sustainment) marks the transition from system development and acquisition activities to primarily systems operations and sustainment activities. In Phase F (Closeout), project space flight and associated ground systems are taken out of service and safely disposed of, although scientific and other analyses might continue under project funding. Independent evaluation activities occur throughout all phases.

2.6 Interrelationships Between NASA Programs and Projects

Figure 2-4 summarizes the NASA life cycles for space flight programs and projects and provides an overview of their interrelated life-cycle management processes.

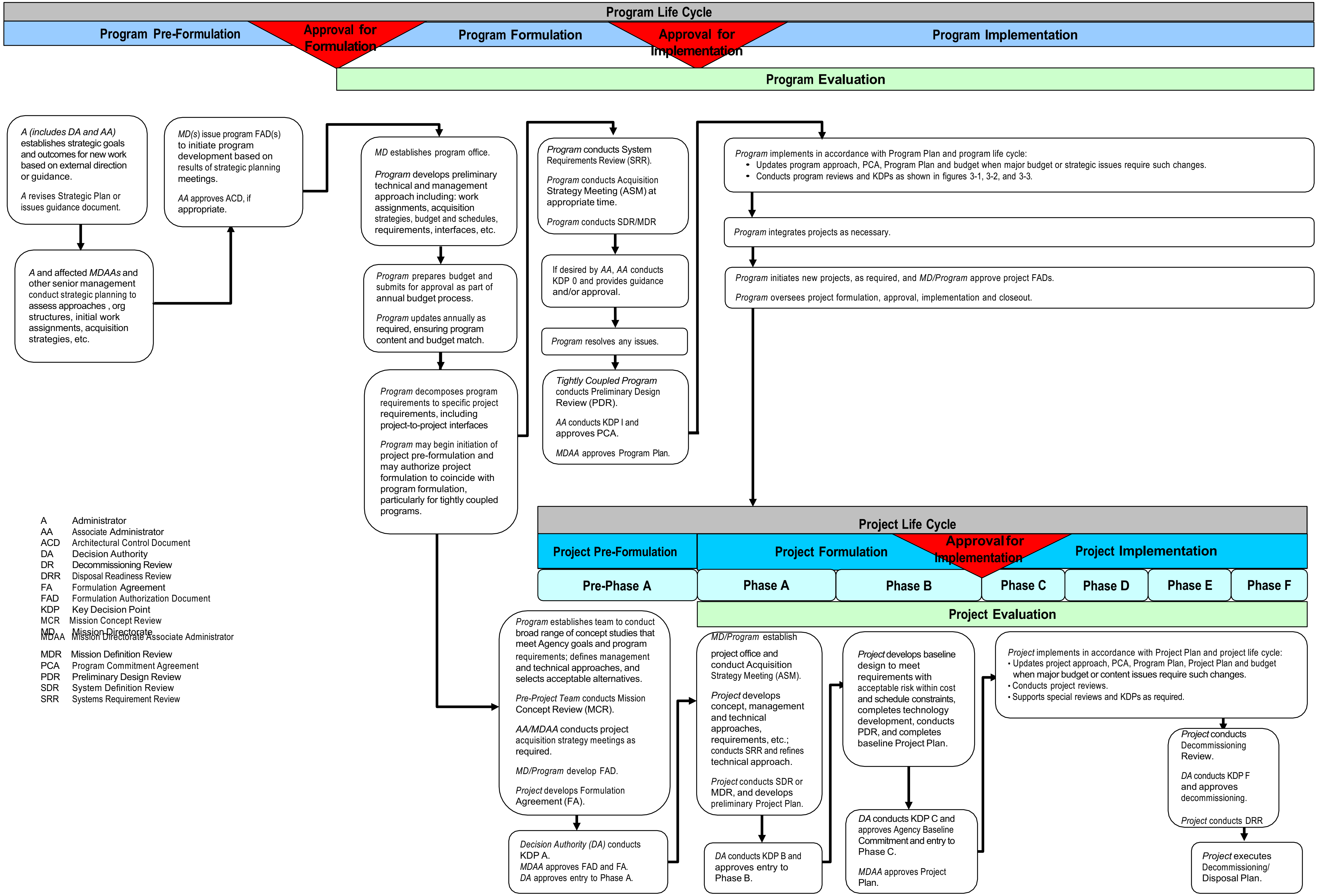


Figure 2-4 Space Flight Program and Project Management Process Overview

3 Program Life Cycles, Oversight, and Activities by Phase

3.1 NASA Programs

A program implements a strategic direction that the Agency has identified as needed to accomplish Agency goals and objectives. Because the scientific and exploration goals of programs vary significantly in scope, complexity, cost, and criticality, different program management strategies are required ranging from simple to complex. To accommodate these differences, NASA identifies four basic types of programs that may be employed:

- Single-project programs (e.g., James Webb Space Telescope (JWST)) tend to have long development and operational lifetimes and represent a large investment of Agency resources. Multiple organizations or agencies contribute to these programs. Single-project programs have one project and implement their program objectives and requirements through one of two management approaches: (1) separate program and project structures or (2) a combined structure. The requirements for both programs and projects apply to single-project programs as described in NPR 7120.5.
- Uncoupled programs (e.g., Discovery Program) are implemented under a broad theme (such as planetary science) and/or a common program implementation mechanism (such as providing flight opportunities for formally competed cost-capped projects or Principal Investigator (PI)-led missions and investigations). Each project in an uncoupled program is independent of the other projects within the program.
- Loosely coupled programs (e.g., Mars Exploration Program) address specific objectives through multiple space flight projects of varied scope. While each project has an independent set of mission objectives, the projects as a whole have architectural and technological synergies and strategies that benefit the program. For example, Mars orbiters designed for more than one Mars year in orbit are required to carry a communication system to support present and future landers.
- Tightly coupled programs have multiple projects that execute portions of a mission or missions. No single project is capable of implementing a complete mission. Typically, multiple NASA Centers contribute to the program. Individual projects may be managed at different Centers. The program may also include other agency or international partner contributions.

3.1.1 Program Life Cycles

Programs follow a life cycle that matches their program type. The different life cycles formalize the program management process. The life cycles for uncoupled and loosely coupled programs, tightly coupled programs, and single-project programs are shown in Figures 3-1, 3-2, and 3-3, respectively. These life-cycle figures illustrate the different life-cycle phases, gates, and major events, including Key Decision Points (KDPs); major Life-Cycle Reviews (LCRs); and principal documents that govern the conduct of each phase. They also show how programs recycle through Formulation when program changes warrant such action.

Each program life-cycle phase includes one or more LCRs, each designed to provide a periodic assessment of a program's technical and programmatic status and health at a key point in the life cycle. Life-cycle reviews are essential elements of conducting, managing, evaluating, and approving space flight programs and are an important part of NASA's system of checks and balances. Most life-cycle reviews are conducted by the program and an independent Standing Review Board (SRB). NASA accords special importance to maintaining the integrity of its independent review process to gain the value of an independent technical and programmatic perspective.

The Standing Review Board (SRB) is a group of independent experts who assess and evaluate program and project activities, advise programs and Convening Authorities (see Table 2-2 in NPR 7120.5), and report their evaluations to the responsible organizations as identified in Figure 3-6 of this handbook. They are responsible for conducting independent reviews (life cycle and special) of a program and providing objective, expert judgments to the Convening Authorities. The reviews are conducted in accordance with approved Terms of Reference (ToR) and life-cycle requirements per NPR 7120.5 and NPR 7123.1, NASA Systems Engineering Processes and Requirements. For more detail, see Section 5.10 of this handbook and NASA/SP-2016-3706, NASA Standing Review Board Handbook.[11]

LCRs provide the program and NASA senior management with a credible, objective assessment of how the program is doing. The final LCR in a program life-cycle phase provides essential information for the KDP, which marks the end of that life-cycle phase. A KDP is the point at which a Decision Authority determines whether and how a program proceeds through the life cycle and authorizes key program cost, schedule, and content parameters that govern the remaining life-cycle activities. For programs, the Decision Authority is the NASA Associate Administrator (AA). A KDP serves as a mandatory gate through which a program must pass to proceed to the next life-cycle phase. During the period between the LCR and the KDP, the program continues its planned activities unless otherwise directed by the Decision Authority.

KDPs associated with uncoupled, loosely coupled, and tightly coupled programs are designated with Roman numerals except for the potential first KDP, which is KDP 0. Because of the close correlation of steps between a single-project program and project life cycles, KDPs for single-project programs are designated by letters (KDP A, etc.).

For uncoupled and loosely coupled programs, the Formulation Phase is completed at KDP I after the program System Definition Review (SDR). Program approval for Implementation occurs at KDP I. After that, as depicted in Figure 3-1, Program Implementation Reviews

[11] https://ntrs.nasa.gov/citations/20170000280

(PIRs) are conducted during the Implementation Phase. (See Section 5.11.3 in this handbook for guidance on PIRs.) The need for PIRs to assess the program's performance, evaluate its continuing relevance to the Agency's Strategic Plan, and authorize its continuation is determined in one of two ways:

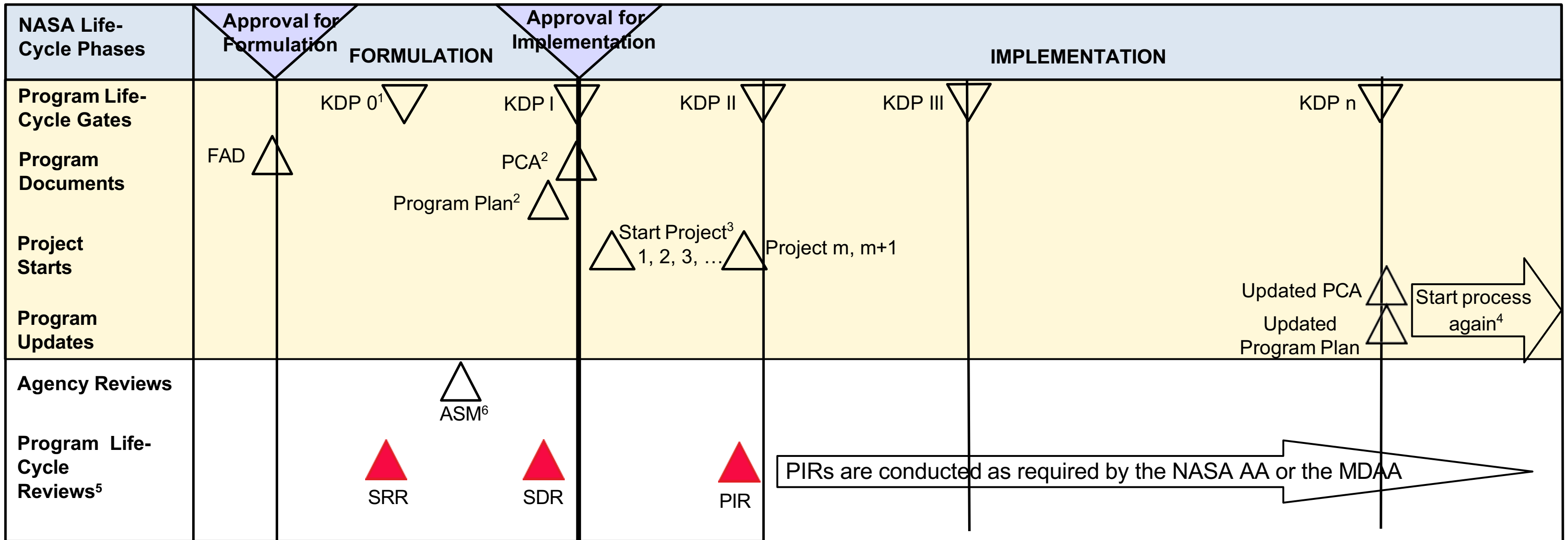
1. The NASA AA determines the need for a PIR based on the occurrence of a trigger and discussion with the Convening Authorities. The MDAA or an independent team member (Technical Authorities (TAs), Office of the Chief Financial Officer (OCFO)) reports to the NASA AA that a trigger for discussing the need for a PIR has occurred. This is reported at the Agency Program Management Council (APMC) during the annual review of Mission Directorate Independent Assessment Manifests. (For considerations that trigger a discussion on the need for a PIR, see Section 5.11.3.)
2. The NASA AA or MDAA, per their discretion, determine that a PIR is needed.

Tightly coupled programs are more complex as shown in Figure 3-2. Since the program is intimately tied to its projects, the Formulation Phase mirrors the single-project program life cycle shown in Figure 3-3, and program approval for Implementation occurs at KDP I after the program-level Preliminary Design Review (PDR). In the Implementation Phase, program LCRs generally continue to be tied to the project LCRs to ensure the proper integration of projects into the larger system. Once a tightly coupled program is in operations, the need for PIRs to assess the program's performance, evaluate its continuing relevance to the Agency's Strategic Plan, and authorize its continuation is determined in the same manner as for uncoupled and loosely coupled programs.

Single-project programs go through similar steps in Formulation and Implementation as projects. However, because of their size, scope, complexity, and importance to the Agency, single-project programs have additional program requirements imposed on them. The management approach for single-project programs can take one of two structures:

1. Separate program and project management organizations, or
2. A combined structure where both program and project functions are integrated, and all functions are managed and performed by the one organization.

As shown in Figure 3-3, the single-project program transitions from Formulation to Implementation at KDP C following the single-project program's PDR. Following approval at KDP C, the single-project program continues with design, fabrication and/or manufacturing, system integration, and test leading up to launch and checkout following KDP E. Once a single-project program is in operations, the need for PIRs to assess the program's performance, evaluate its continuing relevance to the Agency's Strategic Plan, and authorize its continuation is determined in the same manner as for uncoupled and loosely coupled programs.



FOOTNOTES

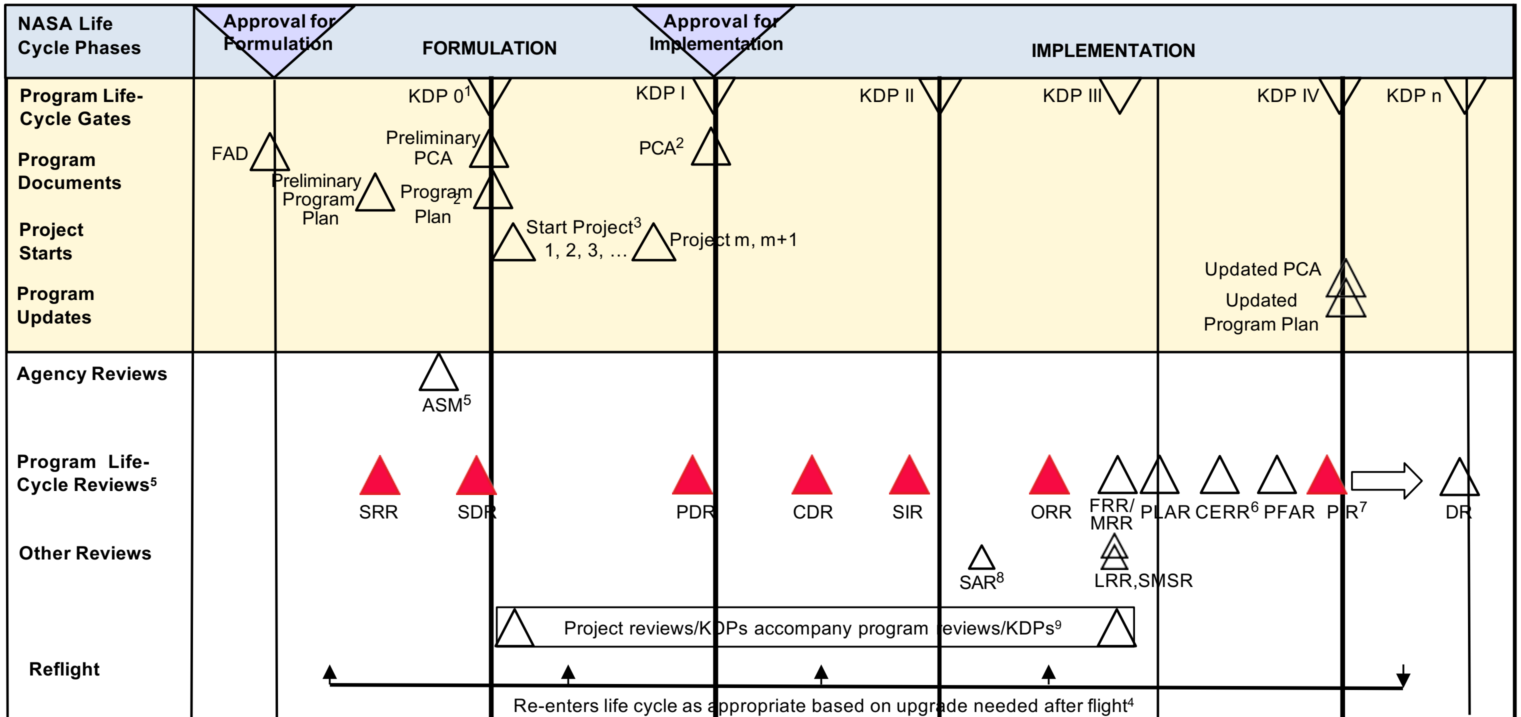
1. KDP 0 may be required by the Decision Authority to ensure major issues are understood and resolved prior to formal program approval at KDP I.
2. Program Plans are baselined at SDR, and PCAs are baselined at KDP I. These are reviewed and updated, as required, to ensure program content, cost, and budget remain consistent.
3. Projects, in some instances, may be approved for Formulation prior to KDP I. Initial project pre-Formulation generally occurs during program Formulation.
4. When programs evolve and/or require upgrades (e.g., new program capabilities), the life-cycle process will be restarted when warranted, i.e., the program's upgrade will go through Formulation and Implementation steps.
5. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-3 of NPR 7120.5.
6. Timing of the ASM is determined by the MDAA or AA, as compliant with NPD 1000.5 and may take place at any time during Formulation.

ACRONYMS

ASM—Acquisition Strategy Meeting FAD—Formulation Authorization Document
KDP—Key Decision Point
PCA—Program Commitment Agreement
PIR—Program Implementation Review
SDR—System Definition Review SRB—Standing Review Board SRR—System Requirements Review

Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB conduct other reviews.

Figure 3-1 NASA Uncoupled and Loosely Coupled Program Life Cycle



FOOTNOTES

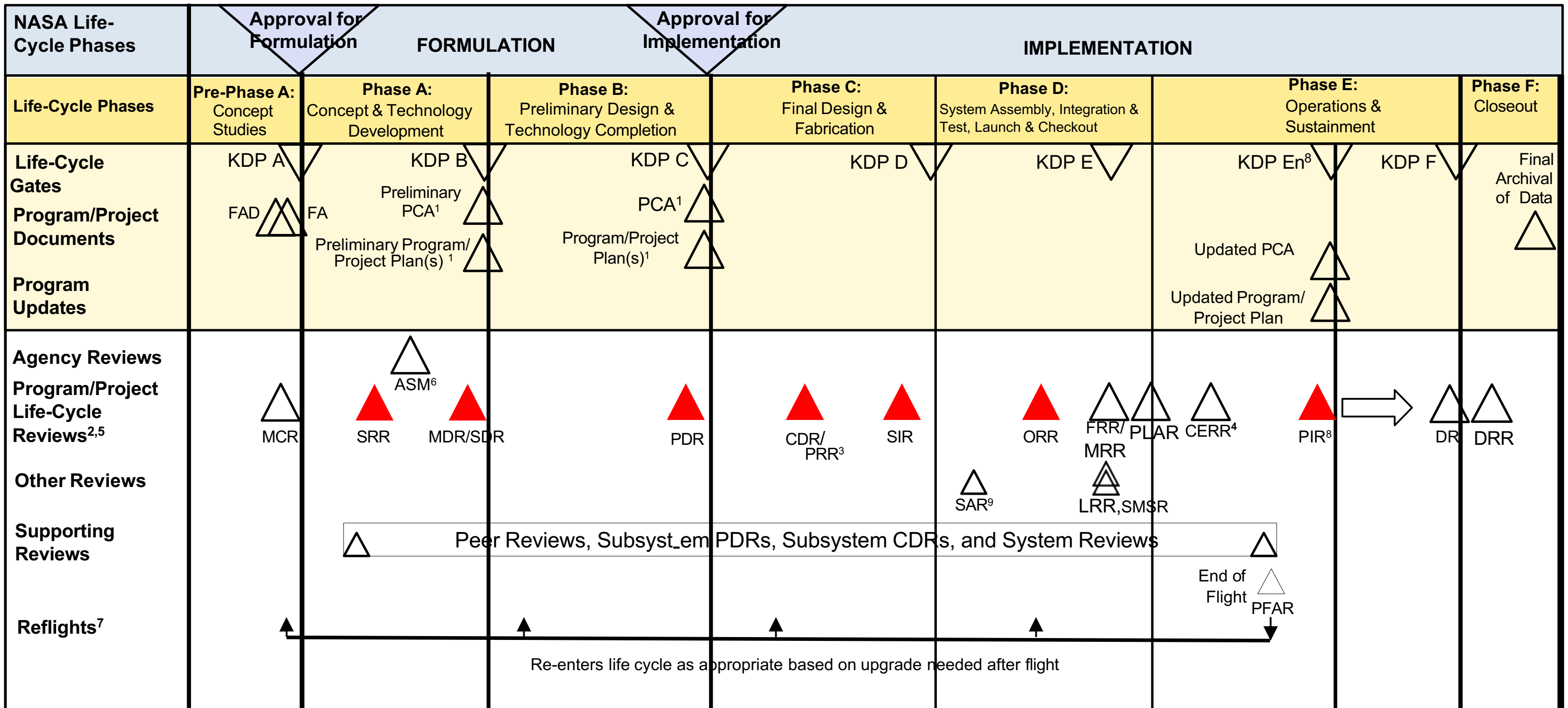
1. KDP 0 may be required by the Decision Authority to ensure major issues are understood and resolved prior to formal program approval at KDP I.
2. Program Plans are baselined at SDR, and PCAs are baselined at KDP I. These are reviewed and updated, as required, to ensure program content, cost, and budget remain consistent.
3. Projects are usually approved for Formulation prior to KDP I.
4. Placement of arrows is notional. See Section 2.2.4.3 of NPR 7120.5 for more guidance on reflights.
5. Timing of the ASM is determined by the MDAA or AA, as compliant with NPD 1000.5 and may take place at any time during Formulation.
6. CERRs are established at the discretion of the Program Offices.
7. Tightly coupled program reviews generally differ from the reviews of other program types because they are conducted to ensure the overall integration of all program elements (i.e., projects). Once the program is in operations, PIRs are conducted as required by the NASA AA or the MDAA.
8. SAR generally applies to human space flight.
9. Life-cycle review objectives, expected maturity states for these reviews, and the attendant KDPs are contained in Table 2-4 of NPR 7120.5.

ACRONYMS

ASM—Acquisition Strategy Meeting
CDR—Critical Design Review
CERR—Critical Events Readiness Review
DR—Decommissioning Review
FAD—Formulation Authorization Document
FRR—Flight Readiness Review
KDP—Key Decision Point
LRR—Launch Readiness Review
MRR—Mission Readiness Review
ORR—Operational Readiness Review
PCA—Program Commitment Agreement
PDR—Preliminary Design Review
PFAR—Post-Flight Assessment Review
PIR—Program Implementation Review
PLAR—Post-Launch Assessment Review
SAR—System Acceptance Review
SDR—System Definition Review
SIR—System Integration Review
SMSR—Safety and Mission Success Review
SRB—Standing Review Board
SRR—System Requirements Review

Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

Figure 3-2 NASA Tightly Coupled Program Life Cycle



FOOTNOTES

1. Program Plans and PCAs are baselined at KDP C. These are reviewed and updated, as required, to ensure program content, cost, and budget remain consistent. Program and Project Plans may be combined if approved by the MDAA.
2. Flexibility is allowed to the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Program/Project Plan(s).
3. PRR needed for multiple system copies. Timing is notional. PRR is not an SRB review.
4. CERRs are established at the discretion of Program Offices.
5. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5 of NPR 7120.5.
6. Timing of the ASM is determined by the MDAA or AA, as compliant with NPD 1000.5 and may take place at any time during Phase A.
7. Placement of arrows is notional. See Section 2.2.4.3 of NPR 7120.5 for more guidance on reflights..
8. Once the program is in operations, PIRs are conducted as required by the NASA AA or the MDAA. KDP En follows the PIRs, i.e., KDP E2 would follow the first PIR, etc.
9. SAR generally applies to human space flight.

ACRONYMS

ASM—Acquisition Strategy Meeting CDR—Critical Design Review CERR—Critical Events Readiness Review DR—Decommissioning Review DRR—Disposal Readiness Review FA—Formulation Agreement FAD—Formulation Authorization Document FRR—Flight Readiness Review KDP—Key Decision Point LRR—Launch Readiness Review MDAA—Mission Directorate Associate Administrator MCR – Mission Concept Review MDR—Mission Definition Review

MRR—Mission Readiness Review ORR—Operational Readiness Review PCA—Program Commitment Agreement PDR—Preliminary Design Review PFAR—Post-Flight Assessment Review PIR—Program Implementation Review PLAR—Post-Launch Assessment Review PRR—Production Readiness Review SAR—System Acceptance Review SDR—System Definition Review SIR—System Integration Review SMSR—Safety and Mission Success Review SRB—Standing Review Board SRR—System Requirements Review

Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

Figure 3-3 NASA Single-Project Program Life Cycle

3.1.2 Program Life-Cycle Reviews

The program LCRs identified in the program life cycles are essential elements of conducting, managing, evaluating, and approving space flight programs. The program manager is responsible for planning for and supporting the LCRs, which assess the following six assessment criteria identified in NPR 7120.5:

- **Alignment with and contribution to Agency strategic goals and the adequacy of requirements that flow down from those.** The scope of this criterion includes, but is not limited to, alignment of program requirements and designs with Agency strategic goals, program requirements and constraints, mission needs and success criteria; allocation of program requirements to projects; and proactive management of changes in program scope and shortfalls.
- **Adequacy of management approach.** The scope of this criterion includes, but is not limited to, program authorization, management framework and plans, acquisition strategies, and internal and external agreements.
- **Adequacy of technical approach** as defined by *NPR 7123.1, NASA Systems Engineering Processes and Requirements* entrance and success criteria. The scope of this criterion includes, but is not limited to, flow down of project requirements to systems and subsystems, architecture and design, and operations concepts that respond to and satisfy requirements and mission needs.
- **Adequacy of the integrated cost and schedule estimate and funding strategy** in accordance with *NPD 1000.5, Policy for NASA Acquisition*. The scope of this criterion includes, but is not limited to, cost and schedule control plans; cost and schedule estimates (prior to KDP I (KDP C for single-project programs)) and baselines (at KDP I (KDP C for single-project programs)) that are consistent with the program requirements, assumptions, risks, and margins; Basis of Estimate (BoE); Joint Cost and Schedule Confidence Level (JCL) (when required); and alignment with planned budgets.
- **Adequacy and availability of resources other than budget.** The scope of this criterion includes, but is not limited to, planning, availability, competency and stability of staffing, infrastructure, and the industrial base and supply chain requirements.
- **Adequacy of the risk management approach and risk identification and mitigation** in accordance with *NPR 8000.4, Agency Risk Management Procedural Requirements* and *NASA/SP-2011-3422, NASA Risk Management Handbook.*[12] The scope of this criterion includes, but is not limited to, risk-management plans, processes (e.g., Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM)), open and accepted risks, risk assessments, risk mitigation plans, and resources for managing and mitigating risks.

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[12] https://ntrs.nasa.gov/api/citations/20120000033

The Joint Cost and Schedule Confidence Level (JCL) is the product of a probabilistic analysis of the coupled cost and schedule to measure the likelihood of completing all remaining work at or below the budgeted levels and on or before the planned completion of the development phase. A JCL is required for all single-project programs (regardless of LCC or initial capability cost) at KDP C. A JCL is also required for all single-project programs in the event of a rebaseline during the Implementation phase. For single-project programs with LCC or initial capability cost ≥ $1B, a JCL is also required at KDP B and the Critical Design Review (CDR), and at KDP D if current reported development costs have exceeded the development ABC cost by 5 percent or more. The JCL calculation includes consideration of the risk associated with all elements, whether they are funded from appropriations or managed outside of the program. JCL calculations include content from the milestone at which the JCL is calculated through the completion of Phase D activities. Per NPR 7120.5, at KDP B, if applicable, and KDP C, Mission Directorates plan and budget single-project programs (regardless of LCC or initial capability cost) based on a 70 percent JCL or as approved by the Decision Authority. At KDP C, Mission Directorates ensure funding for single-project programs is consistent with the Management Agreement and in no case less than the equivalent of a 50 percent JCL or as approved by the Decision Authority.

LCRs are designed to provide the program an opportunity to ensure that it has completed the work of that phase and an independent assessment of the program's technical and programmatic status and health. LCRs are conducted under documented Agency and Center review processes. (See Section 5.10 and *NASA/SP-2016-3706*, *NASA Standing Review Board Handbook*.)

A life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment and sign the Decision Memorandum.

The life-cycle review process provides:

- The program with a credible, objective independent assessment of how it is doing.
- NASA senior management with an understanding of whether:
  - The program is on track to meet objectives,
  - The program is performing according to plan, and
  - Impediments to program success are addressed.
- For a LCR that immediately precedes a KDP, a credible basis for the Decision Authority to approve or disapprove the transition of the program at the KDP to the next life-cycle phase.

The independent review also provides vital assurance to external stakeholders that NASA's basis for proceeding is sound.

The program finalizes its work for the current phase during the LCR. In some cases, the program uses the life-cycle review meeting(s) to make formal programmatic and technical decisions necessary to complete its work. In all cases, the program utilizes the results of the independent assessment and the resulting management decisions to finalize its work. In addition, the independent assessment serves as a basis for the program and management to determine if the program's work has been satisfactorily completed, and if the plans for the following life-cycle phases are acceptable. If the program's work has not been satisfactorily completed, or its plans are not acceptable, the program addresses the issues identified during the life-cycle review or puts in place the action plans necessary to resolve them.

Prior to LCRs, programs conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. These internal reviews are key components of the process used by programs to solidify their plans, technical approaches, and programmatic commitments and are part of the normal systems engineering work processes defined in NPR 7123.1. Internal reviews assess major technical and programmatic requirements along with the system design and other implementation plans. Major technical and programmatic performance metrics are reported and assessed against predictions.

Any LCR can be either a one-step or a two-step review. The program manager has the authority to determine which type of review to hold. This determination usually depends on the state of the program's cost and schedule maturity as described below. The program manager documents the program's review approach in the program **Review Plan**.

Descriptions of the one-step and two-step life-cycle review processes are provided in Figures 3-4 and 3-5. These descriptions are written from the perspective of reviews conducted by a program and an SRB. For life-cycle reviews that do not require an Agency-led SRB, i.e., MCR, FRR/MRR, PLAR, CERR, PFAR, DR, and DRR, the program manager will work with the Center Director or designee to prepare for and conduct the life-cycle review in accordance with Center practices and a Center-assigned independent review team. For such reviews conducted by the program and a Center independent review team, the remaining references to SRB are replaced with Center independent review team:

- In a one-step review, the program's technical maturity and programmatic posture are assessed together against the six assessment criteria. In this case, the program has typically completed all its required technical work as defined in NPR 7123.1 life-cycle review entrance criteria and has aligned the scope of this work with its cost estimate, schedule, and risk posture before the life-cycle review. The life-cycle review is then focused on presenting this work to the SRB. Except in special cases, a one-step review is chaired by the SRB. The SRB assesses the work against the six assessment criteria and then provides an independent assessment of whether the program has met these criteria. Figure 3-4 illustrates the one-step life-cycle review process. (A one-step review for a program is analogous to a one-step review for a project.)

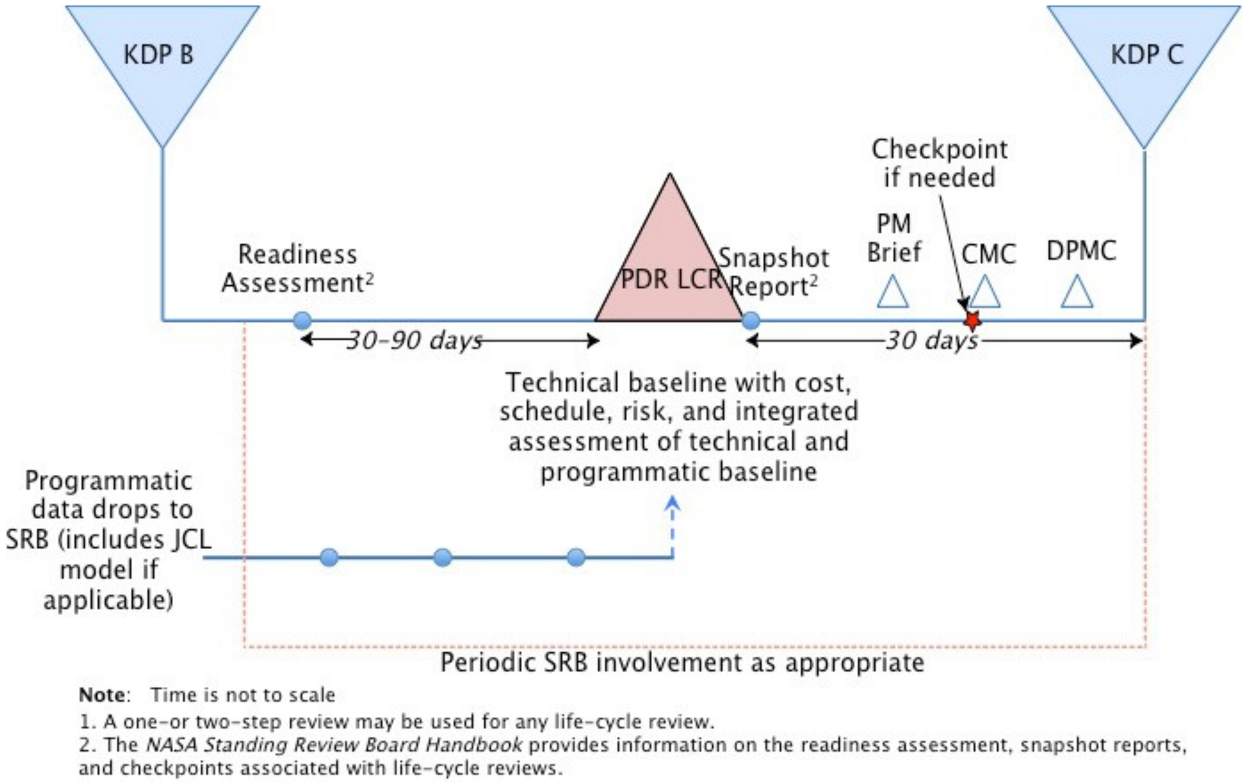


Figure 3-4 One-Step[1] PDR Life-Cycle Review Overview

- In a two-step review, the program typically has not fully integrated the program's cost and schedule with the technical work. In this case, the first step of the life-cycle review is focused on finalizing and assessing the technical work described in NPR 7123.1. However as noted in Figure 3-5, which illustrates the two-step life-cycle review process, the first step does consider the preliminary cost, schedule, and risk as known at the time of the review. This first step is only one half of the life-cycle review. At the end of the first step, the SRB will have fully assessed the technical approach criteria but will only be able to determine preliminary findings on the remaining criteria since the program has not yet finalized its work. Thus, the second step is conducted after the program has taken the results of the first step and fully integrated the technical scope with the cost, schedule, and risk, and has resolved any issues that may have arisen as a result of this integration. The period between steps may take up to six months depending on the complexity of the program. In the second step, which may be referred to as the Independent Integrated Life-Cycle Review Assessment, the program typically presents the integrated technical, cost, schedule, and risk, just as is done for a one-step review, but the technical presentations may simply update information provided during the first step. The SRB then completes its assessment of whether the program has met the six assessment criteria. In a two-step life-cycle review, both steps are necessary to fulfill the life-cycle review requirements. Except in special cases, the SRB chairs both steps of the life-cycle review. (A two-step review for a program is analogous to a two-step review for a project.)

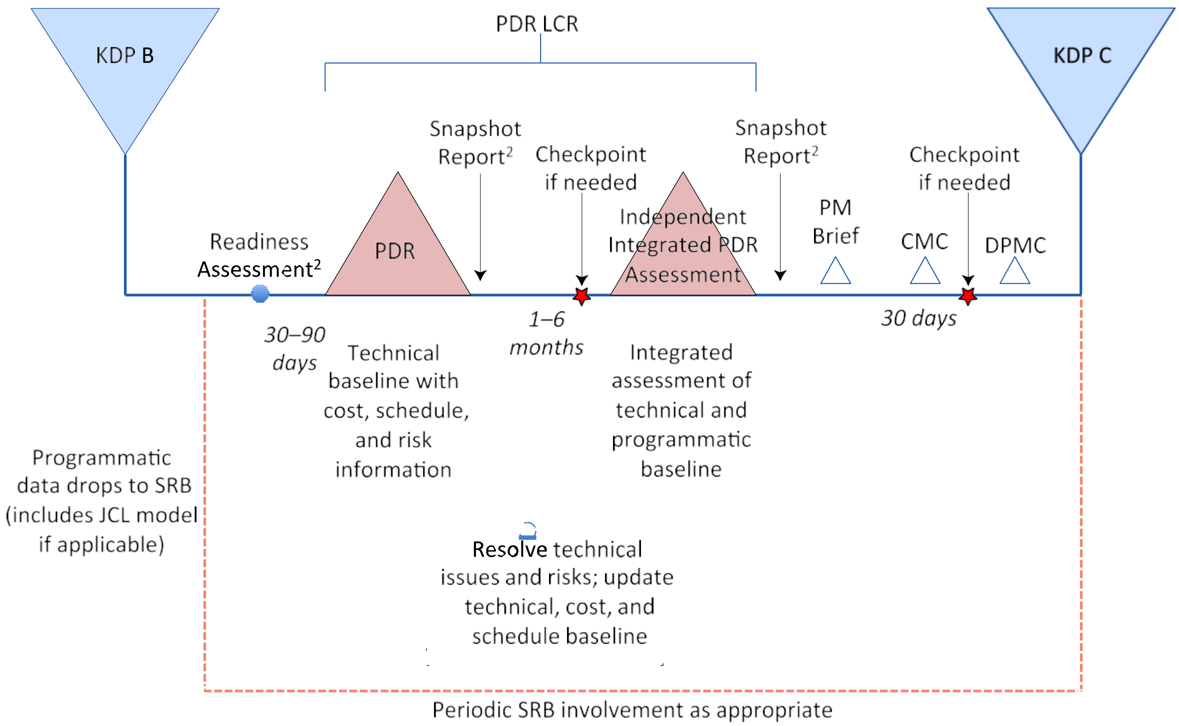


Figure 3-5 Two-Step[1] PDR Life-Cycle Review Overview

There are special cases, particularly for human space flight programs, where the program uses the life-cycle review to make formal decisions to complete the program's technical work and align it with the cost and schedule. In these cases, the program manager may co-chair the life-cycle review since the program manager is using this forum to make program decisions, and the SRB will conduct the independent assessment concurrently. The program manager will need to work with the SRB chair to develop the life-cycle review agenda and agree on how the life-cycle review will be conducted to ensure that it enables the SRB to fully accomplish the independent assessment. The program manager and the SRB chair work together to ensure that the life-cycle review Terms of Reference (ToR) reflect their agreement and the Convening Authorities approve the approach.

Details on program review activities by life-cycle phase are provided in the sections below. *NASA/SP-2016-3706, NASA Standing Review Board Handbook* and Section 5.10 in this handbook also contain more detailed information on conducting life-cycle reviews. NPR 7123.1 provides life-cycle review entrance and success criteria, and Appendix I in NPR 7120.5F and Appendix E in this handbook provide specifics for addressing the six assessment criteria required to demonstrate that the program has met the expected maturity state for the KDP.

3.1.3 Other Reviews and Resources

Special reviews may be convened by the Office of the Administrator, the Mission Directorate Associate Administrator (MDAA), Center Director, the Technical Authorities (TAs),[13] or other Convening Authority. Special reviews may be warranted for programs not meeting expectations for achieving safety, technical, cost, or schedule requirements; not being able to develop an enabling technology; or experiencing some unanticipated change to the program baseline. Special reviews include a Rebaseline Review and Termination Review. Rebaseline Reviews are conducted when the Decision Authority determines the Agency Baseline Commitment (ABC) needs to be changed. (For more detail on Rebaseline Reviews, see Section 5.5.5.1. For more detail on the ABC, see Sections 3.2.4 and 5.5.1.) A Termination Review may be recommended by a Decision Authority, MDAA, or program executive if he or she believes it may not be in the Government's best interest to continue funding a program.

Other reviews, such as Safety and Mission Assurance (SMA) reviews, are part of the regular management process. For example, SMA Compliance Verification reviews are spot reviews that occur on a regular basis to ensure programs are complying with NASA safety principles and requirements. For more detail on Termination Reviews and SMA reviews, see Section 5.11.

Other resources are also available to help a program manager evaluate and improve program performance. These resources include:

- The NASA Engineering and Safety Center (NESC), an independently funded organization with a dedicated team of technical experts, provides objective engineering and safety assessments of critical, high-risk programs. NESC is a resource to benefit programs and organizations within the Agency, the Centers, and the people who work there by promoting safety through engineering excellence that is unaffected and unbiased by the programs it is evaluating. The NESC mission is to proactively perform value-added independent testing, analysis, and assessments to ensure safety and mission success and help NASA avoid future problems. Programs seeking an independent assessment or expert advice on a particular technical problem can contact the NESC at http://www.nasa.gov/offices/nesc/contacts/index.html or the NESC Chief Engineer at their Center.
- The NASA Independent Verification and Validation (IV&V) Facility strives to improve the software safety, reliability, and quality of NASA programs and missions through effective applications of systems and software IV&V methods, practices, and techniques. The NASA IV&V Facility applies software engineering best practices to evaluate the correctness and quality of critical and complex software systems. When applying systems and software IV&V, the NASA IV&V Facility seeks to ensure that the software exhibits behaviors exactly as intended, does not exhibit behaviors that were not

[13] That is, individuals with specifically delegated authority in Engineering (ETA), Safety and Mission Assurance (SMA TA), and Health and Medical (HMTA). See 5.2 for more information on Technical Authorities.

intended, and exhibits expected behaviors under adverse conditions. Software IV&V has been demonstrated to be an effective technique on large, complex software systems to increase the probability that software is delivered within cost and schedule, and that software meets requirements and is safe. When performed in parallel with systems development, software IV&V provides for the early detection and identification of risk elements, enabling early mitigation of the risk elements. For projects that either are required or desire to do software IV&V, contact information is available on the Katherine Johnson IV&V Facility home page at http://www.nasa.gov/centers/ivv/home/index.html. (All Category 1 projects; all Category 2 projects that have Class A or Class B payload risk classification per *NPR 8705.4, Risk Classification for NASA Payloads;* and projects specifically selected by the NASA Chief, Safety and Mission Assurance (SMA) are required to do software IV&V. See NPR 7120.5F and Section 4.1 in this handbook for project categorization guidelines.)

3.1.4 Program Evolution and Recycling

A program may evolve over time in ways that require it to go back and restart parts of its life cycle. A program may evolve as a result of a planned series of upgrades, with the addition of new projects, when the need for new capabilities is identified, or when a new mission is assigned to the program.

For tightly coupled and single project programs, when the requirements imposed on a program significantly change, the program typically evaluates whether the changes impact the program's current approved approach and/or system design and performance. In these cases, the Decision Authority may ask the program to go back through the necessary life-cycle phases and reviews and update program documentation to ensure that the changes have been properly considered in light of the overall program and/or system performance. Each case is likely to be different and thus may not require completely restarting the process at the beginning. The decision on when and where to recycle through the life-cycle reviews will be based on a discussion between the program, the Mission Directorate, and the Decision Authority. This case is depicted in Figures 3-2 and 3-3 as the "Reenters life cycle as appropriate based on upgrade needed after flight" arrows. As an example, after the Hubble Space Telescope (HST) was deployed in April 1990 and was in operations, a component for the HST started back through the life cycle. The Corrective Optics Space Telescope Axial Replacement (COSTAR) program for correcting the optics of the HST was required to repeat a concept definition phase after approval in January 1991 and start back through the life cycle at the PDR.

There are also cases of evolution for a single-project program where operational reusable systems are refurbished after each flight or modifications are required between flights. A program going back through a part of its life cycle is depicted in Figure 3-3 on the "Reflight" line.

Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, may implement major upgrades, i.e., upgrades that meet the Agency criteria for a major project for external reporting. These upgrades enter the life cycle at the appropriate life-cycle review in the Formulation Phase. (See Section 3.5.1 for additional information on these major upgrades.)

For uncoupled and loosely coupled programs, program evolution is also possible. An example of a simple change to an uncoupled program that might warrant performing another SDR and subsequent program reapproval might be the addition of a new science discipline to the program that requires a totally different implementation approach. In this case, the Decision Authority may wish to have the program evaluated to ensure the program's approach is satisfactory.

3.1.5 Program Tailoring

Program teams are expected to tailor the requirements of NPR 7120.5 to meet the specific needs of the program. When a program team and its management determine that a requirement is not needed, the process for tailoring that requirement requires getting permission from the requirement owner. Tailoring can be done using the Compliance Matrix attached to the Program Plan. Tailoring of NPR 7120.5F requirements is approved when the proper authorities for the Program Plan and the requirement owners (indicated in the Compliance Matrix) have signed off on the tailoring. Tailoring processes, consultation and assistance, guidance, and resources to help the program manager tailor requirements can be found in Section 5.4 of this handbook, Appendix C of NPR 7120.5F, and the Agency Tailoring Website.[14] Resources available on the Agency Tailoring Website include:

- The full Compliance Matrix.
- Pre-customized Compliance Matrix templates that eliminate non-applicable requirements for specific types of programs and projects.
- Points of Contact provided by HQ requirements owners and some Mission Directorates for consulting with and assisting programs and projects in developing their tailoring approach and in obtaining approval for tailoring.
- Information on how the NASA Program and Project Management Board (PPMB) may assist programs and projects in tailoring requirements and provide guidance through the tailoring process.
- Guidance documents for developing a program's tailoring approach provided by some HQ requirements owners (e.g., OCE, OCFO).
- Guidance documents from some Mission Directorates for developing a program's tailoring approach.

[14] https://appel.nasa.gov/npr-7120-5-tailoring-resources

The full Compliance Matrix (*NPR 7120.5 Rev F Compliance Matrix*) can also be found on the OCE tab in NODIS under "Other Policy Documents."

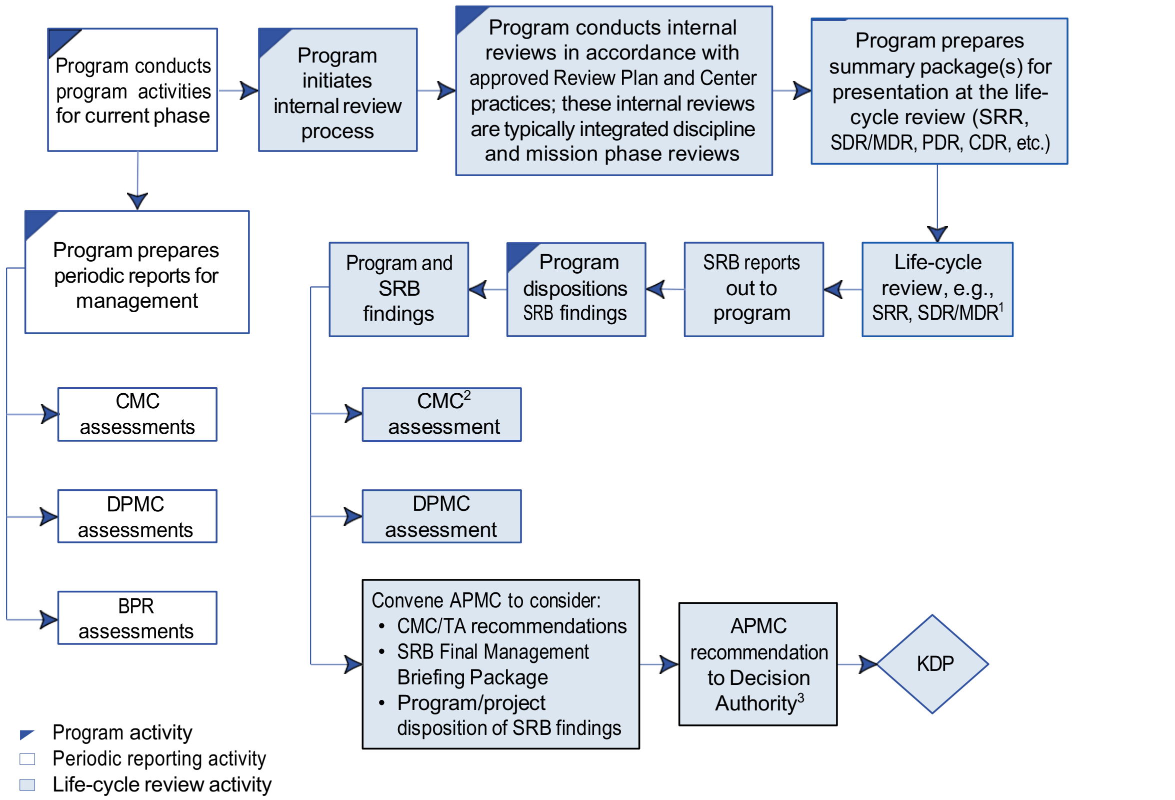
Tailoring allows programs to perform only those activities that are needed for mission success while still meeting Agency external requirements and receiving the benefits of NASA policy, reflecting lessons learned and best practice. Program managers are encouraged to thoughtfully examine and tailor requirements so programs perform only those requirements that contribute to achieving mission success. Requirements imposed by Federal law or external entities generally cannot be waived.

The Agency's directives, procedural requirements, standards, and handbooks have been developed to assist program managers in achieving mission success by establishing requirements and best practices. It is not possible to generate the proper requirements and guidelines for every possible scenario. Program managers work with their Center and the Mission Directorate when tailoring to ensure that all parties agree with the proposed approach.

3.2 Program Oversight and Approval

NASA has established a program management oversight process to ensure that the experience, diverse perspectives, and thoughtful programmatic and technical judgment at all levels is available and applied to program activities. The Agency employs management councils and management forums, such as the Baseline Performance Review (BPR), to provide insight to upper management on the status and progress of programs and their alignment with Agency goals. This section describes NASA's oversight approach and the process by which programs are approved to move forward through their life cycles. It defines and describes NASA's Decision Authority, KDPs, management councils, and the BPR. (See Section 3.2.5 for information on the BPR and Section 4.2.2 for more information on management councils for projects.)

The general flows of the program oversight and approval process for LCRs that require SRBs and of the periodic reporting activity for programs are shown in Figure 3-6. Prior to the LCR, the program conducts its internal reviews. Then the program and the SRB conduct the LCR. Finally, the results are reported to senior management through the management councils.



[1] See the *NASA Standing Review Board Handbook* for details.
[2] May be an Integrated Center Management Council when multiple Centers are involved.
[3] Life-cycle review that occurs at the end of a life cycle phase is complete when the governing PMC and Decision Authority complete their assessment.

Figure 3-6 Program Life-Cycle Review Process and Periodic Reporting Activity

Additional insight is provided by the independent perspective of SRBs at LCRs identified in Figures 3-1, 3-2, and 3-3. Following each LCR, the independent SRB chair and the program manager brief the applicable management councils on the results of the LCR to support the councils' assessments. These briefings are completed within 30 days of the LCR. The 30 days ensures that the Decision Authority is informed in a timely manner as the program moves forward to preclude the program from taking action that the Decision Authority does not approve. These briefings cover the objectives of the review; the maturity expected at that point in the life cycle; findings and recommendations to rectify issues or improve mission success; the program's response to these findings; and the program's proposed cost, schedule, safety, and technical plans for the follow-on life-cycle phases. This process enables a disciplined approach for developing the Agency's assessment, which informs the Decision Authority's KDP determination of program readiness to proceed to the next life-cycle phase. LCRs are conducted under documented Agency and Center review processes.

3.2.1 Decision Authority

The Decision Authority is the Agency individual who makes the KDP determination on whether and how the program proceeds through the life cycle and authorizes the key program cost, schedule, and content parameters that govern the remaining life-cycle activities. The NASA AA is the Decision Authority for all programs.

The Decision Authority is the individual authorized by the Agency to make important decisions on programs and projects under their purview. The Decision Authority makes the KDP decision by considering a number of factors, including technical maturity; continued relevance to Agency strategic goals; adequacy of cost and schedule estimates; associated probabilities of meeting those estimates (confidence levels); continued affordability with respect to the Agency's resources; maturity and the readiness to proceed to the next phase; and remaining program risk (safety, cost, schedule, technical, management, and programmatic). The NASA AA signs the Decision Memorandum as the Decision Authority for programs at the KDP. This signature indicates that the Decision Authority, as the approving official, has been made aware of the technical and programmatic issues within the program, approves the mitigation strategies as presented or with noted changes requested, and accepts technical and programmatic risk on behalf of the Agency.

3.2.2 Management Councils

3.2.2.1 Program Management Councils

At the Agency level, NASA Headquarters has two levels of Program Management Councils (PMCs): the Agency PMC (APMC) and the Mission Directorate PMCs (DPMCs). The PMCs evaluate the safety, technical, and programmatic performance (including cost, schedule, risk, and risk mitigation) and content of a program under their purview for the entire life cycle. These evaluations focus on ensuring that the program is meeting its commitments to the Agency and is successfully achieving the Agency's strategic goals.

For all programs, the governing PMC is the APMC. The APMC is chaired by the NASA AA and comprises Headquarters senior managers and Center Directors. The council members advise the AA in his or her role as the PMC Chair and Decision Authority. The APMC:

- Ensures that NASA is meeting the commitments specified in the relevant management documents for program performance and mission assurance.
- Ensures implementation and compliance with NASA program management processes and requirements.
- Reviews programs routinely, including the institutional ability to support program commitments.
- Approves PCAs.
- Reviews special and out-of-cycle assessments.
- Approves the Mission Directorate strategic portfolio and its associated risk.

As the governing PMC for programs, the APMC evaluates programs in support of KDPs. A KDP normally occurs at the APMC review as depicted in Figure 3-6. The APMC makes a recommendation to the NASA AA on a program's readiness to progress in its life cycle and provides an assessment of the program's proposed cost, schedule, and content parameters. The NASA AA, as the Decision Authority for programs, makes the KDP determination on whether and how the program progresses in its life cycle and authorizes the key program cost, schedule, and content parameters that govern the remaining life-cycle activities. Decisions are documented in a formal Decision Memorandum, and actions are tracked in a Headquarters tracking system such as the Headquarters Action Tracking System (HATS). (See Section 3.2.4 and Section 5.5.6 for a description of the Decision Memorandum.)

A Directorate PMC (DPMC) provides oversight for the MDAA and evaluates all programs executed within that Mission Directorate. The DPMC is usually chaired by the MDAA and comprises senior Headquarters executives from that Mission Directorate. The MDAA may delegate the chairmanship to one of the senior executives. The activities of the DPMC are directed toward periodically (usually monthly) assessing program performance and conducting in-depth program assessments at critical milestones. The DPMC makes recommendations regarding:

- Initiation of new programs based on the results from advanced studies.
- Transition of ongoing programs from one phase of the program life cycle to the next.
- Action on the results of periodic or special reviews, including rebaselining or terminating programs.

The results of the DPMC are documented and include decisions made and actions to be addressed. The MDAA may determine that a program is not ready to proceed to the APMC and may direct corrective action. If the program is ready to proceed, the MDAA carries forward the DPMC findings and recommendations to the APMC.

3.2.2.2 Center Management Council

Centers have a Center Management Council (CMC) that provides oversight and insight for the Center Director (or designee) for all program work executed at that Center. The CMC evaluation focuses on whether Center engineering, SMA, health and medical, and management best practices (e.g., program management, resource management, procurement, institutional) are being followed by the program under review; whether Center resources support program requirements; and whether the program is meeting its approved plans successfully. As chair of the CMC, the Center Director (or designee) may provide direction to the program manager to correct program deficiencies with respect to these areas. However, with respect to programmatic requirements, budgets, and schedules, the Center Director does not provide direction but only recommendations to the program manager, Mission Directorate, or Agency leadership. The CMC also assesses program risk and evaluates the status and progress of activities to identify and report trends and provide guidance to the Agency and affected programs. For example, the CMC may note a trend of increasing risk that potentially indicates a bow wave of accumulating work or may communicate industrial base issues to other programs that might be affected. Prior to

KDPs, the Center Director, as CMC chair, provides the Center's findings and recommendations to program managers and to the DPMC and APMC regarding the performance, technical, and management viability of the program. This includes making recommendations to the Decision Authority at KDPs regarding the ability of the program to execute successfully. (Figure 3-6 shows this process.) These recommendations consider all aspects (including safety, technical, programmatic, and major risks and strategy for their mitigation) and are supported by independent analyses, when appropriate.

In accordance with NPR 7120.5: "Center Directors are responsible and accountable for all activities assigned to their Center. They are responsible for the institutional activities and for ensuring the proper planning for and successful execution of programs and projects assigned to the Center." This means that the Center Director is responsible for ensuring that programs develop plans that are executable within the guidelines from the Mission Directorate and that these programs are executed within the approved plans. In cases where the Center Director believes a program cannot be executed within approved guidelines and plans, the Center Director works with the program and Mission Directorate to resolve the problem. (See Section 5.1.2 for additional information on Center Directors' responsibilities.)

The relationship of the various management councils to each other is shown in Figure 3-7.

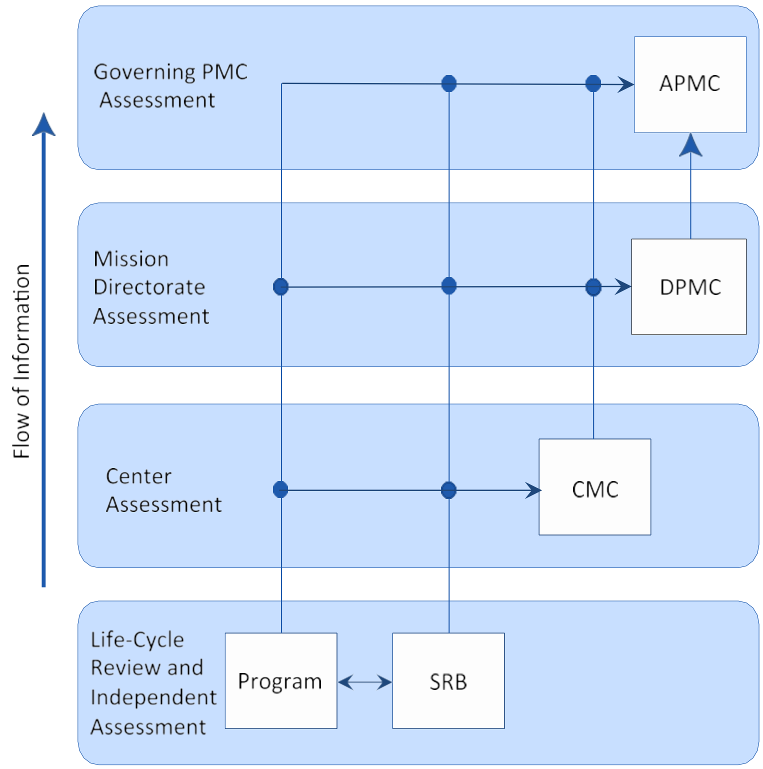


Figure 3-7 Management Council Reviews in Support of KDPs

3.2.2.3 Integrated Center Management Councils

An Integrated Center Management Council (ICMC) is generally used for any program conducted by multiple Centers. This is particularly true for tightly coupled programs. The ICMC performs the same functions as the CMC but includes the Center Director (or representative) from each Center responsible for management of a project within the program and each Center with a substantial program development role. The ICMC is chaired by the Center Director (or representative) of the Center responsible for program management.

When an ICMC is used to oversee the program, the participating Centers work together to define how the ICMC will operate, when it will meet, who will participate, how decisions will be made, and how Formal Dissents will be resolved. (See Section 5.3 on Formal Dissent.) In general, final decisions are made by the chair of the ICMC. When a participating Center Director disagrees with a decision made at the ICMC, the standard Formal Dissent process is used. As an example, this would generally require that the NASA Chief Engineer resolve disagreements for engineering or program management policy issues.

3.2.3 Key Decision Points

At Key Decision Points (KDPs), the Decision Authority reviews all the materials and briefings at hand to determine the program's maturity and readiness to progress through the life cycle and authorizes the content, cost, and schedule parameters for the ensuing phase(s). KDPs conclude the life-cycle review at the end of a life-cycle phase. A KDP is a mandatory gate through which a program must pass to proceed to the next life-cycle phase.

A life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment and sign the Decision Memorandum.

The potential outcomes at a KDP include the following:

- Approval to enter the next program phase, with or without actions.
- Approval to enter the next phase, pending resolution of actions.
- Disapproval for continuation to the next phase. In such cases, follow-up actions may include:
  - A request for more information and/or a follow-up review that addresses significant deficiencies identified as part of the life-cycle review preceding the KDP;
  - A request for a Termination Review;
  - Direction to continue in the current phase; or
  - Redirection of the program.

The KDP decision process is supported by submitting the appropriate KDP readiness products to the Decision Authority and APMC members. This material includes:

- The program's proposed cost, schedule, safety, and technical plans for their follow-on phases. This includes the proposed preliminary and final baselines.
- Summary of accepted risks and waivers.
- Program documents or updates signed or ready for signature; e.g., the program Formulation Authorization Document (FAD), Program Plan, Program Commitment Agreement (PCA), Formulation Agreement (single-project programs), Memoranda of Understanding (MOUs), and Memoranda of Agreement (MOAs).
- Summary status of action items from the previous KDP (with the exception of KDP 0/A).
- Draft Decision Memorandum and supporting data. (See Section 3.2.4.)
- The program manager recommendation.
- The final SRB Management Briefing Package.
- The CMC or ICMC recommendation.
- The MDAA recommendation.

- The governing PMC review recommendation.

After reviewing the supporting material and completing discussions with all parties, the Decision Authority determines whether and how the program proceeds and approves any additional actions. These decisions are summarized and recorded in the Decision Memorandum. The Decision Authority completes the KDP process by signing the Decision Memorandum. The expectation is to have the Decision Memorandum signed by concurring members as well as the Decision Authority at the conclusion of the governing PMC KDP meeting. (See more information on the Decision Memorandum, including signatories and their respective responsibilities in Section 5.5.6.)

The Decision Authority archives the KDP documents with the Agency Chief Financial Officer, and the program manager attaches the approved Decision Memorandum to the Program Plan. Any appeals of the Decision Authority's decisions go to the next higher Decision Authority, who (for programs) is the NASA Administrator.

3.2.4 Decision Memorandum, Management Agreement, and Agency Baseline Commitment

The Decision Memorandum is a summary of key decisions made by the Decision Authority at a KDP, or, as necessary, in between KDPs. Its purpose is to ensure that major program decisions and their basis are clearly documented and become part of the retrievable records. The Decision Memorandum supports the clearly defined roles and responsibilities and a clear line of decision making and reporting documented in the official program documentation.

When the Decision Authority approves the program's entry into the next phase of the life cycle at a KDP, the Decision Memorandum describes this approval and the key program cost, schedule, and content parameters authorized by the Decision Authority that govern the remaining life-cycle activities. The Decision Memorandum also describes the constraints and parameters within which the Agency and the program manager will operate, i.e., the Management Agreement, the extent to which changes in plans may be made without additional approval, and any additional actions from the KDP.

The Management Agreement contained within the Decision Memorandum defines the parameters and authorities over which the program manager has management control. A program manager has the authority to manage within the Management Agreement and is accountable for compliance with the terms of the agreement. The Management Agreement, which is documented at every KDP, may be changed between KDPs as the program matures with approval from the Decision Authority. The Management Agreement typically is viewed as a contract between the Agency and the program manager and requires renegotiation and acceptance if it changes.

During Formulation, the Decision Memorandum documents the key parameters related to work to be accomplished during each phase of Formulation. It also documents a target

Life-Cycle Cost (LCC) or initial capability cost range (and schedule range, if applicable) that the Decision Authority determines is reasonable to accomplish the program. (For uncoupled and loosely coupled programs, the LCC range may be represented merely as a single annual funding limit consistent with the budget.) Given the program's lack of maturity during Formulation, the LCC or initial capability cost range reflects the broad uncertainties regarding the program's scope, technical approach, safety objectives, acquisition strategy, implementation schedule, and associated costs. When applicable, the range is also the basis for coordination with the Agency's stakeholders, including the White House and Congress. Tightly coupled programs document their Life-Cycle Cost Estimate (LCCE) in accordance with the life-cycle scope defined in their FAD or PCA. (Projects that are part of tightly coupled programs document their LCCE or initial capability cost estimate in accordance with the life-cycle scope defined in their program's Program Plan, PCA or FAD, or the project's FAD.)

Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, define an initial capability during Phase A and develop an initial capability cost. Initial capability is the first operational mission flight (or as defined in the KDP B Review Plan) and is documented in the KDP B Decision Memorandum. The scope of the initial capability is also documented in the PCA and Program Plan.

During Implementation, the Decision Memorandum documents the parameters for the entire life cycle of the program. At this point, the approved LCCE or initial capability cost estimate of the program is no longer documented as a range but instead as a single number. The LCCE includes all costs, including all Unallocated Future Expenses (UFE) and funded schedule margins, for development through prime mission operation to disposal, excluding extended operations.[15] The initial capability cost estimate is the total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred with the scope of the initial capability.

Unallocated Future Expenses (UFE) are the portion of estimated cost required to meet the specified confidence level that cannot yet be allocated to the specific Work Breakdown Structure (WBS) subelements because the estimate includes probabilistic risks and specific needs that are not known until these risks are realized. (For programs and projects that are not required to perform probabilistic analysis, the UFE should be informed by the program or project's unique risk posture in accordance with Mission Directorate and Center guidance and requirements. The rationale for the UFE, if not conducted using a probabilistic analysis, should be appropriately documented and be traceable, repeatable, and defendable.) UFE may be held at the program level and the Mission Directorate level.

[15] Tightly coupled programs document their life-cycle cost estimate in accordance with the life-cycle scope defined in the Formulation Authorization Document (FAD) or Program Commitment Agreement (PCA). Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point do not use extended operations.

Extended operations are conducted after the planned prime mission operations are complete. (The planned prime mission operations period is defined in a program's FAD or PCA and in a project's FAD.)

- *Extended operations may be anticipated when the PCA or FAD is approved, but the complexity and duration of the extended operations cannot be characterized. Examples of this case include long-duration programs such as the space shuttle and space station programs.*
- *Alternatively, the need for extended operations may be identified later as the program or project is nearing the completion of its planned prime mission operations period. Examples include cases when extended operations contribute to the best interests of the Nation and NASA. For example, a mission may become vital to the success of programs run by another Federal agency, such as the need for mission data for terrestrial or space weather predictions by the National Oceanic and Atmospheric Administration (NOAA). NASA's best interest may include continuing value to compelling science investigations that contribute to NASA's strategic goals.*

All extended operations periods need to be approved. The approval process is determined by the program or project's Mission Directorate and may require Agency-level approval. Program or project documentation, such as the Program or Project Plan, needs to be revised to continue the mission into extended operations.

Single-project programs establish a program baseline, called the Agency Baseline Commitment (ABC), at approval for Implementation (KDP C). The ABC and other key parameters are documented in the Decision Memorandum.

The Agency Baseline Commitment (ABC) is an integrated set of program requirements, cost, schedule, technical content, and JCL. The ABC cost is equal to the program LCC or initial capability cost approved by the Agency at approval for Implementation. The ABC is the baseline against which the Agency's performance is measured during the Implementation Phase of a program. Only one official baseline exists for a program, and it is the ABC. The ABC for single-project programs forms the basis for the Agency's external commitment to the U.S. Office of Management and Budget (OMB) and Congress and serves as the basis by which external stakeholders measure NASA's performance for these programs. Changes to the ABC are controlled through a formal approval process. An ABC is not required for loosely coupled programs, uncoupled programs, or tightly coupled programs.

(See Section 5.5 for a detailed description of maturing, approving, and maintaining program plans, LCCs, initial capability cost, baselines, and commitments and for additional information on the Decision Memorandum and Management Agreement.)

3.2.5 Management Forum: Baseline Performance Review

NASA's Baseline Performance Review (BPR) serves as NASA's monthly, internal senior performance management review, integrating Agency-wide communication of performance metrics, analysis, and independent assessment for both mission and mission support programs, projects, and activities. While not a council, the BPR is closely linked with the councils and integral to council operations. As an integrated review of institutional, program, and project activities, the BPR highlights interrelated issues that impact performance and program and project risk enabling senior management to quickly address issues, including referral to the governing councils for decision, if needed. The BPR forum fosters communication across organizational boundaries to identify systemic issues and address mutual concerns and risks. The BPR is the culmination of all the Agency's regular business rhythm performance monitoring activities, providing ongoing performance assessment between KDPs. The BPR is also used to meet requirements for quarterly progress reviews contained in the Government Performance Reporting and Accountability Modernization Act of 2010 (GPRAMA) and OMB Circular A-11 Part 6.[16]

The NASA Associate Administrator (AA) and Associate Deputy Administrator cochair the BPR. Membership includes Agency senior management and Center Directors. The Office of the Chief Engineer (OCE) leads the program and project performance assessment process conducted by a team of independent assessors drawn from OCE, the Office of the Chief Financial Officer (OCFO), and the Office of Safety and Mission Assurance (OSMA).

A typical BPR agenda includes an assessment of each Mission Directorate's program and project performance, including performance against Management Agreements and ABCs, if applicable, with rotating in-depth reviews of specific mission areas. The schedule ensures that each mission area is reviewed on a quarterly basis. Mission support functions are included in the BPR. Assessors use existing materials when possible. Table 3-1 shows typical information sources that may be used by the BPR assessors. Different emphasis may be placed on different sources depending on the mission being assessed.

[16] Additional information on GPRAMA can be found at http://www.gpo.gov/fdsys/pkg/PLAW-111publ352/pdf/PLAW-111publ352.pdf. Additional information on A-11 Part 6 can be found at http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/s200.pdf.

Table 3-1 Typical Information Sources Used for BPR Assessment

Program/Project Documents	FAD, Formulation Agreement, PCAs, and Program and Project Plans
Reviews	Life-cycle reviews
	Monthly, quarterly, midyear, and end-of-year Mission Directorate reviews
	Other special reviews (see Section 3.1.3)
	Monthly Center status reviews
Meetings	APMC (presentations and decision memorandums)
	DPMC (presentations and decision memorandums)
	Recurring staff and/or status meetings including project monthly status
	Program Control Board (meetings and weekly status reports)
	Biweekly tag-ups with the SMA TAs supporting and overseeing the program
Reports	Annual Performance Goals (for programs)
	Reports from Agency assessment studies
	Planning, Programming, Budgeting, and Execution (PPBE) presentations
	Quarterly cost and schedule reports on major programs and/or projects delivered to OCFO
	Center summaries presentations at BPR
	Weekly Mission Directorate report
	Weekly project reports
	Weekly reports from the NESC
	Monthly Earned Value Management (EVM) data
	Project anomaly reports
	Center SMA reports
	Technical Authority reports
Databases	N2 Agency budget database
	SAP and Business Warehouse financial databases
	OMB and Congressional cost and schedule data

3.3 Program Formulation

3.3.1 Program Activities Leading to the Start of Formulation

The process for initiating programs begins at the senior NASA management level with strategic acquisition planning. When a need for a program is first identified, the Agency examines and considers acquisition alternatives from several perspectives. This process enables NASA management to consider the full spectrum of acquisition approaches for its programs from Commercial Off-the-Shelf (COTS) buys to in-house design and build efforts. For a "make or buy" decision, the Agency considers whether to acquire the capability in-house, where NASA has a unique capability and capacity or the need to maintain or develop such capability and capacity; to acquire it from outside the Agency; or to acquire it through some combination of the two. Other than preservation of core competencies and unique facilities, considerations include maturity of technologies affecting the technical approach, priorities from the White House and Congress, and commercialization goals. Strategic acquisition at the Agency level promotes best-value approaches by considering the Agency as a whole.

The strategic acquisition process is the Agency process for ensuring that NASA's strategic vision, programs, projects, and resources are properly developed and aligned throughout the mission and life cycle. (See NPD 1000.0, NASA Governance and Strategic Management Handbook, and NPD 1000.5, Policy for NASA Acquisition, for additional information on the strategic acquisition process.)

NASA defines acquisition as the process for obtaining the systems, research, services, construction, and supplies that the Agency needs to fulfill its mission. Acquisition, which may include procurement (contracting for products and services), begins with an idea or proposal that aligns with the NASA Strategic Plan and fulfills an identified need and ends with the completion of the program or project or the final disposition of the product or service. (The definition of acquisition in accordance with NPD 1000.5 is used in a broader context than the Federal Acquisition Regulation (FAR)[17] definition to encompass strategic acquisition planning and the full spectrum of various NASA acquisition authorities and approaches to achieve the Agency's mission and activities.)

Many processes support acquisition, including the program management system, the budget process, and the procurement system. The NASA Planning, Programming, Budgeting, and Execution (PPBE) process supports allocating the resources of programs through the Agency's annual budgeting process. (See Section 5.8, Federal Budgeting Process; *NPR 9420.1, Budget Formulation;* and *NPR 9470.1, Budget Execution*.) The NASA procurement system supports the acquisition of assets and services from external sources.

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[17] https://www.acquisition.gov/browse/index/far

(See NPD 1000.5, the Federal Acquisition Regulation (FAR), and, for NASA's specific implementation of the FAR, the NASA FAR Supplement (NFS).[18])

3.3.2 Program Formulation Activities

Programs provide the critically important linkage between the Agency's strategic goals and the projects that are the specific means for achieving them. The purpose of program Formulation activities is to establish a cost-effective program that is demonstrably capable of meeting Agency and Mission Directorate goals and objectives. The program team does the following during Formulation:

- Derives a technical approach from an analysis of alternatives.
- Develops and allocates program requirements to initial projects.
- Initiates project pre-Formulation activities.
- Develops organizational structures and initiates work assignments.
- Defines and gains approval for program acquisition strategies.
- Develops interfaces to other programs.
- Establishes required annual funding levels and develops preliminary cost and schedule estimates.
- Develops products required during Formulation in accordance with the Program Product Maturity tables at the end of this chapter.
- Designs a plan for Implementation.
- Puts in place management systems.
- Obtains approval of formal program documentation, all consistent with the NASA Strategic Plan and other higher level requirements.

Official program Formulation begins with a **Formulation Authorization Document** (FAD)[19] that authorizes a program manager to initiate the planning of a new program and to perform the analyses of alternatives required to formulate a sound Program Plan. However, in many cases, Mission Directorates engage in pre-Formulation activities prior to the development of a FAD to develop the basic program concept and have it approved by NASA's senior management.

The FAD is issued by the MDAA to authorize the formulation of a program whose goals will fulfill part of the Agency's Strategic Plan and Mission Directorate strategies and establish the expectations and constraints for activity in the Formulation Phase. The FAD:

[18] https://www.acquisition.gov/nfs
[19] In this chapter, bolding of a product or control plan indicates a requirement. (Repeated references in the same paragraph are not bolded.)

- *Describes the program type and the purpose of the program, including a clear traceability from the goals and objectives in the Mission Directorate strategies.*
- *Identifies the Decision Authority and the governing Program Management Council (PMC) for oversight of the program including any delegations of Decision Authority and PMC.*
- *Describes the level or scope of work and the goals and objectives to be accomplished in the Formulation Phase.*
- *Describes the NASA organizational structure for managing the formulation process from the MDAA to the NASA Center program or project managers, as applicable, and includes lines of authority, coordination, and reporting.*
- *Identifies Mission Directorates, mission support offices, and Centers to be involved in the activity, their scope of work, and any known constraints related to their efforts (e.g., the program is cofunded by a different Mission Directorate).*
- *Identifies any known participation by other organizations external to NASA that are to be involved in the activity, their scope of work, and any known constraints related to their efforts (e.g., the program or project must be cofunded by the external participant).*
- *Identifies the funding that will be committed to the program during each year of Formulation.*
- *Specifies the program life-cycle reviews planned during the Formulation Phase.*
- *Identifies tailoring to accommodate aspects of innovative acquisition approaches and when the tailoring approach will be defined.*

One of the first activities is to select the management team.

3.3.2.1 Program Formulation Activities Across Program Types

The following paragraphs describe the activities all program types complete to develop a sound **Program Plan**. However, programs vary significantly in scope, complexity, cost, and criticality, and the activities vary as a result. The differences in activities are described by program type in Section 3.3.2.2.

Program Formulation is initiated at approval for Formulation and completes when the Decision Authority approves the program's transition from Formulation to Implementation at KDP I (KDP C for single-project programs). Authorization of program transition from Formulation to Implementation is documented in the **Program Commitment Agreement** (PCA) and other retrievable program records. The program assists the Mission Directorate in preparing this agreement, as requested. A draft PCA is prepared by KDP 0 and baselined by KDP I. (Single-project programs are the exception: they follow a life cycle similar to projects, so they are approved at KDP C. However, single-project programs are also required to develop a Program Plan and have a PCA, unless the Mission Directorate approves otherwise.)

The PCA (see NPR 7120.5, Appendix D) is an agreement between the MDAA and the NASA AA (the Decision Authority) that authorizes program transition from Formulation to Implementation. The PCA is prepared by the Mission Directorate and documents Agency and Mission Directorate requirements that flow down to the program; program objectives, management and technical approach and associated architecture; program technical performance, schedule, time-phased cost plans, safety and risk factors; internal and external agreements; life-cycle reviews; and all attendant top-level program requirements.

Major program and life-cycle reviews leading to approval at KDP I (KDP C for single-project programs) are the Acquisition Strategy Meeting (ASM); the System Requirements Review (SRR); the System Definition Review (SDR)/Mission Definition Review (MDR);[20] the governing PMC review; and for single-project programs and tightly coupled programs, the PDR.

Acquisition Strategy. As early as possible in Formulation, all program types begin to define the program's Acquisition Strategy, which is the plan or approach for using NASA's acquisition authorities to achieve the program's mission. The strategy includes recommendations from make versus buy analyses, the recommendations from competed versus directed analyses, proposed partnerships and contributions, proposed infrastructure use and needs, budget, and any other applicable considerations. This strategy addresses the program's initial plans for obtaining the systems, research, services, construction, and supplies that it needs to fulfill its mission, including any known procurement(s); the availability of the industrial base capability and supply chain needed to design, develop, produce, and support the program and its planned projects; identifying risks associated with single source or critical suppliers; and attendant mitigation plans.

The program develops a preliminary strategy, which is informed by the Agency's strategic planning process, prior to the SRR. The MDAA or AA determine when and whether a Pre-Acquisition Strategy Meeting (Pre-ASM) is required and when and whether an Aquisition Strategy Meeting (ASM) is required[21]. If a Pre-ASM and/or ASM are required, the team plans, prepares for, and supports these meetings as part of the formulation of its acquisition strategy. The Pre-ASM and ASM are typically held early in Formulation and precede making partnership commitments, but the timing is determined by the Mission Directorate. The results of the ASM meeting are used to finalize the **Acquisition Strategy**. (See Section 3.3.3.5.)

[20] The SDR and the MDR are the same review. Robotic programs tend to use the terminology MDR and human space flight programs tend to use SDR.

[21] Information on Pre-ASMs and ASMs, the associated Convening Authorities, and criteria for determining the Convening Authority is provided in *NPD 1000.5, Policy for NASA Acquisition* and its NASA Advisory Implementing Instructions (*NAII 1000.1, Pre-Acquisition Strategy Meeting (Pre-ASM) Guide* and *NAII 1000.2, Acquisition Strategy Meeting (ASM) Guide*).

The Acquisition Strategy Meeting (ASM) is a decision-making forum where senior Agency management reviews and approves program acquisition strategies. The ASM focuses on considerations such as impacting the Agency workforce, maintaining core capabilities, make versus buy decisions, supporting Center assignments, potential partnerships, and risk. The ASM is held at the Agency level, implementing the decisions that flow out of the earlier Strategy Implementation Planning (SIP) process. (See Section 5.8.3.1 for information on the SIP process.)

The purpose of the ASM is for senior Agency management to review and agree on the acquisition strategy before authorizing resource expenditures for major acquisitions. The ASM review is based on information provided by the associated Mission Directorate or mission support office, and results in the approval of plans for Formulation and Implementation. Decisions are documented in the **ASM Decision Memorandum** or **ASM meeting summary**. The results of the ASM are used to finalize the **Acquisition Strategy**. (See Sections 3.3.2.)

Major acquisitions are directed at and critical to fulfilling the Agency's mission, entail the allocation of relatively large resources, or warrant special management attention.

System Requirements Review. For all program types, the purpose of the System Requirements Review (SRR) is to evaluate whether the program functional and performance requirements are properly formulated and correlated with the Agency and Mission Directorate strategic objectives and to assess the credibility of the program's estimated budget and schedule. For uncoupled and loosely coupled programs, a KDP 0 may be required, at the discretion of the Decision Authority, to ensure that major issues are understood and resolved prior to proceeding to SDR and KDP I. At a KDP 0, the program shows how it meets critical NASA needs and proves it has a good chance of succeeding as conceived.

System Definition Review/Mission Definition Review. For uncoupled and loosely coupled programs, the purpose of the System Definition Review (SDR) or Mission Definition Review (MDR) is to evaluate the proposed program requirements and architecture and allocation of requirements to initial projects, to assess the adequacy of project pre-Formulation efforts, and to determine whether the maturity of the program's definition and associated plans is sufficient to begin Implementation. After a successful SDR/MDR, the program proceeds to KDP I. The program is expected to demonstrate that it (1) is in place and stable, (2) addresses critical NASA needs, (3) has adequately completed Formulation activities, (4) has an acceptable plan for Implementation that leads to mission success, (5) has proposed projects that are feasible within available resources, and (6) has a level of risk that is commensurate with the Agency's risk tolerance.

For tightly coupled and single-project programs, the purpose of the SDR/MDR is to evaluate the credibility and responsiveness of the proposed program requirements and architecture to the Mission Directorate requirements and constraints, including available resources and allocation of requirements to projects. The SDR/MDR also determines whether the maturity of the program's system/mission definition and associated plans is sufficient to begin preliminary design.

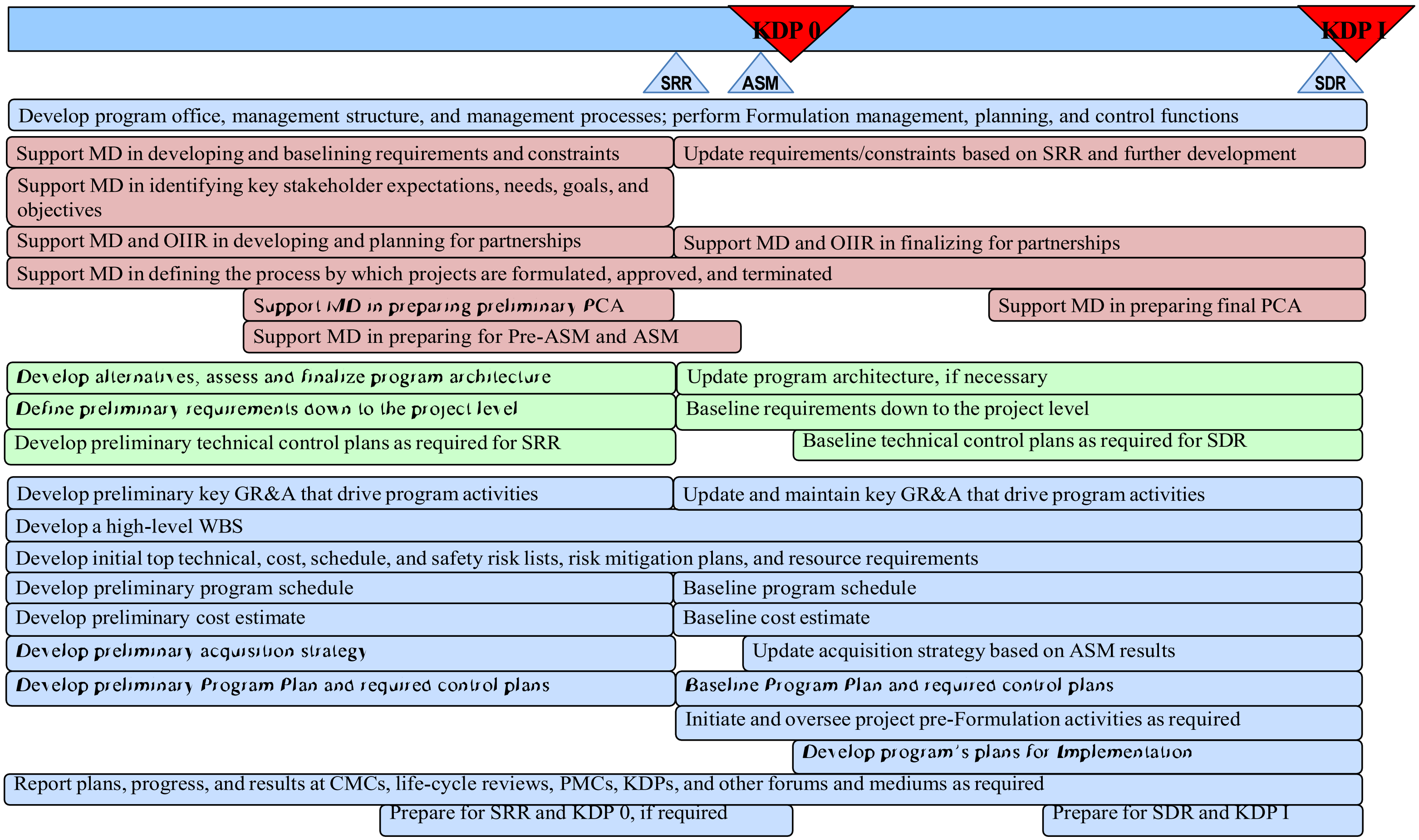
- For tightly coupled programs, a KDP 0 may be required, at the discretion of the Decision Authority, to ensure that major issues are understood and resolved prior to proceeding to PDR and KDP I. If the KDP 0 is held, the tightly coupled program will be expected to demonstrate how it meets critical NASA needs and that projects are feasible within available resources.
- For single-project programs, the program proceeds to KDP B, where the program is expected to demonstrate that (1) the proposed system/mission architecture is credible and responsive to program requirements and constraints, including resources; (2) the maturity of the system/mission definition and associated plans is sufficient to begin Phase B; and (3) the mission can likely be achieved within available resources with acceptable risk.

Preliminary Design Review. For tightly coupled and single-project programs, [22] the purpose of the PDR is to evaluate the completeness and consistency of the program's preliminary design, including its projects, in meeting all requirements with appropriate margins, acceptable risk, and within cost and schedule constraints, and to determine the program's readiness to proceed with the detailed design phase of the program. After the PDR, the program proceeds to KDP I (KDP C for single-project programs).

- The tightly coupled program is expected to demonstrate that (1) it is in place and stable, (2) it addresses critical NASA needs, (3) it has adequately completed Formulation activities, (4) it has an acceptable plan for Implementation that leads to mission success, and (5) the proposed projects are feasible with acceptable risk within Agency cost and schedule baselines.
- The single-project program is expected to demonstrate that (1) planning, technical, cost, and schedule baselines developed during Formulation are complete and consistent, (2) the preliminary design complies with its requirements, (3) it is sufficiently mature to begin Phase C, and (4) the cost and schedule are adequate to enable mission success with acceptable risk. For single-project programs, the decisions made at KDP C establish the ABC for the program. (See Section 5.5.1.)

The general flow of activities for the various program types in Formulation is shown in Figures 3-8, 3-9, and 3-10.

[22] Uncoupled and loosely coupled programs do not have a PDR.



Program management, planning, and control tasks

Technical work the program is doing

Work for which Headquarters is responsible but the program helps accomplish (e.g., International partnerships are a Headquarters responsibility, but the programs help develop and finalize those partnerships)

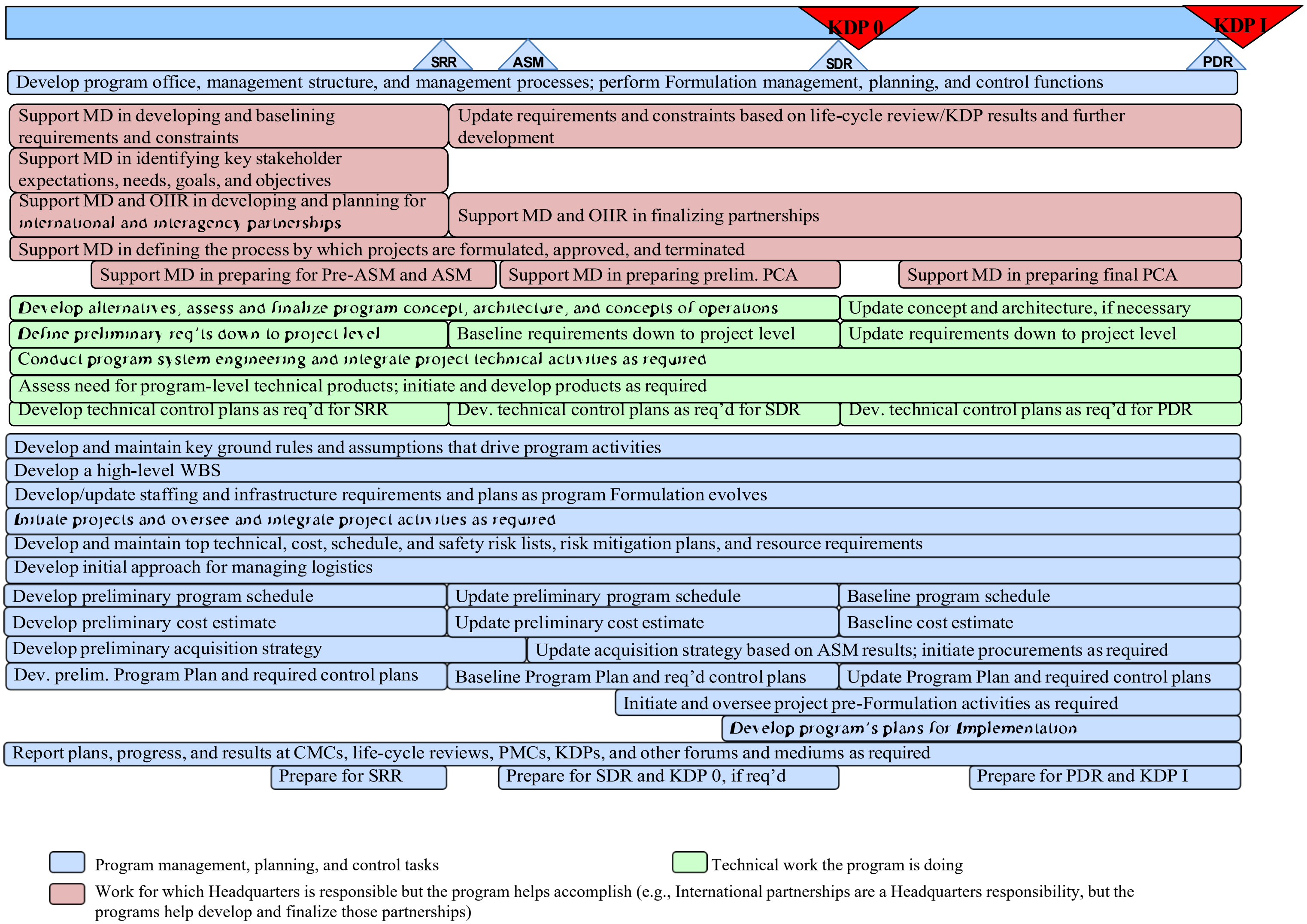
GR&A = Ground rules and assumptions

MD = Mission Directorate

OIIR = Office of International and Interagency Relations

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

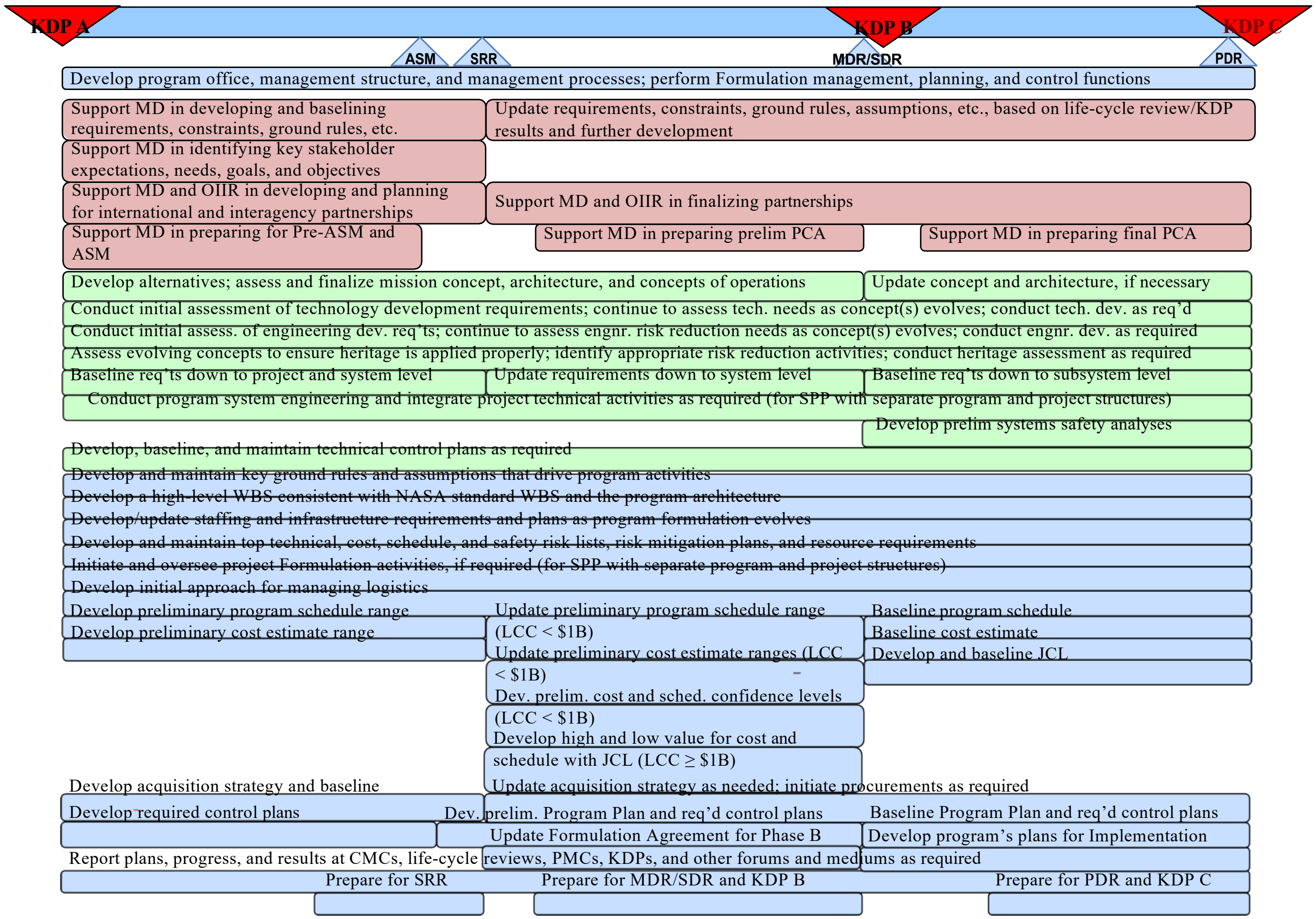
Figure 3-8 Uncoupled and Loosely Coupled Program Formulation Flow of Activities



MD = Mission Directorate
OIIR = Office of International and Interagency Relations

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 3-9 Tightly Coupled Program Formulation Flow of Activities



Program management, planning, and control tasks

Technical work the program is doing

Work for which Headquarters is responsible but the program helps accomplish (e.g., International partnerships are a Headquarters responsibility, but the programs help develop and finalize those partnerships)

MD = Mission Directorate
OIIR = Office of International and Interagency Relations
SPP = Single-Project Program

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 3-10 Single-Project Program Formulation Flow of Activities

While not part of Formulation, some Implementation activities such as initiating project Pre-Phase A may occur during Formulation.

Program Formulation is a recursive and iterative process that requires concurrent development of the program organization, structure, management approach, management processes, and the technical and management products required for program implementation. The level of maturity of each of these items continues to evolve, and each item becomes more mature as the program goes through the formulation process. Each of the life-cycle milestones and associated KDPs provides an opportunity for the program and its management to review and assess the program's progress.

3.3.2.2 Program Activities in Formulation by Program Type

The different program types require different levels of management and planning in Formulation.

Uncoupled and Loosely Coupled Program Formulation. As a result of the loose affiliation between the projects in these programs, the program does not generally require the same degree of system integration that is required of tightly coupled and single-project programs. Thus, the products that are required for these programs are substantially fewer (see Table 3-2 in this Handbook and Table I-1 in NPR 7120.5F) than those required for tightly coupled programs.

For loosely coupled or uncoupled programs, the program office may simply serve as a funding source and provide a management infrastructure, top-level requirements, and project oversight. Program requirements are high level. They are typically stable and have very little impact on day-to-day project management once the project requirements have been established. System engineering plays a major role during Formulation as described in NPR 7123.1, which may include defining or assessing concepts, architecture, requirements, technology, interfaces, and heritage (i.e., the applicability of designs, hardware, and software from past projects to the present one).

Tightly Coupled Program Formulation. Tightly coupled programs define and initiate constituent projects during Program Formulation after the Program Plan is baselined at SDR. The constituent projects have a high degree of organizational, programmatic, and technical interdependence and commonality with the program and with each other. The program ensures that the projects are synchronized and well integrated throughout their respective life cycles, both with each other and with the program. Tightly coupled programs are more complex, and since the program is intimately tied to the projects, the Formulation Phase mirrors the single-project program project life cycle. Projects' Preliminary Design Reviews (PDRs) are usually completed prior to the program-level PDR. Program approval (KDP I) occurs after the program-level PDR, which allows for a more developed definition of the preliminary design before committing to the complete scope of the program. Once approved for Implementation, the tightly coupled program continues to have program life-cycle reviews tied to the project life-cycle reviews to ensure the proper integration of projects into the larger system.

During Formulation, a tightly coupled program, in conjunction with its constituent projects, establishes performance metrics, explores the full range of implementation options, defines an affordable concept to meet requirements specified in the Program Plan, and develops needed technologies. Formulation is an iterative set of activities rather than discrete linear steps. System engineering plays a major role during Formulation as described in NPR 7123.1. The primary activities, which, in some cases, may be performed in conjunction with, or by, the constituent projects, include the following:

- Developing and defining the program requirements.
- Assessing the technology requirements, developing the plans to achieve them, and developing the technology.
- Developing the program's knowledge management strategy and processes.
- Examining the Lessons Learned database for lessons that might apply to the current program's planning.
- Developing the program architecture down to the project level.
- Flowing down requirements to the project level.
- Planning acquisitions, including an analysis of the industrial base capability to design, develop, produce, support, and even possibly restart an acquisition program or project.
- Evaluating and refining project to project interfaces.
- Assessing heritage using *NASA/SP-2016-6105, Systems Engineering Handbook,* Appendix G, Technology Assessment/Insertion[23] (the applicability of designs, hardware, and software in past projects to the present one).
- Conducting safety, performance, technical, cost, and schedule risk trades.
- Identifying and mitigating development and programmatic risks, including supply chain risks.
- Conducting engineering development activities, including developing engineering prototypes and models for the higher-risk components and assemblies that have not been previously built or flown in the planned environment and testing them to demonstrate adequate performance.
- Developing time-phased cost and schedule estimates and documenting the basis of these estimates.
- Preparing the **Program Plan** for Implementation.

[23] https://ntrs.nasa.gov/citations/20170001761

Tightly coupled programs typically have greater integration functions at the program level, such as systems engineering, risk management, and requirements management. The program manager has a significant role and influence over the management and execution of the projects. In the case of tightly coupled programs, major project decisions frequently require the approval of the program manager. Decisions to change elements, such as reduce scope or extend schedule, for one project may affect all other projects within that program. The project manager provides frequent briefings and regular progress status to the program manager. Certain project risks may be integrated into a list of top program risks. Change in program requirements may have a direct impact on project requirements.

Formulation activities continue until Formulation output products (see Tables 3-3 and 3-4) have matured and are acceptable to the program manager, Center Director, MDAA, and Decision Authority. Tightly coupled programs have many of the characteristics of single-project-programs and develop the technical products required for single-project programs (see Table 3-5) in NPR 7120.5, in some cases, in conjunction with, or by, the constituent projects.[24] These activities allow the Agency to present high-confidence cost and schedule commitments to external stakeholders at KDP I.

Single-Project Program Formulation. MDAAs may initiate single-project program pre-Formulation activities. In that case, a Mission Directorate provides resources for Pre-Phase A concept studies along with the mission objectives and the ground rules and assumptions to be used by the study team. While not formally part of Formulation, concept studies might involve pre-Formulation activities such as Design Reference Mission (DRM) analysis, feasibility studies, technology needs analyses, engineering systems assessments, human systems assessments, logistics support, and analyses of alternatives that typically are performed before a specific single-project program concept emerges. These trade studies are not considered part of formal planning since there is no certainty that a specific proposal will emerge.

Pre-Formulation activities also involve identification of risks that are likely to drive the single-project program's cost and schedule range estimates at KDP B and cost and schedule commitments at KDP C and include development of mitigation plans for those risks.

During Pre-Phase A, the program initiates development of a **Formulation Agreement** to document the plans and resources required for Formulation. (See the "Formulation Agreement" box for more information. See NPR 7120.5F, Appendix F for the Formulation Agreement template.) Assessments and products developed during Pre-Phase A may be documented in the Formulation Agreement, as opposed to developing separate plans.

[24] See Appendix H in this handbook for a list of technical products that the tightly coupled program develops and a list of technical products that may be developed by constituent projects or the tightly coupled program, as determined by the program.

The Mission Concept Review (MCR) is held at the end of Pre-Phase A. The MCR is the first major life-cycle review in the single-project program life cycle. The purpose of the MCR is to evaluate the feasibility of the proposed mission concept(s) and how well the concept(s) fulfill the program's needs and objectives. After the MCR, the program proceeds to KDP A where the program demonstrates that it has addressed critical NASA needs; the proposed mission concept(s) is feasible; the associated planning is sufficiently mature to begin Phase A; and the mission can probably be achieved as conceived.

At the conclusion of Pre-Phase A, the **FAD** is issued authorizing Formulation to begin. (See NPR 7120.5F*,* Appendix E.)

Single-project program Formulation comprises two sequential phases, i.e., Phase A (Concept and Technology Development) and Phase B (Preliminary Design and Technology Completion). During Formulation, the single-project program establishes performance metrics, explores the full range of implementation options, defines an affordable concept to meet requirements specified in the Program Plan, and develops needed technologies. Formulation is an iterative set of activities rather than discrete linear steps. Systems engineering plays a major role during Formulation as described in NPR 7123.1. The primary activities in these phases include the following:

- Developing and defining the single-project program requirements.
- Assessing the technology requirements, developing the plans to achieve them, and developing the technology.
- Developing the program's knowledge management strategy and processes.
- Examining the Lessons Learned database for lessons that might apply to the current program's planning.
- Developing the system architecture.
- Completing mission and preliminary system designs.
- Flowing down requirements to the system and subsystem levels.
- Planning acquisitions, including an analysis of the industrial base capability to design, develop, produce, support, and even possibly restart an acquisition program or project.
- Evaluating and refining subsystem interfaces.
- Assessing heritage using *NASA/SP-2016-6105, Systems Engineering Handbook,* Appendix G, Technology Assessment/Insertion (the applicability of designs, hardware, and software in past projects to the present one).
- Conducting safety, performance, technical, cost, and schedule risk trades.
- Identifying and mitigating development and programmatic risks, including supply chain risks.

- Conducting engineering development activities, including developing engineering prototypes and models for the higher-risk components and assemblies that have not been previously built or flown in the planned environment, and testing them to demonstrate adequate performance.
- Developing time-phased cost and schedule estimates and documenting the basis of these estimates.
- Preparing the **Program or Project Plan** for Implementation.

Formulation Agreement

The Formulation Agreement serves as a tool for communicating and negotiating the single-project program's schedule and funding requirements during Phase A and Phase B with the Mission Directorate. It identifies and prioritizes the technical and acquisition activities that will have the most value during Formulation and inform follow-on plans.

The Formulation Agreement focuses on the work necessary to accurately characterize the complexity and scope of the single-project program; increase understanding of requirements; and identify and mitigate safety, technical, cost, and schedule risks. This work enables the single-project program to develop high-fidelity cost and schedule range estimates and associated confidence levels (if LCC or initial capability cost is under $1 billion) or associated JCL (if LCC or initial capability cost is greater than or equal to $1 billion) at KDP B, and high-fidelity cost and schedule commitments and associated JCL at KDP C, and to commit to a successful plan for Implementation at KDP C. These activities include establishing the internal management control functions that will be used throughout the life of the single-project program.

The Agreement is approved and signed at KDP A (baselined for Phase A and preliminary for Phase B). The Agreement is updated in preparation for SDR/MDR and resubmitted for signature at KDP B (baselined for Phase B). The Formulation Agreement for KDP A includes detailed Phase A information, preliminary Phase B information, and the Formulation Cost, which is based on the estimated costs for Phase A and Phase B. The Formulation Agreement for KDP B identifies the progress made during Phase A, updates and details Phase B information, and updates the Formulation Cost, which is based on the actual cost for Phase A and an updated cost for Phase B. The Formulation Cost at KDP B is the total authorized cost for Formulation activities required to get to KDP C.

In practice, the FAD and the Formulation Agreement are developed concurrently so that both documents can be approved at KDP A. Documentation products developed as part of, or as a result of, the Formulation Agreement may be incorporated into the Single-Project Program Plan, if appropriate, as the Single-Project Program Plan is developed during Formulation.

During Phase B, there is an overlap between the **Formulation Agreement** and the preliminary **Program Plan**. The Formulation Agreement is the agreement between the Mission Directorate and the single-project program that governs the work during Phase B, but the baselined Program Plan control plans govern the management and technical control processes used during this phase.

Formulation activities continue until Formulation output products (i.e., the products listed in Tables 3-5 and 3-6) have matured and are acceptable to the program manager, Center

Director, MDAA, and Decision Authority. These activities allow the Agency to present to external stakeholders time-phased cost plans and schedule range estimates at KDP B and high-confidence cost and schedule commitments at KDP C.

Single-project programs follow steps in Formulation and Implementation that are similar to projects. However, because of their importance to the Agency, single-project programs are required to develop and have approved a **Program Commitment Agreement (PCA)** to move from Formulation to Implementation. A Program Plan is also required, but this document may be combined with the **Project Plan** if approved by the MDAA and OCE. However, if the Program and Project Plans are combined, the unique parts of the Program and Project Plans still need to be developed. A draft version of the Program Plan is due at KDP B with final versions baselined by KDP C.

3.3.3 Program Management, Planning and Control Activities

3.3.3.1 Supporting Headquarters Planning

During Formulation (and possibly pre-Formulation), the program manager and program team support the Mission Directorate in developing the program. When requested, the team helps identify the main stakeholders of the program (e.g., Principal Investigator (PI), science community, technology community, public, education community, and Mission Directorate sponsor) and gather and document key external stakeholder expectations, needs, goals, and objectives. The program also develops the process to be used within the program to ensure stakeholder advocacy. The team supports alignment of the program-level requirements with Agency strategic goals and Mission Directorate requirements and constraints. The MDAA uses this information in developing and obtaining approval of the **Formulation Authorization Document** (FAD).

One of the first activities is to select the management team.

3.3.3.2 Program Structure and Management Framework

The program team, regardless of program type, develops and implements the management framework, including the program team, organizational structure, and management processes, consistent with the program authority, management approach, and Governance structure specified in the **FAD**. The team identifies the responsibilities related to the respective roles of each involved organization (e.g., Headquarters, Centers, other government agencies, academia, industry, and international partners). The team identifies the chain of accountability along with the frequency of reporting and the decision path outlining the roles and responsibilities of the Mission Directorate sponsor(s), program manager, Center Director, and other authorities including the Technical Authorities (TAs), as required. This will delineate clear lines of authority from projects and Centers to the program and to the Mission Directorate. The team also integrates knowledge from applicable lessons learned into the planning and determines how participating Centers' implementation policies and practices will be applied in the execution of the program. The management approach also includes the process by which projects are formulated, approved, and ended.

The program team supports the MDAA and the NASA Headquarters Office of International and Interagency Relations (OIIR) in identifying, planning for, and obtaining approved **interagency and international agreements**, including the planning and negotiation of agreements and recommendations on joint participation in reviews, integration and test, and risk management. To the degree known for uncoupled and loosely coupled programs and tightly coupled programs, these partnership agreements are typically preliminary at SRR and baselined by the SDR/MDR. For single-project programs, these partnership agreements are typically preliminary at MCR, updated at SRR, and baselined by the SDR/MDR (interagency partnerships) or baselined at PDR (international partnerships).

3.3.3.3 Program Requirements, Ground Rules and Assumptions

For all program types, the program team conducts planning that enables formulation and implementation of program and project concepts, architectures, scenarios or DRMs, and requirements. At SRR, uncoupled and loosely coupled programs and tightly coupled programs document the traceability of preliminary **program-level requirements** on both the program and the known individual projects to Agency strategic goals and outcomes as described in *NPD 1001.0, NASA Strategic Plan*. Single-project programs baseline these requirements at SRR. The team selects technical standards in accordance with *NPR 7120.10, Technical Standards for NASA Programs and Projects*.

At the Program/System Requirements Review (SRR), the team documents the preliminary **driving ground rules and assumptions** on the program. After the SRR, the team updates, as required, the program-level requirements and the driving ground rules and assumptions on the program. Specifically:

- The program team identifies and documents the key requirements derived by the program (as opposed to those derived by the Mission Directorate) and the ground rules and assumptions that drive development of the program and initial projects. Once the program team has defined the ground rules and assumptions, it tracks them through Formulation to determine if they are being realized (i.e., remain valid) or if they need to be modified.
- When establishing the requirements for the program, there are additional high-level requirements levied on the program from the Agency, Center, and Mission Directorate levels as well as requirements that come from support offices like SMA. The traceability of requirements that flow down from Agency- and Center-level policy to the program and from the program to projects should be documented.
- For all programs, these high-level requirements are typically decomposed into requirements on constituent projects or systems. The requirements are specified in the Program Plan or in a separate, configuration-controlled program requirements document prepared by the program team and approved by the MDAA. This

documentation is typically controlled by the Mission Directorate. Requirements thus documented, and any subsequent changes, require approval of the program manager and the MDAA.

For each known project, the program team develops a top-level description of the project, including the mission's science or exploration objectives; the project's category, governing PMC, and risk classification; and the project's mission, performance, and safety requirements. For science missions, it includes both baseline and threshold science requirements and identifies the mission success criteria for each project based on the threshold science requirements. (See Appendix A for definitions of baseline and threshold science requirements.)

- Each requirement is stated in objective, quantifiable, and verifiable terms. Requirements can identify the program's principal schedule milestones, including PDR, Critical Design Review (CDR), launch, mission operations critical milestones, and the planned decommissioning date. They can state the development and/or total life-cycle cost constraints on the program and set forth any budget constraints by fiscal year. They can state the specific conditions under which a project Termination Review would be triggered. They can also describe any additional requirements on the project; e.g., international partners. If the mission characteristics indicate a greater emphasis is necessary on maintaining technical, cost, or schedule, then the requirements can identify which is most important (e.g., state if the mission is cost-capped; or if schedule is paramount, as for a planetary mission; or if it is critical to accomplish the technical objectives, as for a technology demonstration mission).

3.3.3.4 Program Activities for Project Initiation

Program offices support the MDAA in beginning project pre-Formulation activities and approving project entry into Formulation. Projects can be initiated in two basic ways: a direct assignment of a project to a Center(s) or a competitive process, typically through a Broad Agency Announcement (BAA) such as an Announcement of Opportunity (AO).[25]

For projects that are not competed, prior to initiating the new project, a Mission Directorate and the program office typically provide resources for concept studies (i.e., Pre-Phase A (Concept Studies)). These pre-Formulation activities involve DRM analysis, feasibility studies, technology needs analyses, engineering systems assessments, and analyses of alternatives. These are performed before a specific project concept emerges. At

[25] NASA uses Broad Agency Announcements (BAAs) to solicit bids for work, a form of public/private competition. One form of BAA applicable to space flight programs and projects is Announcements of Opportunity (AOs). Another type is NASA Research Announcements (NRAs). An AO is used to acquire investigations, which may involve complete missions or special instruments to be flown aboard NASA aircraft or spacecraft, and to invite investigator-initiated research proposals. NASA solicits, accepts, and evaluates proposals submitted by all categories of proposers in response to an AO, including academia, industry, not-for-profits, Government laboratories, Federally Funded Research and Development Centers (FFRDC), NASA Centers, and the Jet Propulsion Laboratory (JPL).

the conclusion of pre-Formulation with a decision to proceed with the project, the Mission Directorate, supported by the program office, issues a project **FAD** authorizing project Formulation to begin. (See NPR 7120.5F, Appendix E.) The Mission Directorate also agrees to a project **Formulation Agreement** developed by the project to document the plans and resources required for Formulation. (See NPR 7120.5F, Appendix F.)

For competed or "AO-driven" missions, some Mission Directorates choose to use either a one- or two-step process to initiate projects within a space flight program. In a one-step AO process, projects are competed and selected for Formulation in a single step. In two-step competitions, several projects may be selected in Step 1 and given time to mature their concepts in a funded concept study before the Step 2 down-selection. Program resources are invested (following Step 1 selections) to bring these projects to a state in which their science content, cost, schedule, technical performance, project implementation strategies, SMA strategies, heritage, technology requirements and plans, partnerships, and management approach can be better judged. Programs are not typically involved in the proposal evaluation process or the selection. They generally provide input into the BAA in the form of requirements to ensure that the BAA is consistent with the program's requirements. Once the project is selected, the program assumes management responsibility for the project's development and implementation.

From the point of view of the selected AO-driven project, the proposing teams are clearly doing preparatory work and formal project Formulation (e.g., typical Pre-Phase A and Phase A tasks, such as putting together a detailed WBS, schedules, cost estimates, and implementation plan) during the concept study and the preparation of the Step 2 concept study report. From the point of view of the program, no specific project has been chosen, the total cost is not yet known, and project requirements are not yet finalized, yet Formulation has begun. Therefore, for competed missions, the selection of a proposal for concept development is the equivalent of KDP A.

In a one-step AO process, projects enter Phase A after selection (KDP A) and the process becomes the conventional process for directed missions. In a two-step AO process, projects perform concept development in the equivalent of Phase A and go through evaluation for down-selection at the equivalent of KDP B. Following this selection, the process becomes conventional with the exception that KDP B products requiring Mission Directorate input are finished as early in Phase B as feasible.

3.3.3.5 Management Control Processes and Products

As the program team develops its planning, management processes are documented in control plans, which are designed to keep the program activities aligned, on track, and accounted for as the program moves forward. (See Appendix F for a description of control plans required by NPR 7120.5F.) These control plans are described in this and subsequent sections of this handbook in conjunction with the phase where they are required. Control plans can either be incorporated into the central planning document, which is the Program

Plan or separate stand-alone documents referenced in the appropriate part of the Program Plan. NPR 7120.5F, Appendices G and I, and Section 3.5.4 in this handbook provide considerations for determining if a control plan should be a stand-alone document. NPR 7120.5F, Appendix I, Tables I-1, I-3, I-7, and Tables 3-2, 3-4, and 3-6 of this handbook identify, for each control plan, whether it is a requirement or a best practice and what the maturation expectations for the control plan are, i.e., when the preliminary and baseline versions are expected, and when updates are expected. Centers may have existing plans that programs can use to satisfy requirements for some of the control plans.

All programs prepare a **Program Plan** that follows the template in NPR 7120.5F, Appendix G. For uncoupled, loosely coupled, and tightly coupled programs, a preliminary version of the Program Plan is prepared prior to the SRR, and the Program Plan is finalized and baselined by the System Definition Review (SDR). For single-project programs, a preliminary version of the Program Plan is developed prior to the SDR/Mission Definition Review (MDR), and the Program Plan is finalized and baselined by the PDR. Some control plans incorporated into the Program Plan are required to be baselined before the Program Plan is fully finished and baselined. These early control plans are required to assist the program in managing its early work and become part of the preliminary Program Plan.

For all program types during early Formulation, the program team begins to develop the **Technical, Schedule, and Cost Control Plan**. A preliminary version of this plan is expected at SRR with the final plan baselined at SDR (SDR/MDR for single-project programs). This plan is required early so that the program team has the tools and processes necessary to manage and control the work during Formulation and the team is prepared to baseline all program content by program approval at KDP I (KDP C for single-project programs). This plan documents how the program plans to control program requirements, technical design, schedule, and cost to achieve its high-level requirements. This control plan includes the program's performance measures in objective, quantifiable, and measurable terms and documents how the measures are traced from the program high-level requirements. The plan establishes baseline and threshold values for the performance metrics to be achieved at each KDP, as appropriate.

Tightly coupled and single-project programs also develop and maintain the status of a set of **programmatic and technical leading indicators** that are defined in the Program Plan to ensure proper progress and management of the program.[26] (See the "Required and Recommended Programmatic and Technical Leading Indicators" box.) Per NPR 7123.1, three indicators are required: Mass Margins, Power Margins, and Request for Action (RFA) (or other means used by the project to track review comments). The status and trend of leading indicators should be presented at life-cycle reviews and KDPs. In addition to these required indicators, NASA highly recommends the use of a common set of programmatic

[26] See Section 5.13 and the NASA Common Leading Indicators Detailed Reference Guide located at https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_52.pdf for additional information on leading indicators, and for specific details and examples of the three required and set of recommended indicators.

and technical indicators to support trending analysis throughout the life cycle. Programs may also identify unique programmatic and technical leading indicators.

Margins are the allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, or memory) to account for uncertainties and risks. Margins are allocated in the formulation process based on assessments of risks and are typically consumed as the program or project proceeds through the life cycle.

Required and Recommended
Programmatic and Technical Leading Indicators

Required (per NPR 7123.1)

1. Technical Performance Measures (mass margin, power margin)
2. Review Trends (Review Item Discrepancy (RID)/Request for Action (RFA)/action item burndown per review)

Recommended

1. Requirement Trends (percent growth, To Be Determined (TBD) and To Be Resolved (TBR) closures, # requirement changes)
2. Interface Trends (percent Interface Control Document (ICD) approval, TBD and TBR burndown, # interface requirement changes)
3. Verification Trends (closure burndown, # deviations and waivers approved and open)
4. Software Unique Trends (# software requirements per build or release versus plan)[27]
5. Problem Report and/or Discrepancy Report Trends (# open, # closed)
6. Manufacturing Trends (# nonconformance and/or corrective actions)
7. Cost Trends (plan versus actual, Unallocated Future Expenses (UFE), Earned Value Management (EVM), New Obligation Authority (NOA))
8. Schedule Trends (critical path slack or float, critical milestones, EVM schedule metrics, etc.)
9. Staffing Trends (Full-Time Equivalent (FTE) and Work-Year Equivalent (WYE) plans versus actuals)
10. Manufacturing Trends (# nonconformance and/or corrective actions (open, closed, or resolved))
11. Additional project-specific indicators as needed (e.g., human systems integration compliance)

The **Technical, Schedule, and Cost Control Plan** also describes:

- How tightly coupled and single-project programs monitor and control the program's Management Agreement.

[27] Note that there are software measurement requirements other than Technical Leading Indicators in *NPR 7150.2, NASA Software Engineering Requirements* (e.g., SWE-091) which have implementation guidance in *NASA-HDBK-2203, NASA Software Engineering and Assurance Handbook* (http://swehb.nasa.gov).

- How single-project programs monitor and control the program's ABC.
- How single-project programs will mitigate exceeding the development cost documented in the ABC and take corrective action prior to triggering the 30 percent breach threshold.[28]
- How single-project programs will support a Rebaseline Review in the event the Decision Authority directs one. (For more information on Rebaseline Reviews, see Section 5.5.5.1.)
- What the program's systems engineering organization and structure will be, and how these functions will be executed.
- How the program will use systems of measurement and identify units of measure in all product documentation. (See Section 3.3.4 for more information on the use of the International System of Units (SI), commonly known as the Système Internationale (SI) or metric system of measurement.)
- How the program will implement Technical Authority (engineering, safety and mission assurance, and health and medical), including how the program will address technical waivers and deviations and how Formal Dissents will be handled.
- How single-project programs will use an Earned Value Management System (EVMS); how tightly coupled programs will use an EVMS if EVM requirements are to be levied at the program level; or how loosely coupled or uncoupled programs flow EVM requirements down to the projects, including the reporting of project EVM. (See Section 4.3.4.2.2 and Section 5.14 for details on Earned Value Management.)
- What the program's descope plans are, including key decision dates, savings in cost and schedule, and how the descopes are related to the program's threshold requirements.
- What if any additional specific tools the program will use to implement its control processes, e.g., systems for requirements management; program scheduling; program information management.
- How the program will monitor and control the Integrated Master Schedule (IMS), including utilization of its technical and schedule margins and UFE to stay within the terms of the Management Agreement and ABC, if applicable.
- How the program plans to report technical, schedule, and cost status to the MDAA, including frequency and the level of detail.

All program teams develop a program **Work Breakdown Structure (WBS).** The NASA standard WBS template is intended to apply to projects, not programs. There is no standard program WBS due to the variance in structure of the Mission Directorates. Tightly coupled and single-project programs generally have a product-oriented WBS like the standard WBS for space flight projects illustrated in Figure 4-10 in this handbook and in NPR 7120.5F

[28] A breach occurs when the projected cost estimate for development cost exceeds the ABC cost for Phase C through D by 30 percent or more. See Section 5.5 for additional information.

Figure H-2. The WBS for uncoupled and loosely coupled programs will probably be more focused at the project level than the system level shown in the figure. All programs develop a WBS dictionary down to at least the project level. The WBS supports cost and schedule allocation down to a project level that allows for unambiguous cost reporting. (See Section 5.9.1 and Section 5.9.7 for additional guidance on developing a program WBS.)

After developing the WBS and the initial program architecture, the program team develops the cost and schedule estimate and appropriate annual budget submissions. Cost and schedule typically are informed by **technology, engineering development and heritage assessments** using *NASA/SP-2016-6105, Systems Engineering Handbook,* Appendix G, Technology Assessment/Insertion acquisition strategies, **infrastructure and workforce requirements**, and identified **risks**. Infrastructure requirements include the acquisition, renovation, and/or use of real property and/or facilities, aircraft, personal property, and information technology. The program identifies the means of meeting infrastructure requirements through synergy with other existing and planned programs and projects to avoid duplication of facilities and capabilities; identifies necessary infrastructure upgrades or new developments, including those needed for environmental compliance; and identifies and documents concurrence for any investments, divestments, acquisition strategies, procurements, agreements, and changes to capability portfolio capability components in accordance with requirements and strategic guidance included in *NPR 8600.1, NASA Capability Portfolio Management Requirements.*

The program develops the **life-cycle cost or initial capability cost and schedule estimates** consistent with **driving assumptions, risks, requirements**, and available funding and schedule constraints:

- The program team develops its cost estimates using many different techniques. These include, but are not limited to, bottoms-up estimates where specific work items are estimated by the performing organization using historical data or engineering estimates; vendor quotes; analogies; and parametric cost models. (See Section 5.6 for a discussion of probabilistic cost estimating.)
- The program team develops its resource baseline, which includes funding requirements by fiscal year and the New Obligation Authority (NOA) in real-year dollars for all years: prior, current, and remaining. The funding requirements are consistent with the program's WBS and include funding for all cost elements required by the Agency's full-cost accounting procedures. Funding requirements are consistent with the budget. The resource baseline provides a breakdown of the program's funding requirements to at least the WBS Level 2 elements. The resource baseline provides the workforce requirements specific to the program (i.e., not project workforce) by fiscal year, consistent with the program's funding requirements and WBS. The resource baseline identifies the **driving ground rules and assumptions** and constraints that affect it. Throughout the Implementation Phase, single-project program baselines are based on the approved JCL in accordance with *NPD 1000.5, Policy for NASA Acquisition* and NPR

7120.5. (The resource baseline also includes the **infrastructure requirements**, discussed elsewhere in this section.)

- The program team develops a summary of its IMS, including all critical milestones, major events, life-cycle reviews, and KDPs throughout the program life cycle. The summary of the IMS includes the logical relationships (interdependencies) for the various program elements and projects and critical paths, as appropriate, and identifies the **driving ground rules and assumptions** and constraints affecting the schedule baseline. The summary of the IMS is included in the Program Plan.
- In doing these estimates, the program team documents the **Basis of Estimate** (BoE) and the rationales and assumptions that went into the estimate.

  The Basis of Estimate (BoE) documents the ground rules and assumptions and the drivers used in developing the cost and schedule estimates, including applicable model inputs, rationale or justification for analogies, and details supporting cost and schedule estimates. The BoE is contained in material available to the Standing Review Board (SRB) and management as part of the life-cycle review and Key Decision Point (KDP) process. Good BoEs are well documented, comprehensive, accurate, credible, traceable, and executable. Sufficient information on how the estimate was developed needs to be included to allow review team members, including independent cost analysts, to reproduce the estimate if required. Types of information can include estimating techniques (e.g., bottoms-up, vendor quotes, analogies, parametric cost models), data sources, inflation, labor rates, new facilities costs, operations costs, sunk costs, etc.

- Finally, all single-project programs, regardless of LCC or initial capability cost, develop a JCL prior to their PDR/KDP C, and, if the program is rebaselined during the Implementation phase, calculate a JCL as part of the rebaselining approval process. (For more information on rebaseline, see Section 5.5.5.) In addition, single-project programs with an LCC or initial capability cost greater than or equal to $1 billion also:
  - Establish a high and low value for cost and schedule with the corresponding JCL value at KDP B. The JCL is informed by a probabilistic analysis of development cost and schedule duration.[29]
  - Update their KDP C JCL at CDR and communicate the updated JCL values for the ABC and Management Agreement to the APMC for informational purposes.
  - Update their JCL at KDP D if current reported development costs have exceeded the development ABC cost by 5 percent or more and document the updated JCL values for the ABC and Management Agreement in the KDP D Decision Memorandum.

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[29] The methodology for JCL analysis at KDP B is not limited to a probabilistic analysis of the coupled cost and schedule specified for KDP C. Other parametric and bivariate methodologies may be applied.

All program types plan, prepare for, and support the ASM, if required, as part of developing the Acquisition Strategy, generally prior to SRR for single-project programs and prior to SDR for uncoupled and loosely coupled and tightly coupled programs. The results of this meeting are documented in the **ASM Decision Memorandum** or **ASM meeting summary** and used to finalize the **Acquisition Strategy**, which is baselined at SDR for uncoupled, loosely coupled, and tightly coupled programs. Single-project programs baseline the Acquisition Strategy earlier at SRR to allow procurement actions earlier in Formulation. The program Acquisition Strategy is developed by the program manager with support by the Office of Procurement. The plan needs to be consistent with the results of the acquisition planning process, which includes such things as assignment of lead Center, considerations for partnering, and decisions made at the ASM.

The **Acquisition Strategy**:

- Is developed by the program manager, supported by the host Center's Procurement Officer, and needs to be consistent with *NPD 1000.5, Policy for NASA Acquisition*, the results of the Agency strategic acquisition process, and the ASM.
- Documents an integrated acquisition strategy that enables the program to meet its mission objectives and provides the best value to NASA.
- Identifies all major proposed acquisitions (such as engineering design study, hardware and software development, mission and data operations support, and sustainment) in relation to the program WBS and provides summary information on each proposed acquisition, including a contract WBS; major deliverable items; recommended type of procurement (e.g., competitive, Announcement of Opportunity for instruments); type of contract (e.g., cost-reimbursable, fixed-price); source (e.g., institutional, contractor, other Government agency, or international organization); procuring activity; and surveillance approach.
- Identifies the major procurements that require a Procurement Strategy Meeting (PSM).
- Describes completed or planned studies supporting make-or-buy decisions, considering NASA's in-house capabilities and the maintenance of NASA's core competencies, as well as cost and best overall value to NASA.
- Describes the state of the industrial base capability and identifies potential critical and single-source suppliers needed to design, develop, produce, support, and, if appropriate, restart an acquisition program or project.
- Promotes sufficient program and project stability to encourage industry to invest in, plan for, and bear its share of risk.
- Describes the internal and external mechanisms and procedures used to identify, monitor, and mitigate supply chain risks and includes data reporting relationships that allow continuous surveillance of the supply chain and provide for timely notification and mitigation of potential risks.
- Describes the process for reporting industrial and supply chain risks to the MDAA.

- Identifies the program's approach to strengthening SMA in contracts.
- Describes all agreements, MOUs, barters, in-kind contributions, and other arrangements for collaborative and/or cooperative relationships, including partnerships created through mechanisms other than those prescribed in the FAR and NFS. It lists all such agreements (the configuration control numbers, the date signed or projected dates of approval, and associated record requirements) necessary for program success. It includes or references all agreements concluded with the authority of the program manager and references agreements concluded with the authority of the MDAA and above. These include (1) NASA agreements (e.g., space communications, launch services, inter-Center MOAs) and (2) non-NASA agreements, both domestic (e.g., U.S. Government agencies) and international (e.g., MOUs).
- Describes intellectual property considerations and goals for advanced technologies to protect core NASA interests during the program life cycle; the process for respecting and protecting privately developed intellectual property; the process for ensuring acquisition strategies, proposals, and contract awards reflect intellectual property considerations established for the program; the approach for ensuring that the intellectual property strategy promotes competition for post-production sustainment and/or modernization contracts; the approach for seeking flexible and creative solutions to intellectual property issues that meet the desires of the parties and reflect NASA's investment; the approach for ensuring procurement contracts specify both (1) the delivery of necessary technical data and computer software and (2) the license rights necessary for technical data and computer software; and the approach for ensuring the delivery of technical data and computer software under procurement contracts is marked in accordance with the contract at the time of delivery.

The program supports Procurement Strategy Meetings (PSM) for individual procurements that require PSMs. The elements of the program **Acquisition Strategy** should be reflected in any resulting PSM for individual procurement activity supporting the program Acquisition Strategy.

The Procurement Strategy Meeting (PSM) provides the basis for approval of the approach for major procurements for programs and projects and ensures they are following the law including the Federal Acquisition Regulation (FAR). Detailed PSM requirements and processes, prescribed by the FAR and the NASA FAR Supplement (NFS) and formulated by the Office of Procurement, ensure the alignment of portfolio, mission acquisition, and subsequent procurement decisions. The contents of written acquisition plans and PSMs are delineated in FAR Subpart 7.1, Acquisition Plans, NFS Subpart 1807.1, Acquisition Plans,[30] and in the Guide for Successful Headquarters Procurement Strategy Meetings.[31]

All acquisitions over $10 million are required by the NASA FAR Supplement (NFS) to conduct a PSM. The Office of Procurement at Headquarters determines which PSMs require

30 https://prod.nais.nasa.gov/far/far0595-nfs012617/1807.htm

31 https://ooptechportal.hq.nasa.gov/Documents/NASA%20PSM%20Guide.pdf

a Headquarters review and which can be delegated to the Centers by reviewing the procurements on the Master Buy List, which is updated periodically by the Centers. The PSM is chaired by the Assistant Administrator for Procurement at Headquarters. Each Center has its own tailored procedure for Center-level PSMs and may specify who chairs their PSMs. (It is usually the Center Procurement Officer.) The PSM covers subjects such as how the acquisition fulfills mission need, budget and funding profile, small business opportunities, contract type, EVM requirements, and length of contract. It implements the decisions that flow from the higher-level meetings.

All program types identify and assess risks that threaten program requirements and development. Uncoupled, loosely coupled, and tightly coupled programs develop a preliminary **Risk Management Plan** by SRR and baseline the plan by SDR, whereas the single-project program baselines its plan by SRR since system hardware design is being conducted prior to SDR/MDR. This plan summarizes how the program implements the NASA risk management process (including Risk-Informed Decision-Making (RIDM) and Continuous Risk Management (CRM)) in accordance with *NPR 8000.4, Agency Risk Management Procedural Requirements* and *NASA/SP-2011-3422, NASA Risk Management Handbook*. It includes the initial risk list, appropriate actions to mitigate each risk, and the resources needed for managing and mitigating these risks. Programs with international or other U.S. Government agency contributions need to plan for, assess, and report on risks due to international or other government partners and plan for contingencies.

Loosely coupled and uncoupled programs develop a Communications Plan and baseline the plan by SDR. Tightly coupled and single-project programs develop a preliminary plan by SRR and baseline the plan by PDR. (This plan is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.) The plan is developed in collaboration with the Associate Administrator (AA) for the Office of Communications or designee. It identifies key program milestones that will be of interest to the general public, the media, and other key stakeholders, and it identifies plans to engage these audiences via audio and real and/or near real-time high-resolution video and/or imagery for each milestone including during full mission operations. The plan summarizes how these efforts will promote understanding of and engagement with program objectives, elements, benefits, and contributions to overarching NASA goals. Resources and technical requirements for implementation of communications for the general public, media, and other key stakeholders are identified in collaboration with the Office of Communications AA or designee. (See the Communications Plan Template on the website for the Office of Communications, http://communications.nasa.gov/content/nasa-comm-guidelines.)

Uncoupled, loosely coupled, and tightly coupled programs develop a preliminary Knowledge Management Plan by SRR and baseline the plan by SDR; the single-project program develops a preliminary plan by SDR/MDR and baselines the plan at PDR. (This plan is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.) This plan describes the program's approach to creating the program's knowledge management strategy and processes, including practices and approaches for identifying, capturing and transferring knowledge; examining the lessons learned database for relevant lessons that can be reflected into the program early in the planning process to avoid known issues; and continuously capturing, documenting, and using lessons learned throughout the program life cycle in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy* and as described in *NPD 7120.6, Knowledge Policy for Programs and Projects* and other appropriate requirements and standards documentation.

3.3.4 Technical Activities and Products

For all program types, the program team continues to develop the architecture of the program and document its major structural elements, including functional elements and projects, required to make the program work. The architecture includes how the major program components (hardware, software, human systems) will be integrated and are intended to operate together and with heritage systems, as applicable, to achieve program goals and objectives. By implication, the architecture defines the system-level processes necessary for development, production, human systems integration, verification, deployment, operations, support, disposal, and training. The architecture also includes facilities, logistics concepts, and planned mission results and data analysis, archiving, and reporting. The architecture development process usually considers a number of alternative approaches to both the architecture and the program's **Concept Documentation.**

Tightly coupled programs and single-project programs develop the **Concept Documentation** and candidate (preliminary) **mission, spacecraft, and ground systems architectures**. The Concept Documentation includes all activities such as integration and test, launch integration, launch, deployment and on-orbit checkout (robotic programs) or initial operations (human space flight programs), in-space operations, landing and recovery, as applicable, and decommissioning and disposal.

In analyzing the **Concept Documentation**, tightly coupled programs and single-project programs develop the preliminary approach to verification and validation, system integration, and human rating, if applicable. Tightly coupled programs and single-project programs assess unique workforce and infrastructure needs and include these requirements in the initial concept(s).

As the tightly coupled or single-project program approaches the MCR, it develops and documents at least one feasible preliminary concept (included as part of **Concept Documentation** in NPR 7120.5F, Table I-6 and Table 3-5 at the end of this chapter), including the key preliminary ground rules and assumptions that drive the concept(s). A feasible concept is one that is probably achievable technically within the cost and schedule resources allocated by the Mission Directorate. This preliminary concept includes key drivers, preliminary estimates of technical margins for candidate architectures, and a preliminary Master Equipment List (MEL). (If applicable, tightly coupled programs develop the preliminary MEL no later than SRR.) This concept is sometimes referred to as the mission concept, particularly in the robotic community. As a minimum, the principal concept will be approved following the MCR and KDP A. Future changes to this concept (and others if approved for further study) will be identified at each follow-on life-cycle review and KDP so that management understands how the concept is evolving as formulation progresses.

The term "concept documentation" used in NPR 7120.5 is the documentation that captures and communicates a feasible concept at MCR that meets the goals and objectives of the mission, including results of analyses of alternative concepts, the concept of operations (baselined at MCR per NPR 7123.1), preliminary risks, and potential descopes. (Descope is a particular kind of risk mitigation that addresses risks early in the program Formulation Phase.)

The Master Equipment List (MEL) summarizes all major components of each flight element subsystem and each instrument element component. Description for each major component includes current best estimates and contingency allocation for mass and power (including for individual components), number of flight units required, and some description of the heritage basis. Power values generally represent nominal steady-state operational power requirements. Information includes identification of planned spares and prototypes, required deliveries and/or exchanges of simulators for testing, and other component descriptions and/or characteristics. Certain items (like electronic boxes and solar arrays) usually include additional details to identify and separate individual elements. The MEL is useful to single-project program managers for understanding where the design is, where the mass is being carried, what the power needs are, what the margins are, and what the values of other parameters are as the single-project program progresses in development.

Based on the leading concept, the tightly coupled and single-project programs develop and mature the initial mission objectives and requirements and develop a mission or science traceability matrix that shows how the requirements flow from the objectives of the mission through the operational requirements (such as science measurement requirements) to the top-level infrastructure implementation requirements (such as orbit characteristics and pointing stability). At this point, tightly coupled and single-project programs, with guidance from their stakeholders, begin to select technical standards for use as program requirements in accordance with *NPR 7120.10, Technical Standards for NASA Programs and Projects*. Based on currency and applicability, technical standards required by law and those designated as mandatory by NPDs and NPRs are selected first. When all other factors are the same, NASA promotes the use of voluntary consensus standards when they meet or can be tailored to meet the needs of NASA and other Government agency technical standards.

In addition, single-project programs develop an initial **assessment of engineering development needs**, including defining the need for engineering prototypes and models for the higher-risk components and assemblies that have not been previously built or flown in the planned environment and testing them to demonstrate adequate performance. As with technology development, identification at this point will enable single-project programs to plan and initiate engineering development activities early in Formulation knowing that the funding has been planned for these activities.

For concepts and architectures that plan to use heritage systems, single-project programs use *NASA/SP-2016-6105, Systems Engineering Handbook,* Appendix G. Technology Assessment/Insertion to develop an initial **assessment of heritage hardware and software systems** that may be utilized outside the environments and configurations for which they were originally designed and used.

All these activities help tightly coupled and single-project programs develop an initial assessment of preliminary technical risks for candidate architectures.

If not already defined, single-project programs identify their payload risk classification in accordance with *NPR 8705.4, Risk Classification for NASA Payloads*.

In accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects*, all programs develop the preliminary **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status**. This product is developed by single-project programs in preparation for MCR and updated by SRR. Loosely coupled, uncoupled, and tightly coupled programs develop this product in preparation for SRR. Single-project programs also develop the preliminary **Criticality Identification Method for Hardware** and the preliminary Hardware Quality Data Management Analytics in preparation for MCR and update these products at SRR. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.)

Following the SRR, tightly coupled and single-project programs update the **Concept Documentation**, architectures, and requirements based on the results of the SRR and continue to perform analyses and trades in support of concept or design refinement. Single-project programs develop and update **Design Documentation** for use during peer reviews, subsystem reviews, and system reviews during Formulation and establish the preliminary Design Documentation at PDR.

Single-project programs implement **engineering development plans**, **heritage hardware and software assessments**, and **risk mitigation plans** identified in their **Formulation Agreement** for Phase A. As these risk reduction plans are executed, single-project programs monitor, assess, and report the status of engineering development results and heritage assessments**.**

To provide additional options in case development begins to exceed the resources allocated, tightly coupled and single-project programs typically begin to develop an initial list of descope options. Descope is a particular kind of risk mitigation that addresses risks early in the program Formulation Phase. Documentation of tightly coupled and single-project programs' descope plans typically includes a detailed description of the potential descope, the effect of the descope on tightly coupled and single-project programs' success criteria, the cost and schedule savings resulting from the descope, and key decision dates by when the descope needs to be exercised to realize these savings.

Tightly coupled programs and single-project programs develop preliminary **Systems Safety Analyses** by PDR as required by NPR 7120.5 and *NPR 8715.3, NASA General Safety Program Requirements*. (The Systems Safety Analyses are baselined at CDR and updated at SIR, ORR, and MRR/FRR.)

Loosely coupled, uncoupled, and tightly coupled programs baseline the **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status** by SDR. Tightly coupled programs also update this product at PDR. (Loosely coupled and uncoupled programs update this product in preparation for PIRs during the Implementation phase.) Single-project programs update the preliminary **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status**, the **Criticality Identification Method for Hardware**, and the Hardware Quality Data Management Analytics by SDR and baseline these products by PDR. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.)

For all program types, the program team assesses the ability of the program and its component project(s) and all contributors to the program and its projects (including contractors, industrial partners, and other partners) to use the International System of Units (SI), commonly known as the Système Internationale (SI) or metric system of measurement. This assessment determines an approach that maximizes the use of SI while minimizing short- and long-term risk to the extent practical and economically feasible or to the extent that the supply chain can support utilization without loss of markets to U.S. firms. Use of the SI or metric system of measurement is especially encouraged in cooperative efforts with international partners. This assessment documents an integration strategy if both SI and U.S. customary units are used in the program or its projects. The assessment is completed and documented in the **Program Plan** no later than the SDR/MDR. To the degree possible, programs need to use consistent measurement units throughout all documentation to minimize the risk of errors.

All programs that plan to develop technologies develop a Technology Development Plan. (This plan is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.) Generally, technologies developed at the program level cut across projects within the program. Uncoupled, loosely coupled, and tightly coupled programs develop a preliminary Technology Development Plan prior to SRR and baseline the plan at SDR. The single-project program baselines its plan by MCR so that technology requirements can be implemented early in Formulation. The Technology Development Plan describes:

- The technology assessment, development, management, and acquisition strategies (including intellectual property considerations) needed to achieve the program's mission objectives.
- How the program will assess its technology development requirements, including how the program will evaluate the feasibility, availability, readiness, cost, risk, and benefit of the new technologies and ensure timely reporting of new technologies to the Center Technology Transfer Office and supporting technology transfer activities as described in *NPR 7500.2, NASA Technology Transfer Requirements*.
- How the program will identify opportunities for leveraging on-going technology efforts.
- How the program will transition technologies from the development stage to the manufacturing and production phases.
- The supply chain needed to manufacture the technology and any costs and risks associated with the transition to the manufacturing and production phases, including appropriate mitigation plans for the identified risks.
- The program's strategy for ensuring that there are alternative development paths available in case technologies do not mature as expected. (Refer to NPR 7123.1 for TRL definitions and *NASA/SP-20205003605, Technology Readiness Assessment Best Practices Guide*, which can be found in NODIS on the OCE tab under the "Other NASA-Level Documents" menu.)
- How the program will remove technology gaps, including maturation, validation, and insertion plans, performance measurement at quantifiable milestones, off-ramp decision gates, and resources required.
- How the program will ensure that all planned technology exchanges, contracts, and partnership agreements comply with all laws and regulations regarding export control and the transfer of sensitive and proprietary information.
- How the program will transition technologies from the development stage to manufacturing, production, and insertion into the end system, including any potential costs and risks associated with the transition to manufacturing, production, and insertion and appropriate mitigation plans for the identified risks.

In accordance with *NPR 8705.2, Human-Rating Requirements for Space Systems* for crewed missions and *NPR 8705.4, Risk Classification for NASA Payloads* for uncrewed missions and payloads, programs develop a **Safety and Mission Assurance (SMA) Plan**. Loosely coupled, uncoupled, and tightly coupled programs develop a preliminary SMA Plan by SRR and baseline the plan by SDR. Single-project programs baseline their plan at SRR to ensure that proper SMA procedures are in place for the system design activities. The SMA Plan reflects a program life-cycle SMA process perspective, addressing areas including SMA domain management and SMA domain integration (e.g., for safety, reliability, maintainability, quality, planetary protection) with other engineering and management functions (e.g., concept and design trade-studies, risk analysis and risk assessments, risk-informed decision making, fault tolerance and contingency planning, knowledge capture, hardware and software design assurance, supply chain risk management and procurement, hardware and software design verification and test, manufacturing process design and control, manufacturing and product quality assurance, system verification and test, pre-flight verification and test, operations, maintenance, logistics planning, maintainability and sustainability, operational reliability and availability, decommissioning, and disposal). In addition, the SMA Plan describes:

- How the program will develop and manage a closed-loop problem reporting and resolution system and how it develops, tracks, and resolves problems. The data-collection process needs to be well-defined and include a data collection system for hardware and software problem and anomaly reports, problem analysis, and corrective action.
- The program's approach to flow down requirements as appropriate to external developers and suppliers in acquisitions (e.g., contracts and purchase orders).
- How the program will develop, evaluate, and report indications of SMA program maturity and effectiveness at life-cycle reviews or other executive reviews including through the use of metrics and indicators that are not otherwise included in formal life-cycle review deliverables or are not elements of the Certification of Flight Readiness (COFR) process (e.g., satisfactory progress towards human rating).

Loosely coupled, uncoupled, and tightly coupled programs develop a preliminary **Systems Engineering Management Plan** (SEMP) that includes the content required by NPR 7123.1 by SRR and baseline the plan by SDR. Single-project programs baseline their plan at SRR to ensure that proper system engineering procedures are in place for the system design activities. Single-project programs update their SEMP at SDR/MDR and PDR. The plan summarizes the key elements of the program systems engineering and includes descriptions of the program's overall approach for systems engineering. The systems engineering process typically includes system design and product realization processes (implementation and/or integration, verification and validation, and transition), as well as the technical management processes.

If applicable, in accordance with NPR 7120.5 and NPR 7123.1, tightly coupled and single-project programs develop a **Human Systems Integration (HSI) Plan**. The HSI Plan is baselined at SRR and updated at SDR (SDR/MDR for single-project programs) and PDR. This plan describes how human systems integration and human-centered design will be integrated into the program design process and life cycle, including what types of human systems integration resources, tools, analysis, testing, and products will be employed or developed to ensure successful human systems integration, thereby reducing mission risk and total life-cycle cost while increasing overall safety. The plan also describes roles and responsibilities related to implementation of HSI. (See *NASA/SP-20210010952, NASA Human Systems Integration Handbook* for additional information.)

Tightly coupled and single-project programs develop a preliminary **Verification and Validation Plan** by SDR (SDR/MDR for single-project programs) and baseline the plan by PDR. This plan summarizes the approach for performing verification and validation of the program products. It indicates the methodology to be used in the verification and validation (test, analysis, inspection, or demonstration) as defined in NPR 7123.1.

All programs develop a preliminary **System Security Plan** by SRR in accordance with *NPR 2810.1, Security of Information and Information Systems*. Uncoupled and loosely coupled programs baseline the plan by SDR and update the plan for PIRs; tightly coupled and single-project programs update the plan by PDR and baseline the plan by CDR. This plan identifies and prepares a System Security Plan for each information system. The System Security Plan provides an overview of the security requirements for an information system and describes the security controls in place or planned for meeting those requirements. System Security Plans are generated and stored within the NASA Risk Information and Security Compliance System (RISCS) at https://riscs-info.nasa.gov/. Multiple systems may be covered under a single System Security Plan. Controls selected within the System Security Plan are included as system requirements for the system or systems covered by the plan. This plan also describes the program's approach to implementing cybersecurity requirements in accordance with *NPR 2810.1, Security of Information and Information Systems* if there are requirements outside the scope of the System Security Plan(s).

All programs develop and baseline a **Review Plan** by SRR in time to establish the independent SRB and permit adequate planning and definition of the program's approach for conducting the series of reviews. The reviews include internal reviews and program life-cycle reviews in accordance with Center best practices, Mission Directorate review requirements, and the requirements in NPR 7123.1 and NPR 7120.5. The Review Plan identifies the life-cycle reviews the program plans to conduct and the purpose, content, and timing of those life-cycle reviews, and documents any planned deviations or waivers granted from the requirements in NPR 7123.1 and NPR 7120.5F, including tailoring to accommodate aspects of innovative acquisition approaches. The Review Plan also specifies the considerations that will be used to trigger a discussion on the need for a PIR with the NASA AA. (See Section 5.11.3.) It also provides the technical, scientific, schedule, cost, and other criteria that will be used in the consideration of a Termination Review.

Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, define the initial capability in the **Review Plan** for KDP B if the initial capability is not the first operational mission flight.

For tightly coupled programs, the **Review Plan** documents the program life-cycle review requirements on the supporting projects that represent an integrated review process for the various projects. When multiple Centers are involved, review plans take into consideration the participating Centers' review process best practices. For each program life-cycle review and KDP, the Review Plan documents the sequencing of the associated project life-cycle reviews and KDPs, i.e., whether the associated project life-cycle reviews and KDPs precede or follow the program life-cycle review and KDP. In addition, the plan documents which projects need to proceed to their KDPs together, which projects need to proceed to their KDPs simultaneously with the program KDP, and which projects may proceed to their KDPs as individual projects. The sequencing of project life-cycle reviews and KDPs with respect to program life-cycle reviews and KDPs is especially important for project PDR life-cycle reviews that precede the KDP Cs. At KDP C, the Agency makes project technical, cost, and schedule commitments to its external stakeholders at the established JCL in accordance with NPR 7120.5 requirements. Since changes to one project can easily impact other projects' technical, cost, and schedule baselines, and potentially impact other projects' risk assessments and mitigation plans, projects and their program may need to proceed to KDP I/KDP C together.

All programs develop **NEPA Compliance Documentation.** Uncoupled, loosely coupled, and single-project programs baseline the documentation by SDR. Tightly coupled programs develop preliminary documentation by SDR and baseline the documentation by PDR. The program identifies the level of NEPA analysis planned to comply with *NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114*. The NEPA Compliance Documentation is prepared based on consultation with the appropriate NEPA manager (Center NEPA Manager or Mission Direction NEPA Liaison) and describes the program's NEPA strategy at all affected Centers, including decisions regarding programmatic NEPA documents. Critical NEPA milestones are inserted into the program schedule if preparation of an Environmental Assessment or Environmental Impact Statement is planned.

Early in Formulation, tightly coupled and single-project programs develop a logistics support concept that supports the overall mission concept and that accommodates the specific characteristics of the program's component projects, including identifying the infrastructure and procurement strategies necessary to support the program. This concept typically includes expected levels of contractor effort for life-cycle logistics support functions through all life-cycle phases. These logistics support concepts are integrated into the system design process. Tightly coupled and single-project programs finalize a preliminary **Integrated Logistics Support (ILS) Plan** by SDR/MDR (SDR for tightly coupled programs) and baseline the document by PDR. The Integrated Logistics Support Plan describes how the program will implement *NPD 7500.1, Program and Project Life-Cycle Logistics Support Policy*, including a maintenance and support concept; participation in the design process to enhance supportability; supply support, including spares, procurement and replenishment, resupply and return, and supply chain management related to logistics support functions; maintenance and maintenance planning; packaging, handling, and transportation of deliverable products; technical data and documentation; support and test equipment; training; manpower and personnel for ILS functions; facilities required for ILS functions; and logistics information systems for the life of the program.

Tightly coupled and single-project programs develop a preliminary Science Data Management Plan by PDR that describes how the program will manage the scientific data generated and captured by the operational mission(s) and any samples collected and returned for analysis. (This plan is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.) For uncoupled and loosely coupled programs, this plan is developed at the project level. The plan includes descriptions of how data will be generated, processed, distributed, analyzed, and archived. It also describes how any samples will be collected and stored during the mission and managed when returned to Earth, including any planetary protection measures. The plan typically includes definitions of data rights and services and access to samples, as appropriate, and identifies where the preliminary science data requirements will be documented. (These requirements should be documented by SRR.) The plan is developed in consultation with the Mission Directorate data leads and the Office of the Chief Information Officer (OCIO) early in the program life cycle to ensure that metadata standards and data formats are appropriately considered and that infrastructure and security requirements are addressed. The plan explains how the program will accomplish the information management and disposition requirements in *NPD 2200.1, Management of NASA Scientific and Technical Information*, *NPR 2200.2, Requirements for Documentation, Approval and Dissemination of Scientific and Technical Information*, and *NPR 1441.1, NASA Records Management Program Requirements* as applicable to program science data. The plan further describes how the program will adhere to all NASA sample handling, curation, and planetary protection directives and rules, including *NPR 8715.24, Planetary Protection Provisions for Robotic Extraterrestrial Missions*.

All program types develop a **Configuration Management Plan** early in Formulation to assist the program in managing requirements and the control plans that are needed before the Program Plan is finalized. Uncoupled and loosely coupled programs develop and baseline the plan by SDR/MDR. Single-project programs develop and baseline the plan by SRR and update it by SDR/MDR and PDR. Tightly coupled programs develop a preliminary plan by SRR, baseline the plan by SDR, and update the plan by PDR. Configuration management addresses hardware, software, and firmware. This plan describes the configuration management approach the program team will implement, consistent with NPR 7123.1 and *SAE/EIA 649, Configuration Management Standard*. It describes:

- The configuration management planning and management function including the configuration management organization and tools to be used.
- The methods and procedures to be used for configuration identification, configuration control, interface management, configuration change management; configuration verification and audit; and configuration status accounting and communications.
- How configuration management will be audited.
- How contractor configuration management processes will be integrated with the program.

All program types develop a **Security Plan**. Uncoupled and loosely coupled programs develop and baseline the plan by SDR. Tightly coupled and single-project programs develop a preliminary plan by SDR/MDR (SDR for tightly coupled programs) and baseline the plan by PDR. This plan describes the program's plans for ensuring security, including security requirements and emergency response requirements. It describes the program's approach for planning and implementing the requirements for physical, personnel, and industrial security, and for security awareness and education requirements in accordance with *NPR 1600.1, NASA Security Program Procedural Requirements.* The plan also describes the program's emergency response plan to meet the emergency response requirements in *NPR 1040.1, NASA Continuity of Operations (COOP) Planning Procedural Requirements* and defines the range and scope of potential crises and specific response actions, timing of notifications and actions, and responsibilities of key individuals.

All program types develop a **Technology Transfer Control Plan**. Uncoupled and loosely coupled programs develop and baseline the plan by SDR. Tightly coupled and single-project programs develop a preliminary plan by SDR (SDR/MDR for single-project programs) and baseline the plan by PDR. This plan describes how the program will implement the export control requirements specified in *NPR 2190.1, NASA Export Control Program*.

Single-project programs develop an **initial assessment of orbital debris** (Initial ODAR) per *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* in accordance with the formats and contents described in *NASA-STD-8719.14, Process for Limiting Orbital Debris*.[32] The Initial ODAR provides a brief description of the mission including potential launch vehicles, launch site, and the spacecraft (including appendages such as solar arrays, antennas, and instruments). It describes the type of propulsion systems planned, any radioactive materials or other non-propulsion system hazardous materials that will be on board, and the operational orbital maintenance requirements. The Initial ODAR also includes a summary of the Orbital Debris Limitations by providing answers to questions such as whether propellant and pressurant tanks can be emptied at end of mission or if there are components that may survive reentry. The responses to the Orbital Debris Limitations questions convey the intended plan for the spacecraft and launch vehicle being presented at the Acquisition Strategy Meeting (ASM). The initial ODAR is due at MCR. The single-project program develops the preliminary design **Orbital Debris Assessment Report (ODAR)** by PDR in accordance with NPR 8715.6 using the format and requirements contained in *NASA-STD-8719.14, Process for Limiting Orbital Debris*. For uncoupled, loosely coupled, and tightly coupled programs, these assessments are performed at the project level.

If a tightly coupled or single-project program includes human space flight systems, the program develops a **Human-Rating Certification Package** (HRCP) per *NPR 8705.2, Human-Rating Requirements for Space Systems*. The initial HRCP is delivered at SRR; updated at SDR/MDR (SDR for tightly coupled programs), PDR, CDR, and ORR; and certified

32 https://standards.nasa.gov/standard/nasa/nasa-std-871914

at MRR/FRR. Human-rating certification focuses on the integration of the human into the system, preventing catastrophic events during the mission and protecting the health and safety of humans involved in or exposed to space activities, specifically the public, crew, passengers, and ground personnel.

All programs develop a preliminary **Quality Assurance Surveillance Plan** by SRR and baseline the plan by SDR (SDR/MDR for single-project programs). This plan is developed per *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects* and NASA FAR Supplement (NFS) Part 1837.604, Quality assurance surveillance plans. The plan provides a consolidated set of detailed instructions for the performance of Government contract quality assurance review and evaluation for the project and might include contractor documents, data, and records; products and product attributes; processes; quality system elements and/or attributes; and requirements related to quality data analysis, nonconformance reporting and corrective action tracking and resolution, and final product acceptance.

Tightly coupled and single-project programs develop and finalize the **Orbital Collision Avoidance Plan** (OCAP) per *NASA Interim Directive (NID) 7120.132, Collision Avoidance for Space Environment Protection* and baseline the plan by PDR. The plan describes how the program implements the design considerations and preparation for operations to avoid in-space collisions and provides a program overview including a concept of operation, how orbit selection was performed, the spacecraft's ascent and disposal plan, how the spacecraft's location tracking data will be generated, and whether there will be any autonomous flight control. The plan discusses how the spacecraft's design will enable it to be acquired and tracked by the Space Surveillance Network and cataloged by the U. S. Space Command, and it describes the process for routinely coordinating with other owners and operator(s) for maneuvering. (See NID 7120.132 for more detail and a plan template.)

Single-project programs work with the Mission Directorate to develop a preliminary **Mishap Preparedness and Contingency Plan** in accordance with *NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping* in preparation for PDR.

Single-project programs without a project (for example, the Space Launch System (SLS)) are required to prepare the following technical products and control plans in accordance with Table I-6 and Table I-7 in NPR 7120.5F. These technical products and control plans are described in the appropriate paragraphs in Chapter 4:

- **Payload Safety Process Deliverables**
- **Project-Level, System, and Subsystem Requirements**
- **Software Management Plan**
- **Integration Plan**
- **Planetary Protection Plan**

- **Nuclear Launch Authorization Plan**
- **Range Safety Risk Management Process Documentation**
- **Project Protection Plan**

Tightly coupled programs also prepare an **Integration Plan**.

3.3.5 Completing Formulation Activities and Preparing for Implementation

3.3.5.1 Establishing the Program's Baseline

As a program approaches its milestone for approval to enter Implementation, KDP I (KDP C for single-project programs), the program team finalizes the baselines: technical (including requirements), resource (including funding, NOA, infrastructure, and staffing), and cost and schedule. Once approved and documented in the Decision Memorandum, these baselines are maintained under configuration control as part of the Program Plan. Section 5.5 provides additional detail on maturing, approving, and maintaining cost and schedule baselines.

Single-project programs (and other programs at the discretion of the MDAA) with EVM requirements also develop and baseline the Performance Measurement Baseline (PMB) at PDR. The Mission Directorate conducts a program-level Integrated Baseline Review (IBR) in preparation for KDP I (KDP C for single-project programs). (Section 5.14 provides additional detail on updating the PMB and conducting IBRs.)

The program documents the **driving ground rules and assumptions** and constraints affecting the resource baseline. (See Section 3.3.3.5 for details on the resource baseline.) When the project resource baselines are approved, the Program Plan is updated with the approved project baselines.

All programs are required to have a **Program Commitment Agreement** (PCA) approved to proceed into Implementation. (For a definition, see Section 3.3.2.1.) Programs support the MDAA in developing the preliminary PCA when required. Uncoupled and loosely coupled programs prepare a preliminary PCA by SRR. Tightly coupled and single-project programs prepare their preliminary PCAs as part of their SDR/MDR (SDR for tightly coupled programs) preparations. All programs support the MDAA in finalizing and obtaining approval of the PCA in preparation for their KDP I (KDP C for single-project programs). The PCA is baselined at SDR for uncoupled and loosely coupled programs and at PDR for tightly coupled and single-project programs.

Uncoupled, loosely coupled, and tightly coupled programs support the MDAA in the selection of projects, either directly assigned or through a competitive process.

All programs develop the program's plans for work to be performed during the Implementation Phase.

All programs summarize and document the results of Formulation activities. The programs generate the appropriate documentation in accordance with Appendix G of NPR 7123.1; Tables I-1, I-2, I-3, and I-6 and I-7 of NPR 7120.5F; and Tables 3-2, 3-3, 3-4, 3-5, and 3-6 at the end of this chapter. These documentation requirements may be satisfied, in whole or in part, by the **FAD**, the basis of cost and schedule estimates, draft and preliminary versions of program documents and plans, and the final LCR briefing packages.

3.3.5.2 Program Reporting Activities and Preparing for Major Milestones

3.3.5.2.1 Program Reporting

The program reports to the Center, as requested by the Center, on whether Center engineering, safety and mission assurance, health and medical, and management best practices (e.g., program and project management, resource management, procurement, institutional best practices) are being followed, and whether Center resources support program or project requirements. The program also provides program and project risks and the status and progress of activities so the Center can identify and report trends and provide guidance to the Agency and affected programs and projects. The CMC (or equivalent) provides its findings and recommendations to program managers and to the appropriate program management councils regarding the performance and technical and management viability of the program prior to the KDPs.

Aside from the Center and Agency reporting already mentioned, many stakeholders will be interested in the status of the program from Congress on down. The program manager will probably be required to report status and performance in many forums, including Mission Directorate monthly meetings and the Agency's monthly BPRs. (See Section 5.12 for further information regarding potential program external reporting.)

3.3.5.2.2 Program Internal Reviews

Prior to the program Formulation life-cycle reviews, programs conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. These internal reviews are the decisional meetings where the programs solidify their plans, technical approaches, and programmatic commitments. This is accomplished as part of the normal systems engineering work processes defined in NPR 7123.1 where major technical and programmatic requirements are assessed along with the system design and other implementation plans. Major technical and programmatic performance metrics are reported and assessed against predictions.

For tightly coupled and single-project programs:

- Non-SRB program technical reviews are divided into several categories: major systems reviews (one or two levels down from the program), Engineering Peer Reviews (EPRs), internal reviews, and tabletop reviews. Program systems reviews are major technical milestones of the program that typically precede the life-cycle review, covering major systems milestones such as the completion of a spacecraft, instrument, or ground system design. The technical progress of the program is assessed at key milestones such as these systems reviews to ensure that the program's maturity is progressing as required. In many cases, these reviews are conducted by the program in coordination with a Center-sponsored independent review panel if the Center is using these reviews as one means to oversee the program's work. In these cases, the program manager works with the Center to ensure that there is a suitable independent review panel in place for each such review and works with systems engineering to ensure that clear technical criteria and an agreed agenda have been established well in advance of each such review.

- System engineering collects and reviews the documentation that demonstrates the technical progress planned for the major systems review and submits the materials as a data package to the review team prior to the review. This allows adequate review by the selected technical representatives to identify problems and issues that can be discussed at the review. Systems engineering is responsible for the agenda, organization, and conduct of the systems review as well as for obtaining closure on any action items and corrective actions. Systems engineering acts as recorder, noting all comments and questions that are not adequately addressed during the presentations. At the conclusion of a major systems review, the independent review panel, if in place, makes a determination as to whether the predetermined criteria for a successful review have been met and makes a recommendation on whether the system is ready to proceed into the next phase of its development.
- An EPR can address an entire system or subsystem, but more typically addresses a lower-level assembly or component. An EPR is a focused, in-depth technical review of a subsystem, lower-level assembly, or component, which adds value and reduces risk through expert knowledge infusion, confirmation of approach, and specific recommendations. The mission systems engineer works with the respective product manager (program manager, program formulation manager, instrument manager, or Principal Investigator (PI)) to ensure that the EPR review panel is comprised of technical experts with significant practical experience relevant to the technology and requirements of the subsystem, lower-level assembly, or component to be reviewed. The key distinction between an EPR and a major subsystem review is that the review panel is selected by personnel supporting the program and not by the Center. An EPR plan is produced that lists the subsystems, lower-level assemblies, and components to be reviewed, and the associated life-cycle milestones for the reviews. A summary of results of the EPRs is presented at each major subsystem review and/or at each life-cycle review.
- Additional program technical reviews sometimes called "internal reviews" or "tabletop reviews" are conducted by program team members as necessary and are one of their primary mechanisms for internal technical program control. These reviews follow the general protocols described above for subsystem reviews and EPRs.

3.3.5.2.3 Preparing for Approval for Program Transition

Programs support the program Formulation LCRs (SRR, SDR/MDR, and PDR) in accordance with NPR 7123.1, Center practices, and NPR 7120.5, including the LCR objectives and expected maturity states defined in Appendix E of this handbook and in NPR 7120.5F Appendix I. LCR entrance and success criteria in NPR 7123.1 and the life-cycle phase and KDP information in the maturity states tables in Appendix E of this handbook provide specifics for addressing the six criteria required to demonstrate the program has met the expected maturity state. MCRs are generally conducted by the Center, but the Decision Authority may request an SRB to perform this review. If this is the case, Section 5.10 and *NASA/SP-2016-3706, NASA Standing Review Board Handbook* provide guidance.

Program teams plan, prepare for, and support the governing PMC review prior to KDP 0 (KDP B for single-project programs) if required by the Decision Authority and prior to KDP I (KDP C for single-project programs). They provide or obtain the KDP readiness products listed in Section 3.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the program team updates its documents as required and plans to reflect the decisions made and actions assigned at the KDP.

3.4 Program Implementation

Program Implementation begins when the program receives approval to proceed to Implementation with the successful completion of KDP I (KDP C for single-project programs) and a fully executed Decision Memorandum. Implementation encompasses program acquisition, operations, and sustainment. If constituent projects have not already been initiated, or if new projects are identified, projects may be initiated during program Implementation. Constituent projects' formulation, approval, implementation, integration, operation, and ultimate decommissioning are constantly monitored. The program is adjusted to respond as needs, risks, opportunities, constraints, resources, and requirements change, managing technical and programmatic margins and resources to ensure successful completion of Implementation. The program develops products required during Implementation in accordance with the applicable program Product Maturity tables (Tables 3-2, 3-3, 3-4, 3-5, 3-6) at the end of this chapter.

Single-project programs have the characteristics of very large projects and are run with requirements similar to the project requirements in NPR 7120.5.

Tightly coupled programs oversee the implementation and integration of the projects in the program. For projects that are part of tightly coupled programs, project LCRs and KDPs should be planned in accordance with the project life cycle and KDP sequencing guidelines in the Program Plan to ensure that the program and all its projects are properly integrated, including proper interface definition and resource allocation across all internal projects and with external programs and organizations. Tightly coupled programs have many of the characteristics of single-project-programs and develop the technical products required for single-project programs (see Table 3-5) in NPR 7120.5, in some cases in conjunction with, or by the constituent projects.[33]

Uncoupled and loosely coupled programs oversee the implementation of the projects in the program, helping with funding, assisting the MDAA in such activities as selecting projects, performing systems engineering between projects, and potentially developing and ensuring technology insertion at appropriate points of the program.

As the program evolves and matures, the program manager ensures that the Program Plan and the attendant program resources remain aligned. Program LCRs for uncoupled or loosely coupled programs ensure that the program continues to contribute to Agency and Mission Directorate goals and objectives within funding constraints. Program LCRs for tightly coupled programs ensure that the program's projects are properly integrated as development and operations activities are implemented. In some cases, programs may recycle through Formulation when program changes are sufficient to warrant such action.

The general flow of activities for the various program types in Implementation are shown in Figures 3-11, 3-12, and 3-13.

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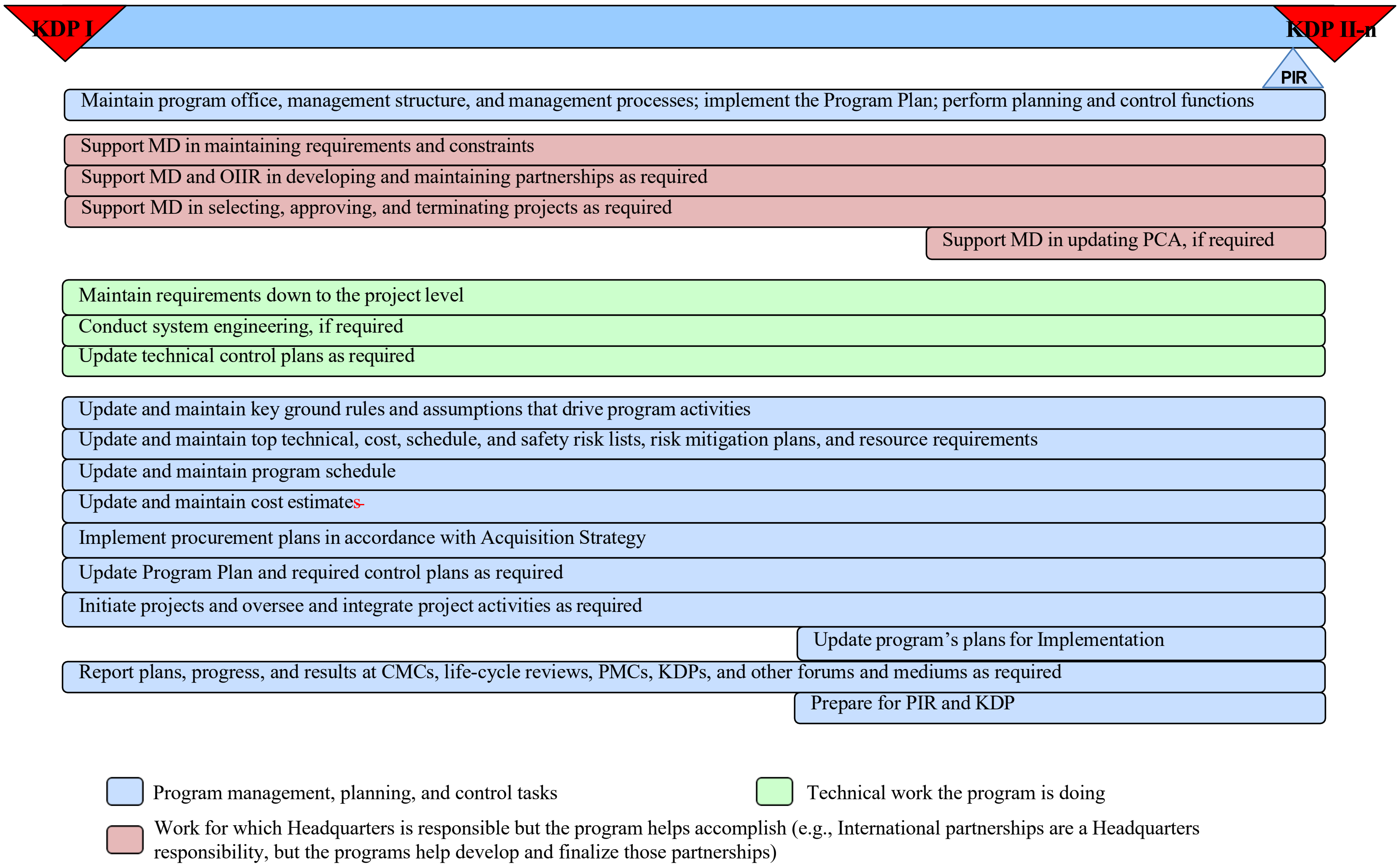
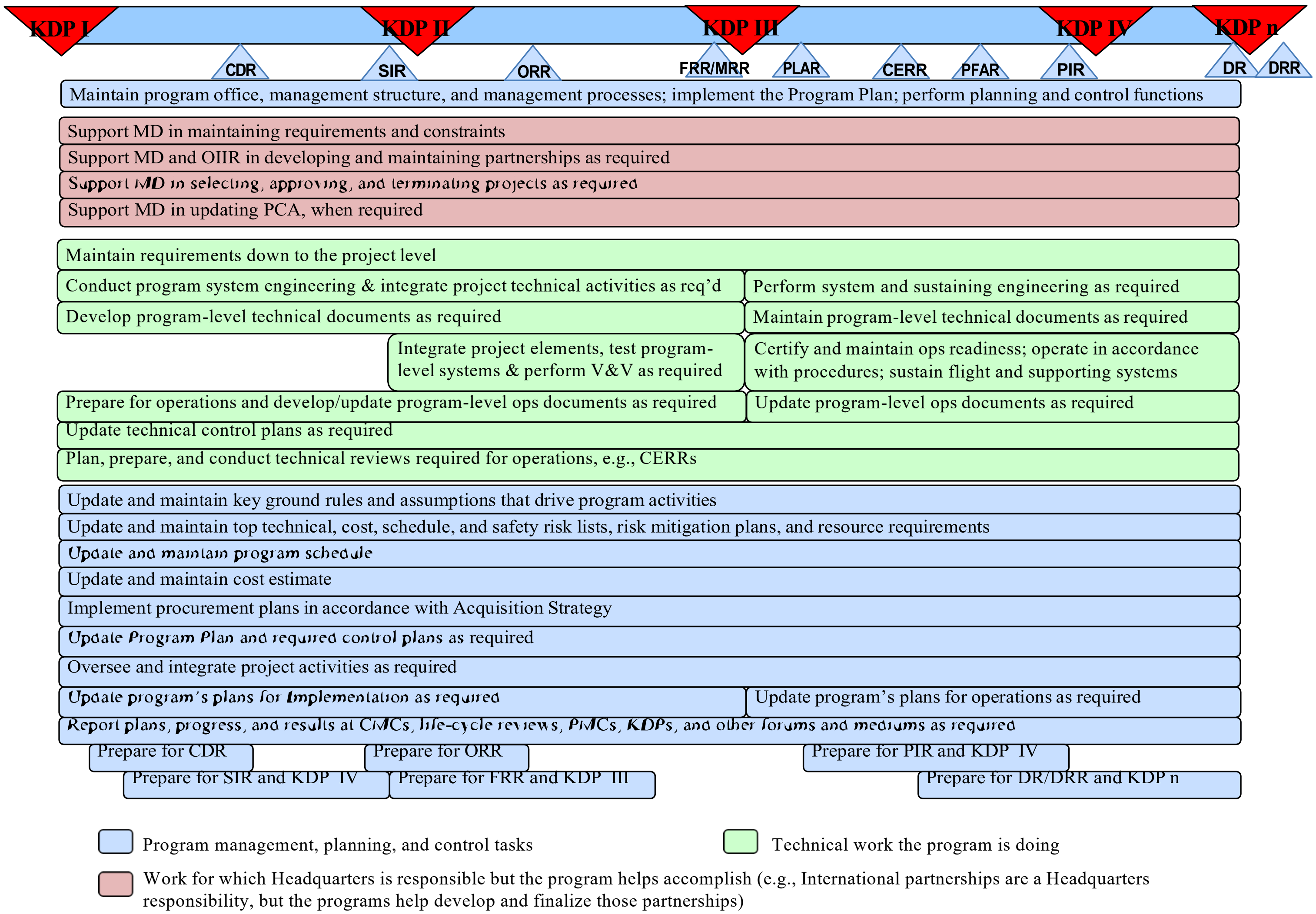
[33] See Appendix H in this handbook for a list of technical products that the tightly coupled program develops and a list of technical products that may be developed by constituent projects or the tightly coupled program, as determined by the program.



MD = Mission Directorate
OIIR = Office of International and Interagency Relations

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 3-11 Uncoupled and Loosely Coupled Program Implementation Flow of Activities



MD = Mission Directorate
OIIR = Office of International and Interagency Relations

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 3-12 Tightly Coupled Program Implementation Flow of Activities

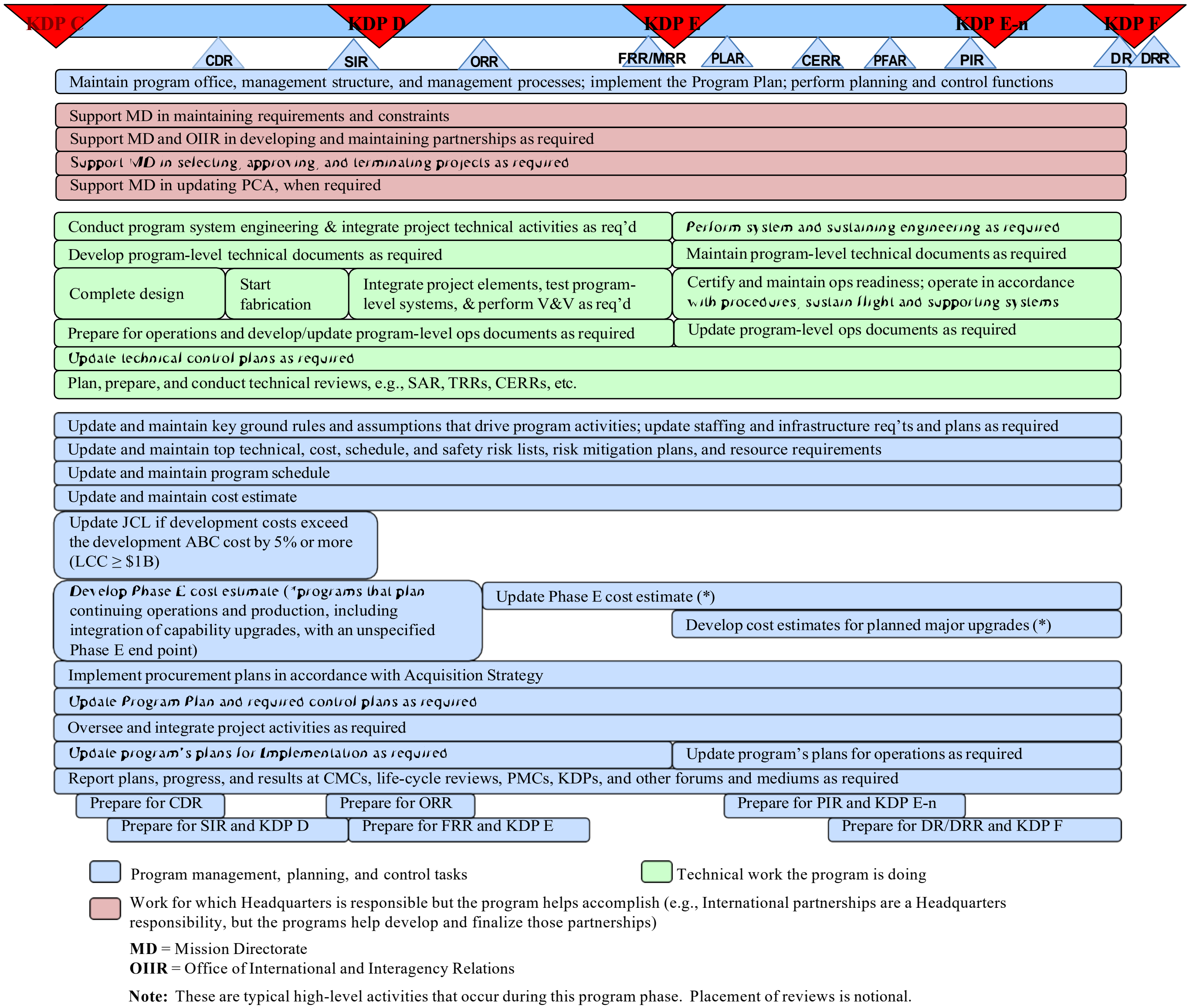


Figure 3-13 Single-Project Program Implementation Flow of Activities

Once in Implementation, the program manager works with the program team, the program's constituent projects, and with the MDAA to execute the Program Plan. As the program conducts its activities, it continues to support the MDAA in ensuring continuing alignment of the program and projects with applicable Agency strategic goals, and Mission Directorate requirements and constraints. When changes occur to the program requirements or resource levels, the program manager works with the MDAA to update the **Program Commitment Agreement** (PCA) and **Program Plan**, as appropriate.

All program teams also continue to support the MDAA and the Office of International and Interagency Relations (OIIR) in obtaining updated **interagency and international agreements** (including the planning and negotiation of updated agreements and recommendations on joint participation in reviews, integration and test, and risk management), as appropriate.

All programs continue management, planning, and control activities. They ensure appropriate infrastructure and in coordination with the Centers engaged in the program, ensure trained and/or certified staff that cut across multiple projects within the program are available and ready when needed to support Implementation activities.

The program updates life-cycle cost or initial capability cost and schedule baselines, as needed, for any changes in the program during Implementation. It documents the **BoE** for the cost and schedule baselines, as needed. It reviews and approves annual project budget submissions and prepares annual program budget submissions. Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point develop the Phase E cost estimate for continuing operations and production at ORR and KDP E for the 5 years after initial capability. The Phase E cost estimate is subsequently updated and documented annually for the next 5-year period. (See Section 5.5.4 for information on the Phase E cost estimate.)

The program confirms key ground rules and assumptions that drive development of the program and projects. Once the program has defined the ground rules and assumptions, it tracks them to determine if they are being realized (i.e., remain valid) or if they need to be modified. The program continues to track, manage, and mitigate risks.

The program executes procurement activities in accordance with the **Acquisition Strategy**. In doing so, it maintains programmatic oversight of industrial base and supply chain issues that might pose a risk to the program or projects and provides timely notification of supply chain disruptions to the MDAA. It establishes procedures to identify and manage industrial base and supply chain risks, including all critical and single-source partners.

Single-project programs (and other programs at the discretion of the MDAA) with EVM requirements update the PMB and conduct IBRs when there are major changes that significantly impact the cost and schedule baseline, including the PMB, and conduct any required IBRs for contracts requiring EVM. (Refer to NFS Subpart 1834.2, Earned Value

Management System.) These programs also report EVM metrics to the Mission Directorate as defined in the Program Plan. Section 5.14 provides additional details on the PMB and the IBR.

The program team conducts planning and program-level systems engineering and integration, as appropriate, to support the MDAA when initiating the project selection process, either through direct assignment or through a competitive process such as a Request for Proposal (RFP) or an Announcement of Opportunity (AO). Once projects are selected, the program and the MDAA approve the project **FADs**, project **Formulation Agreements**, and **Project Plans**. The program maintains programmatic and technical oversight of the projects and reports their status periodically. When required, the program assists projects in the resolution of project issues. The program conducts program-level completion activities for each project in accordance with the project life cycle for Phase F. (See Sections 4.3.14 and 4.3.15.)

The program may continue to develop technologies that cut across multiple projects within the program. These technologies are generally pursued to enable the program's projects to achieve increased results and performance, lower costs and development times, or increased reliability.

3.4.1 Implementation Activities Unique to Tightly Coupled and Single-Project Programs by Phase

Whereas programs only have two formal phases, Formulation and Implementation, the project life cycle is also broken down into subphases. For single-project programs and tightly coupled programs, the activities of the two formal program phases also break down into roughly the equivalent of the project subphases. For uncoupled and loosely coupled programs, these activities are carried out at the project level.

3.4.1.1 Final Design and Fabrication

The purpose of this phase for tightly coupled and single-project programs is to complete and document the final design that meets the detailed requirements and synchronize with the program's project(s) as the program team implements the program in accordance with the Program Plan. During Final Design and Fabrication, the program, in conjunction with its project(s):

- Ensures that the systems engineering activities are performed to determine if the design is mature enough to proceed with full-scale implementation within the constraints of the Management Agreement and the ABC.
- Performs qualification testing.
- Develops product specifications and begins fabrication of test and flight architecture (e.g., flight article components, assemblies, subsystems, and associated software).

- Develops integration plans and procedures and ensures that all integration facilities and personnel are ready and available.

Final Design and Fabrication is a long phase, and these activities will overlap during the phase.

For programs that develop or acquire multiple copies of a product or system(s), the program ensures that the system developers include a production process for multiple copies. When this occurs, the program holds a Production Readiness Review (PRR). The **objectives** of the PRR are to evaluate the readiness of system developer(s) to produce the required number of systems within defined program constraints for programs developing multiple similar flight or ground support systems and to evaluate the degree to which the production plans meet the system's operational support requirements. (See Table G-8 in Appendix G of NPR 7123.1 for entrance and success criteria of the PRR.)

Final Design and Fabrication activities are focused toward the Critical Design Review (CDR) and the System Integration Review (SIR), the life-cycle review preceding KDP II/KDP D.

The **objectives** of the Critical Design Review (CDR) are to evaluate (1) the integrity of the program integrated design, including its projects and supporting infrastructure; (2) the program's ability to meet mission requirements with appropriate margins and acceptable risk within cost and schedule constraints; and (3) whether the integrated design is appropriately mature to continue with the Final Design and Fabrication phase.

The **objective** of the System Integration Review (SIR) is to evaluate the readiness of the program, including its projects and supporting infrastructure, to begin the system Assembly, Integration, and Test (AI&T) part of Implementation with acceptable risk and within cost and schedule constraints.

At KDP II (KDP D for single-project programs), the program demonstrates that it is still on plan; the risk is commensurate with the projects' payload classifications (or Mission Directorate's risk definition if not a payload in accordance with *NPR 8705.4, Risk Classification for NASA Payloads*); and the program is ready for AI&T with acceptable risk within its ABC (single-project programs) or within Agency cost and schedule baselines (tightly coupled programs).

The program team continues to perform the technical activities required in NPR 7123.1 for this phase. It completes the engineering design and development activities (e.g., qualification and life tests) and incorporates the results into the final design. It completes and documents final flight and ground designs by CDR and updates them, as necessary, at SIR. It begins to implement the defined validation and verification program on flight and/or ground products. Single-project programs update the **technology readiness assessments** by CDR if any technology development activities were performed after PDR. Finally, it develops system integration plans and procedures.

The program documents and uses lessons learned in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy* and *NPD 7120.6, Knowledge Policy for Programs and Projects* and the program's Knowledge Management Plan. (This plan is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.)

Tightly coupled and single-project programs develop a preliminary **Mission Operations Plan** by SIR and baseline the plan by ORR and develop the **Operations Handbook** by SIR and baseline the handbook by ORR. Uncoupled and loosely coupled programs do not have these plans since they are only necessary for their projects. This plan is required at this point in development to document the activities required to transition to operations and operate the mission. It describes the activities required to perform the mission and how the program will implement the associated facilities, hardware, software, and procedures required to complete the mission. It describes mission operations plans, rules, and constraints and describes the Mission Operations System (MOS) and Ground Data System (GDS) in the following terms:

- MOS and GDS human resources and training requirements.
- Procedures to ensure that operations are conducted in a reliable, consistent, and controlled manner using lessons learned during the program and from previous programs.
- Facilities requirements (offices, conference rooms, operations areas, simulators, and test beds).
- Hardware (ground-based communications and computing hardware and associated documentation).
- Software (ground-based software and associated documentation).

Operations Handbook

The Operations Handbook provides information essential to the operation of the spacecraft. It generally includes the following:

1. A description of the spacecraft and the operational support infrastructure;
2. Operational procedures, including step-by-step operational procedures for activation and deactivation;
3. Malfunction detection procedures; and
4. Emergency procedures.

The handbook identifies the commands for the spacecraft, defines the functions of these commands, and provides supplemental reference material for use by the operations personnel. The main emphasis is placed on command types, command definitions, command sequences, and operational constraints. Additional document sections may describe uploadable operating parameters, the telemetry stream data contents (for both the science and the engineering data), the Mission Operations System displays, and the spacecraft health monitors.

Single-project programs baseline **Design Documentation** at CDR and update Design Documentation at SIR. They also develop the detailed design **Orbital Debris Assessment Report** (ODAR) by CDR in accordance with *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* using the format and requirements contained in *NASA-STD-8719.14, Process for Limiting Orbital Debris*. Tightly coupled programs and single-project programs baseline the **Systems Safety Analyses** and update the **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status** by CDR. Single-project programs also update the **Criticality Identification Method for Hardware**, and the Hardware Quality Data Management Analytics in preparation for CDR. The Hardware Quality Data Management Analytics is also updated in preparation for SIR, ORR, and MRR/FRR. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.)

Tightly coupled programs and single-project programs update the following control plans at CDR: **Safety and Mission Assurance (SMA) Plan**, **Verification and Validation Plan**, **NEPA Compliance Documentation**, **Integrated Logistics Support (ILS) Plan**, **Technology Transfer Control Plan**, **Orbital Collision Avoidance Plan** (OCAP), **Quality Assurance Surveillance Plan**, and Communications Plan. Programs also update the **Human-Rating Certification Package** and the **Human Systems Integration (HSI) Plan**, if applicable. It is expected that these plans will be updated at this point, but other plans need to be updated as necessary. Single-project programs also update the **Integration Plan**, Knowledge Management Plan, and the preliminary **Range Safety Risk Management Process Documentation**. (The Communications Plan and Knowledge Management Plan are best practices as opposed to requirements. See Section 3.5.1 for additional information on expectations associated with best practices.)

The program updates the following control plans at SIR: **Verification and Validation Plan**, **Quality Assurance Surveillance Plan**, and **System Security Plan**. Single-project programs update the **Mishap Preparedness and Contingency Plan** and baseline the **Range Safety Risk Management Process Documentation** at SIR.

Tightly coupled and single-project programs update the **Systems Safety Analyses** by SIR.

3.4.1.2 System Assembly, Integration and Test, Launch and Checkout

Program Implementation continues with System Assembly, Integration and Test, Launch and Checkout as the program team implements the program in accordance with the Program Plan. During this part of Implementation, the program with its constituent projects(s):

- Performs system AI&T.
- Completes validation testing, finalizes operations preparations, and completes operational training.
- Resolves failures, anomalies, and issues.
- Conducts various internal reviews such as Test Readiness Reviews (TRRs), the System Acceptance Review (SAR), and pre-ship reviews.
- Certifies the system for launch.
- Launches the system.
- Completes on-orbit system checkout (robotic space flight programs) or initial operations (human space flight programs).

The transition from this subphase to the next, Operations and Sustainment, differs from other transitions in that the transition does not occur immediately after the KDP. KDP III (KDP E for single-project programs) marks the decision to launch and conduct early operations. However, the transition to operations occurs after on-orbit checkout (robotic space flight programs) or initial operations (human space flight programs) at the conclusion of the Post-Launch Assessment Review (PLAR) or, for certain human space flight programs, the Post-Flight Assessment Review (PFAR).

The decision to launch and conduct early operations is a critical decision for the Agency. The KDP III (KDP E for projects and single-project programs) decision occurs before launch to provide Decision Authority approval for this decision. The KDP III/KDP E decision includes approval for the transition to the operations phase of the life cycle; however, unlike other life-cycle phase transitions, the transition to operations does not occur immediately after the KDP III/KDP E. This transition occurs after launch and checkout. The timing for this transition stems from the historical practice of funding missions through on-orbit checkout, transitioning from the development team to the operations team following on-orbit checkout, and funding mission operations separately.

The flow of activities in preparation for launch is very formal and involves important reviews by the Agency's stakeholders. Section 4.3.11 provides a detailed description of the flow of the review process in preparation for launch for human and robotic space flight programs and projects. This process is the same for both single-project programs and tightly coupled programs.

The phase activities focus on preparing for the Operational Readiness Review (ORR), Flight Readiness Review (FRR) (for human space flight programs) or the Mission Readiness Review (MRR) (for robotic space flight programs), KDP III (KDP E for single-project programs), launch, the Post-Launch Assessment Review (PLAR), and for certain human space flight programs the Post-Flight Assessment Review (PFAR).

- The **objectives** of the Operational Readiness Review (ORR) are to evaluate the readiness of the program (including its projects, ground systems, personnel, procedures, and user documentation) to operate the flight system and associated ground systems in compliance with program requirements and constraints during the operations phase.
- The **objectives** of the Flight Readiness Review (FRR)/Mission Readiness Review (MRR) are to evaluate the readiness of the program and its projects, ground systems, personnel, and procedures for a safe and successful launch and flight/mission.
- At KDP III (KDP E for single-project programs), the program is expected to demonstrate that it is ready for launch and early operations with acceptable risk within its ABC (single-project programs) or within Agency cost and schedule baselines (tightly coupled programs).
- The Post-Launch Assessment Review (PLAR) is a not affiliated with a KDP. It is conducted after the mission has launched and on-orbit checkout has been completed. The **objectives** of the PLAR are to evaluate the in-flight performance of the program and its projects and to determine the program's readiness to begin the operations phase of the life cycle and transfer responsibility to the operations organization. At the PLAR, the program is expected to demonstrate that it is ready to conduct mission operations with acceptable risk within its ABC (single-project programs) or within Agency cost and schedule baselines (tightly coupled programs).
- For human space flight programs that develop flight systems that return to Earth, the PLAR may be combined with the Post-Flight Assessment Review (PFAR), which is conducted after landing and recovery. See Section 4.3.10 for a detailed discussion of this topic.

Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point develop the Phase E cost estimate for continuing operations and production at ORR and KDP E for the 5 years after initial capability. The Phase E cost estimate is subsequently updated and documented annually for the next 5-year period. (See Section 5.5.4 for information on the Phase E cost estimate.)

The program continues to perform the technical activities required in NPR 7123.1. As the various project assemblies arrive at the integration facility, the program team begins to assemble, integrate, and test the various system pieces and complete verification and validation on the products as they are integrated. Single-project programs update the **Design Documentation** by FRR/MRR. Tightly coupled and single-project programs prepare the preliminary **Verification and Validation Report** before the ORR and then baseline the report by FRR/MRR. Once the hardware is shipped to the launch site, the program with its constituent projects and with launch site support begins the process of receiving and inspecting the hardware, reassembling the spacecraft as required, integrating spacecraft and vehicles produced by constituent projects (tightly coupled programs), completing final spacecraft testing, completing integrated spacecraft/vehicle testing (tightly coupled programs), and resolving any open issues that remain. The program transitions or delivers the final products and baselines the as-built hardware and software documentation. It supports launch rehearsals, participates in press conferences, and supports the launch approval process. Tightly coupled and single-project programs prepare for operations and update the **Operations Concept Documentation** and the **Mission Operations Plan**.

The Operations Concept Documentation is a description of how the flight system and the ground system are used together to ensure that the mission operations can be accomplished reasonably. This might include how mission data of interest, such as engineering or scientific data, are captured, returned to Earth, processed, made available to users, and archived for future reference. The Operations Concept Documentation typically describes how the flight system and ground system work together across mission phases for launch, cruise, critical activities, science observations, and the end of the mission to achieve the mission. The Operations Concept Documentation is baselined at PDR with the initial preliminary Operations Concept Documentation required at MCR.

The program team baselines the **Mission Operations Plan** and Science Data Management Plan at ORR and updates the following control plans at ORR if necessary: **System Security Plan**, **Human-Rating Certification Package**, if applicable, and Communications Plan. (The Science Data Management Plan and the Communications Plan are best practices as opposed to requirements. See Section 3.5.1 for additional information on expectations associated with best practices.) Programs also update the **Systems Safety Analyses**.

Single-project programs develop the final **Orbital Debris Assessment Report** (ODAR) in accordance with *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* using the format and requirements contained in *NASA-STD-8719.14, Process for Limiting Orbital Debris* prior to the Safety and Mission Success Review (SMSR).

Single-project programs support the Mission Directorate in baselining the **Mishap Preparedness and Contingency Plan** and delivering the document to OSMA 30 days prior to the SMSR per *NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping*.

Tightly coupled and single-project programs baseline the **End of Mission Plans** (EOMPs) by the SMSR in accordance with NPR 8715.6. (See NASA-STD-8719.14, Appendix B for additional information on these plans.) These programs also update the **Systems Safety Analyses** and **Operations Handbook** at FRR/MRR, obtain certification of the **Human-Rating Certification Package** at FRR/MRR if applicable, and update the following control plans at FRR/MRR if necessary: **Safety and Mission Assurance (SMA) Plan** (by the SMSR) and Science Data Management Plan. (See Section 4.3.11 for a detailed description of the review process in preparation for launch.)

The Safety and Mission Success Review (SMSR) is held to prepare Agency safety, engineering, and health and medical management to participate in program final readiness reviews preceding flights or launches, including experimental and test launch vehicles or other reviews as determined by the Chief, Safety and Mission Assurance. The SMSR provides the knowledge, visibility, and understanding necessary for senior safety, engineering, and health and medical management to either concur or nonconcur in program decisions to proceed with a launch or significant flight activity.

3.4.1.3 Operations and Sustainment

During Operations and Sustainment, the program implements the Missions Operations Plan. For human space flight programs, this phase begins after initial operations have been successfully completed and all flight test objectives have been met. For robotic space flight programs, the phase begins following a successful launch and on-orbit checkout. (See Section 4.3.11 for robotic and human space flight programs.)

Mission operations may be periodically punctuated with Critical Event Readiness Reviews (CERRs). Human space flight missions may conduct Post-Flight Assessment Reviews (PFARs) specific to their needs. These reviews are not affiliated with a KDP.

- The **objective** of the Critical Event Readiness Review (CERR) is to evaluate the readiness of the program and its projects to execute a critical event during the flight operations phase of the life cycle. CERRs are established at the discretion of the program office.
- The **objectives** of the Post-Flight Assessment Review (PFAR) are to evaluate how well mission objectives were met during a human space flight mission and what the status of the flight and ground systems are, including the identification of any anomalies and their resolution.

The program periodically has Program Implementation Reviews (PIRs) followed by a KDP as determined by the NASA AA or MDAA. The **objectives** of the PIR are to evaluate the program's continuing relevance to the Agency's Strategic Plan, assess performance with respect to expectations, and determine the program's ability to execute its Program Plan with acceptable risk within cost and schedule constraints. The program is expected to demonstrate that it still meets Agency needs and is continuing to meet Agency commitments as planned. (See Sections 3.1.1 and 5.11.3 in this handbook for guidance on PIRs.)

Single-project programs that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, update and document the Phase E cost estimate annually for the next 5-year period. Upgrades during Phase E that meet the Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purposes of establishing their own development ABC outside the Phase E cost estimate. The program Phase E cost estimate is updated to include the production and operations costs associated with these upgrades. Development, production, and operations costs of other (i.e., non-major) upgrades are included in the program Phase E cost estimate. (See Section 5.5.4 for information on the Phase E cost estimate.)

The Operations and Sustainment subphase ends with the Decommissioning Review (DR) and KDP *n* (tightly coupled programs) or KDP F (single-project programs), at which time the end of the program is approved. After KDP F, single-project programs are also required to conduct the project-level Disposal Readiness Review (DRR). (See Section 3.4.1.4.) The DR and DRR may be combined if the disposal of the spacecraft will be done immediately after the DR.

- The **objective** of the Decommissioning Review (DR) is to evaluate the readiness of the program and its projects to conduct closeout activities, including final delivery of all remaining program or project deliverables and safe decommissioning and/or disposal of space flight systems and other program or project assets.
- The **objective** of the Disposal Readiness Review (DRR) is to evaluate the readiness of the project and the flight system for execution of the spacecraft disposal event.

Sustainment and Sustaining Engineering

Sustainment generally refers to supply, maintenance, transportation, sustaining engineering, data management, configuration management, manpower, personnel, training, habitability, survivability, environment, safety, supportability, and interoperability functions.

The term "sustaining engineering" refers to technical activities that can include, for example, updating designs (e.g., geometric configuration), introducing new materials, and revising product, process, and test specifications. These activities typically involve first reengineering items to solve known problems and then qualifying the items and sources of supply. The problems that most often require sustaining engineering are lack of a source (e.g., vendor going out of business), component that keeps failing at a high rate, and long production lead time for replacing items.

As parts age, the need and opportunity for sustaining engineering increase. The practice of sustaining engineering includes not only the technical activity of updating designs but also the business judgment of determining how often and on what basis the designs need to be reviewed.

Tightly coupled and single-project programs and their projects eventually cease as a natural evolution of completing their mission objectives. When this occurs, the Mission Directorate, program, and project(s) need to be sure that all the products or systems produced by the program (e.g., spacecraft, ground systems, test beds, spares, science data, operational data, returned samples) are properly dispositioned and that all program and project activities (e.g., contracts, financial obligations) are properly closed out.

Tightly coupled and single-project programs update the **Operations Handbook** and **End of Mission Plans** (EOMPs).

Single-project programs develop and baseline a **Decommissioning/Disposal Plan** (which includes the project Decommissioning/Disposal Plans) in preparation for the Decommissioning Review to cover all activities necessary to close out the program and its projects. Single-project programs also work with the Mission Directorate to update the **Mishap Preparedness and Contingency Plan** if necessary. The Decommissioning/Disposal Plan includes the updated Mishap Preparedness and Contingency Plan and predefined contingency and/or mishap scenarios. The single-project program conducts a Decommissioning Review in preparation for final approval to decommission by the Decision Authority at the final program KDP. (This process is the same for both programs and projects and is described in Section 4.3.14, which provides an overview of the disposal of a spacecraft, the various documents that are produced as part of this, and the order and timing of major activities and document deliveries.)

At KDP *n*/KDP F following the Decommissioning Review, the program is expected to demonstrate that decommissioning is consistent with program objectives and that the program is ready for final analysis and archival of mission and science data and safe disposal of its assets.

3.4.1.4 Closeout

During Closeout, the program and its projects perform the technical activities required in NPR 7123.1. They perform spacecraft and other in-space asset disposal and closeout and disposition of ground systems, test beds, and spares. They monitor decommissioning and disposal risks, actively assess open risks, and develop and implement mitigation plans.

They complete archiving of mission/operational and science data and document the results of all activities. They complete storage and cataloging of returned samples and archive project engineering and technical management data. They close out contracts, as appropriate. They develop mission reports and document lessons learned in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy* and *NPD 7120.6, Knowledge Policy for Programs and Projects* and the program's Knowledge Management Plan**.** (This plan is a best practice as opposed to a requirement. See Section 3.5.1 for additional information on expectations associated with best practices.)

Tightly coupled and single-project programs update their **End of Mission Plans** (EOMPs). After KDP F, single-project programs are also required to conduct the project-level Disposal Readiness Reviews (DRRs) and update the disposal portions of the **Decommissioning/ Disposal Plan** in preparation for the DRR. If the program's DRR was not performed as part of the Decommissioning Review (DR), the program updates its **Mishap Preparedness and Contingency Plan.** The **objective** of the Disposal Readiness Review (DRR) is to evaluate the readiness of the project and the flight system for execution of the spacecraft disposal event. Tightly coupled and single-project programs prepare a Final Mission Report. This report is described in the appropriate paragraph in Chapter 4. (The Final Mission Report is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

3.4.2 Preparing for Program Decommissioning and Closing Out

Program teams plan, prepare for, and support the governing PMC review prior to the Decommissioning KDP *n*/KDP F and provide or obtain the KDP readiness products listed in Section 3.2.3. Once the Implementation KDPs have been completed and the Decision Memoranda signed, the program updates its documents and plans as needed to reflect the decisions made and actions assigned.

3.5 Program Products by Phase

3.5.1 Product Owner and Requirement or Best Practice

- The Product Owner for each product is indicated in Tables 3-2, 3-3, 3-4, 3-5, and 3-6 in the column titled "Product Owner/Requirement or Best Practice."
- Products listed in Tables 3-2, 3-3, 3-4, 3-5, and 3-6 are either requirements or best practices.

- "R" in the Product Owner/Requirement or Best Practice column indicates that a product is a requirement. Products that are requirements are included in the Compliance Matrix in Appendix C of NPR 7120.5.
- "BP" in the Product Owner/Requirement or Best Practice column indicates that the product is considered a best practice. The expectation is that the product will be developed in accordance with the table as part of normal project management activities.

3.5.2 Non-Configuration-Controlled Documents

For non-configuration-controlled documents, the following terms and definitions are used in Tables 3-2 through 3-6:

- "Initial" is applied to products that are continuously developed and updated as the program or project matures.
- "Final" is applied to products that are expected to exist in this final form, e.g., minutes and final reports.
- "Summary" is applied to products that synthesize the results of work accomplished.
- "Plan" is applied to products that capture work to be performed in the following phases.
- "Update" is applied to products that are expected to evolve as the formulation and implementation processes evolve. Only expected updates are indicated. However, any document may be updated as needed.

3.5.3 Configuration-Controlled Documents

For configuration-controlled documents, the following terms and definitions are used in Tables 3-2 through 3-6:

- "Preliminary" is the documentation of information as it stabilizes but before it goes under configuration control. It is the initial development leading to a baseline. Some products will remain in a preliminary state for multiple life-cycle reviews. The initial preliminary version is likely to be updated at subsequent life-cycle reviews but remains preliminary until baselined.
- "Baseline" indicates putting the product under configuration control so that changes can be tracked, approved, and communicated to the team and any relevant stakeholders. The expectation on products labeled "baseline" is that they will be at least final drafts going into the designated life-cycle review and baselined coming out of the life-cycle review. Baselining of products that will eventually become part of the Program or Project Plan indicates that the product has the concurrence of stakeholders and is under configuration control. Updates to baselined documents require the same formal approval process as the original baseline.

- "Approve" is used for a product, such as Concept Documentation, that is not expected to be put under classic configuration control but still requires that changes from the "Approved" version are documented at each subsequent "Update."
- "Update" is applied to products that are expected to evolve as the formulation and implementation processes evolve. Only expected updates are indicated. However, any document may be updated as needed. Updates to baselined documents require the same formal approval process as the original baseline.

3.5.4 Control Plans

- Control plans in Table 4-7 can either be part of the Project Plan or separate stand-alone documents referenced in the appropriate part of the Project Plan.
- Considerations for determining if a control plan should be a stand-alone document include a requirement that the control plan be stand-alone in the NPR that requires the control plan; differences between when the control plan is baselined and when the Project Plan is baselined; how frequently the control plan will be updated since updates to the Project Plan require signatures; and how long the control plan is.
- When the control plan is a stand-alone document, the Project Plan contains a reference to the stand-alone document.

3.5.5 Formats for Non-Control Plan Products

- Unless a specific form, format, document, or document template is identified by the NPR that requires a production Table 4-6, the documentation format is flexible, e.g., LCR or KDP presentation charts or as part of a document such as the Project Plan.

Table 3-2 Uncoupled and Loosely Coupled Program Milestone Products and Control Plans Maturity Matrix

Products	Product Owner/ Requirement or Best Practice	Formulation		Implementation
		KDP I[1]		KDP II - n
		SRR	SDR	PIR
1. FAD [Required per NPR 7120.5]	OCE/R	Baseline		
2. PCA [Required per NPR 7120.5]	OCE/R	Preliminary	Baseline	
3. Program Plan [Required per NPR 7120.5]	OCE/R	Preliminary	Baseline	Update
3.a. Mission Directorate requirements and constraints [Required per NPR 7123.1]	OCE/R	Baseline	Update	
3.b. Traceability of program-level requirements on projects to the Agency strategic goals and Mission Directorate requirements and constraints [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	
3.c. Documentation of driving ground rules and assumptions on the program [Required per NPR 7120.5}	OCE/R	Preliminary	Baseline	
4. Interagency and international agreements	OCE/R	Preliminary	Baseline	
5. ASM Decision Memorandum or ASM meeting summary [additional information in NPD 1000.5]	OCE/R		Final	
6. Risk mitigation plans and resources for significant risks [Required by NPR 7120.5]	OCE/R	Initial	Update	Update
7. Documented Cost and Schedule Baselines [Required per NPR 7120.5]	OCFO-SID/R	Preliminary	Baseline	Update
8. Documentation of Basis of Estimate (cost and schedule) [Required per NPR 7120.5]	OCFO-SID/R	Preliminary	Baseline	Update
9. Documentation of performance against plan/baseline, including status/closure of formal actions from previous KDP [Required by NPR 7120.5]	OCE/R	Summary	Summary	Summary
10. Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status [Required per NPR 8735.2]	OSMA/R	Preliminary	Baseline	Update
Program Plan Control Plans				
1. Technical, Schedule, and Cost Control Plan [Required per NPR 7120.5]	OCE/R	Preliminary	Baseline	
2. Safety and Mission Assurance Plan [Required per NPRs 8705.2 and 8705.4]	OSMA/R	Preliminary	Baseline	
3. Risk Management Plan [Required per NPR 8000.4]	OSMA/R	Preliminary	Baseline	
4. Acquisition Strategy [Required per NPD 1000.5]	OCE/R	Preliminary	Baseline	

Products	Product Owner/ Requirement or Best Practice	Formulation		Implementation
		KDP I[1]		KDP II - n
		SRR	SDR	PIR
5. Technology Development Plan [additional information in NPR 7500.2, NPR 7123.1, and NPR 7120.5]	OCE/BP	Preliminary	Baseline	
6. Systems Engineering Management Plan [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	
7. System Security Plan [Required per NPR 2810.1]	OCIO/R	Preliminary	Baseline	Update
8. Review Plan [Required per NPR 7120.5][2]	OCE/R	Baseline	Update	
9. NEPA Compliance Documentation [Required per NPR 8580.1]	OSI-EMD/ R		Baseline	
10. Configuration Management Plan [Required per NPR 7120.5; additional information in NPR 7123.1 and SAE/EIA 649]	OCE/R		Baseline	
11. Security Plan [Required per NPR 1040.1 and NPR 1600.1]	OPS/R		Baseline	
12. Technology Transfer (formerly Export) Control Plan [Required per NPR 2190.1]	OIIR/R		Baseline	
13. Communications Plan [additional information in NPR 7120.5]	OComm/BP	Preliminary	Baseline	
14. Knowledge Management Plan [additional information in NPD 7120.4 and NPD 7120.6]	OCE/BP	Preliminary	Baseline	
15. Quality Assurance Surveillance Plan [Required per NPR 8735.2 and NASA FAR Supplement Part 1837.604]	OSMA/R	Preliminary	Baseline	Update

[1] If desired, the Decision Authority may request a KDP 0 be performed generally following SRR.
[2] Review Plan should be baselined before the first review.

Table 3-3 Tightly Coupled Program Milestone Products Maturity Matrix

Products	Product Owner/ Requirement or Best Practice	Formulation			Implementation				
			KDP 0	KDP I		KDP II		KDP III	KDP n
		SRR	SDR	PDR	CDR	SIR	ORR	MRR/FRR	DR
1. FAD [Required per NPR 7120.5]	OCE/R	Baseline							
2. PCA [Required per NPR 7120.5]	OCE/R		Preliminary	Baseline					
3. Program Plan [Required per NPR 7120.5]	OCE/R	Preliminary	Baseline	Update	Update	Update	Update	Update	Update
3.a. Mission Directorate requirements and constraints [Required per NPR 7123.1]	OCE/R	Baseline	Update	Update					
3.b. Traceability of program-level requirements on projects to the Agency strategic goals and Mission Directorate requirements and constraints [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	Update					
3.c. Documentation of driving ground rules and assumptions on the program [Required per NPR 7120.5]	OCE/R	Preliminary	Baseline	Update	Update	Update			
4. Interagency and international agreements	OCE/R	Preliminary	Baseline	Update					
5. ASM Decision Memorandum or ASM meeting summary [additional information in NPD 1000.5]	OCE/R		Final						
6. Risk mitigation plans and resources for significant risks [Required by NPR 7120.5]	OCE/R	Initial	Update	Update	Update	Update	Update	Update	Update
7. Documented Cost and Schedule Baselines [Required per NPR 7120.5]	OCFO-SID/R	Preliminary	Preliminary	Baseline	Update	Update	Update	Update	Update
8. Documentation of Basis of Estimate (cost and schedule) [Required per NPR 7120.5]	OCFO-SID/R	Preliminary	Preliminary	Baseline	Update	Update	Update	Update	Update

Products	Product Owner/ Requirement or Best Practice	Formulation			Implementation				
			KDP 0	KDP I		KDP II		KDP III	KDP n
		SRR	SDR	PDR	CDR	SIR	ORR	MRR/FRR	DR
9. CADRe [Required by NPR 7120.5]	OCFO-SID/R	Baseline	Update	Update	Update	Update		Update[1]	Update
10. Shared Infrastructure [2], Staffing, and Scarce Material Requirements and Plans	OCE/R	Initial	Update	Update	Update				
11. Documentation of performance against plan/baseline, including status/closure of formal actions from previous KDP [Required by NPR 7120.5]	OCE/R		Summary	Summary	Summary	Summary	Summary	Summary	Summary
12. Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status [Required per NPR 8735.2]	OSMA/R	Preliminary	Baseline	Update	Update				

[1] The CADRe for MRR/FRR is considered the "Launch CADRe" to be completed after the launch.
[2] Shared infrastructure includes facilities that are required by more than one of the program's projects.

Table 3-4 Tightly Coupled Program Plan Control Plans Maturity Matrix

(See NPR 7120.5F Appendix G Template for Control Plan Details.)	Product Owner/ Requirement or Best Practice	Formulation			Implementation				
			KDP 0	KDP I		KDP II		KDP III	KDP n
		SRR	SDR	PDR	CDR	SIR	ORR	MRR/FRR	DR
1. Technical, Schedule, and Cost Control Plan [Required per NPR 7120.5]	OCE/R	Preliminary	Baseline	Update					
2. Safety and Mission Assurance Plan [Required per NPRs 8705.2 and 8705.4]	OSMA/R	Preliminary	Baseline	Update	Update			Update (SMSR)	
3. Risk Management Plan [Required per NPR 8000.4]	OSMA/R	Preliminary	Baseline	Update					
4. Acquisition Strategy [Required per NPD 1000.5]	OCE/R	Preliminary Strategy	Baseline	Update					
5. Technology Development Plan [additional information in NPR 7500.2, NPR 7123.1, and NPR 7120.5]	OCE/BP	Preliminary	Baseline	Update					
6. Systems Engineering Management Plan [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline						
7. Verification and Validation Plan [Required per NPR 7120.5, additional information in NPR 7123.1]	OCE/R		Preliminary	Baseline	Update	Update			
8. System Security Plan [Required per NPR 2810.1]	OCIO/R	Preliminary		Update	Baseline	Update	Update		
9. Review Plan [Required per NPR 7120.5][1]	OCE/R	Baseline	Update	Update					
10. Mission Operations Plan [Required per NPR 7120.5]	OCE/R					Preliminary	Baseline	Update	
11. NEPA Compliance Documentation [Required per NPR 8580.1]	OSI-EMD/ R		Preliminary	Baseline	Update				
12. Integrated Logistics Support Plan [Required per NPD 7500.1]	OSI-LMD/R		Preliminary	Baseline	Update				

(See NPR 7120.5F Appendix G Template for Control Plan Details.)	Product Owner/ Requirement or Best Practice	Formulation			Implementation				
			KDP 0	KDP I		KDP II		KDP III	KDP n
		SRR	SDR	PDR	CDR	SIR	ORR	MRR/FRR	DR
13. Science Data Management Plan [additional information in NPD 2200.1 and NPRs 2200.2, 1441.1, and 8715.24]	SMD/BP			Preliminary			Baseline	Update	
14. Configuration Management Plan [Required per NPR 7120.5; additional information in NPR 7123.1 and SAE/EIA 649]	OCE/R	Preliminary	Baseline	Update					
15. Security Plan [Required per NPR 1040.1 and NPR 1600.1]	OPS/R		Preliminary	Baseline					
16. Technology Transfer (formerly Export) Control Plan [Required per NPR 2190.1]	OIIR/R		Preliminary	Baseline	Update				
17. Communications Plan [additional information in NPR 7120.5]	OComm/BP	Preliminary		Baseline	Update		Update		
18. Knowledge Management Plan [additional information in NPD 7120.4 and NPD 7120.6]	OCE/BP	Preliminary	Baseline	Update	Update				
19. Human-Rating Certification Package [Required per NPR 8705.2]	OSMA/R	Initial	Update	Update	Update		Update	Approve Certification	
20. Quality Assurance Surveillance Plan [Required per NPR 8735.2 and NASA FAR Supplement Part 1837.604]	OSMA/R	Preliminary	Baseline	Update	Update	Update			
21. Orbital Collision Avoidance Plan [Required per NID 7120.132]	OCE/R			Baseline	Update				

(See NPR 7120.5F Appendix G Template for Control Plan Details.)	Product Owner/ Requirement or Best Practice	Formulation			Implementation				
			KDP 0	KDP I		KDP II		KDP III	KDP n
		SRR	SDR	PDR	CDR	SIR	ORR	MRR/FRR	DR
22. Human Systems Integration Plan [additional information in NASA/SP-20210010952 NASA HSI Handbook and NPR 7123.1]	OCE-OSMA-OCHMO/R	Baseline	Update	Update	Update				

[1] Review Plan should be baselined before the first review.

Table 3-5 Single-Project Program Milestone Products Maturity Matrix

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A	KDP B	Phase B KDP C	Phase C	KDP D	Phase D	KDP E	Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
Headquarters Products[1]											
1. FAD [Required per NPR 7120.5]	OCE/R	Baseline									
2. PCA [Required per NPR 7120.5]	OCE/R			Preliminary	Baseline						
3. Traceability of Agency strategic goals and Mission Directorate requirements and constraints to program/project-level requirements and constraints. [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	Update	Update						
4. Documentation of driving mission, technical, and programmatic ground rules and assumptions [Required per NPR 7120.5]	OCE/R	Preliminary	Preliminary	Baseline	Update	Update	Update				
5. Partnerships and inter-agency and international agreements	OCE/R	Preliminary	Update	Baseline U.S. partnerships and agreements	Baseline international agreements						
6. ASM Decision Memorandum or ASM meeting summary [additional information in NPD 1000.5]	OCE/R		Final								
7. Mishap Preparedness and Contingency Plan [Required per NPR 8621.1]	OSMA/R				Preliminary		Update		Baseline (SMSR)	Update	Update
Single-Project Program Technical Products[2]											
1. Concept Documentation [Required per NPR 7123.1]	OCE/R	Approve	Update	Update	Update						
2. Mission, Spacecraft, Ground, and Payload Architectures [Required per NPR 7123.1]	OCE/R	Preliminary mission and spacecraft architecture(s) with key drivers	Baseline mission and spacecraft architecture, preliminary ground and payload	Update mission and spacecraft architecture, baseline ground and payload	Update mission, spacecraft, ground, and payload architectures						

Products	Product Owner/ Require-ment or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
			architectures. Classify payload(s) by risk per NPR 8705.4.	architectures							
3. Project-Level, System, and Subsystem Requirements [Required per NPR 7123.1]	OCE/R	Preliminary project-level requirements	Baseline project-level and system-level requirements	Update Project-level and system-level requirements, Preliminary subsystem requirements	Update project-level and system-level requirements. Baseline subsystem requirements						
4. Design Documentation [Required per NPR 7123.1]	OCE/R				Preliminary	Baseline	Update		Update		
5. Operations Concept Documentation [Required per NPR 7120.5]	OCE/R	Preliminary	Preliminary	Preliminary	Baseline						
6. Technology Readiness Assessment Documentation [Required per NPR 7120.5 Appendix F FA Template]	OCE/R	Initial	Update	Update	Update	Update					
7. Engineering Development Assessment Documentation [Required per NPR 7120.5 Appendix F FA Template]	OCE/R	Initial	Update	Update	Update						
8. Heritage Assessment Documentation [Required per NPR 7120.5 Appendix F FA Template]	OCE/R	Initial	Update	Update	Update						
9. Systems Safety Analyses (e.g., safety data packages) [Baseline at CDR] [Required per NPR 8715.3]	OSMA/R				Preliminary	Baseline	Update	Up-date	Update		
10. Payload Safety Process Deliverables [Required per NPR 8715.7]	OSMA/R				Preliminary	Preliminary	Baseline				
11. Verification and Validation Report [Required per NPR	OCE/R							Prelim-inary	Baseline		

Products	Product Owner/ Require-ment or Best Practice	Pre-Phase A KDP A	Phase A	KDP B	Phase B KDP C	Phase C	KDP D	Phase D	KDP E	Phase E KDP F	Phase F
		MCR	**SRR**	**SDR/MDR**	**PDR**	**CDR**	**SIR**	**ORR**	**MRR/FRR**	**DR**	**DRR**
7123.1]											
12. Operations Handbook [additional information in NPR 7120.5 Appendix A]	OCE/R						Preliminary	Base-line	Update	Update	
13. Orbital Debris Assessment [Required per NPR 8715.6]	OSMA/R	Preliminary Assessment			Preliminary design ODAR	Detailed design ODAR			Final ODAR (SMSR)		
14. End of Mission Plans [Required per NPR 8715.6; additional information in NASA-STD-8719.14, App B]	OSMA/R								Baseline (SMSR)	Update per 8715.6	Update
15. Final Mission Report [additional information in NPR 7120.5 Appendix A]	OCE/BP										Final
16. Decommissioning/Disposal Plan [Required per NPR 7123.1]	OCE/R									Baseline	Update disposal portions
17. Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status [Required per NPR 8735.2]	OSMA/R	Preliminary	Update	Update	Baseline	Update					
18. Criticality Identification Method for Hardware [Required per NPR 8735.2]	OSMA/R	Preliminary	Update	Update	Baseline	Update					
19. Hardware Quality Data Management Analytics [additional information in NPR 8735.2]	OSMA/BP	Preliminary	Update	Update	Baseline	Update	Update	Update	Update		
Single-Project Program Management, Planning, and Control Products											
1. Formulation Agreement [Required per NPR 7120.5]	OCE/R	Baseline for Phase A; Preliminary for Phase B		Baseline for Phase B							
2. Program Plan [Required per NPR 7120.5][3]	OCE/R			Preliminary	Baseline						
3. Project Plan [Required per NPR 7120.5][3]	OCE/R			Preliminary	Baseline						

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
4. Documentation of performance against Formulation Agreement (see #1 above) or against plans for work to be accomplished during Implementation life-cycle phase, including performance against baselines and status/closure of formal actions from previous KDP [Required per NPR 7120.5]	OCE/R		Summary	Summary	Summary	Summary	Summary	Sum-mary	Summary	Sum-mary	
5.Project Baselines											
5.a. Top technical, cost, schedule and safety risks, risk mitigation plans, and associated resources [Required per NPR 7120.5]	OCE/R	Initial	Update	Update	Update	Update	Update	Update	Update	Update	Update
5.b. Staffing requirements and plans [Required by NPR 7120.5]	OCE/R	Initial	Update	Update	Update	Update		Update			
5.c.i. Infrastructure requirements and plans [Required per NPR 9250.1, NPD 8800.14, and NPR 8820.2] Business case analysis for infrastructure [Required per NPR 8800.15.]	OSI-FRED/R	Initial	Update	Update	Update	Update					
5.c.ii Capitalization Determination Form (CDF) (NASA Form 1739) [Required per NPR 9250.1]	OCFO/R	Initial	Update	Update	Update	Update					
5.d. Schedule [Required per NPR 7120.5]	OCFO-SID/R	Risk informed at project level with preliminary Phase D completion ranges	Risk informed at system level with preliminary Phase D completion ranges	Risk informed at subsystem level with preliminary Phase D completion ranges or high and low schedule values with JCL.[4] Prelim-inary IMS	Risk informed and cost-loaded. Baseline Integrated Master Schedule	Update IMS	Update IMS	Update IMS	Update IMS	Update IMS	Update IMS

Products	Product Owner/ Require-ment or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	**SRR**	**SDR/MDR**	**PDR**	**CDR**	**SIR**	**ORR**	**MRR/FRR**	**DR**	**DRR**
5.e. Cost Estimate [Required per NPR 7120.5]	OCFO-SID/R	Preliminary Range estimate	Update	Risk-informed range estimate or high and low-cost values with JCL[4]	Risk-informed baseline	Update	Update	Update	Update	Update	Update
5.f. Basis of Estimate (cost and schedule) [Required per NPR 7120.5]	OCFO-SID/R	Initial (for range)	Update (for range)	Update (for range or high and low values with JCL[4])	Update for cost and schedule estimate	Update	Update	Update	Update	Update	Update
5.g. Confidence Level(s) and supporting documentation [Required per NPR 7120.5]	OCFO-SID/R			Preliminary cost confidence level and preliminary schedule confidence level or JCL[4]	Baseline Joint Cost and Schedule Confidence Level	Update[5]	Update[6]				
5.h. External Cost and Schedule Commitments [Required per NPR 7120.5]	OCFO-SID/R			Preliminary for ranges or JCL[4]	Baseline						
5.i. CADRe [Required per NPR 7120.5]	OCFO-SID/R		Baseline	Update	Update	Update	Update		Update[7]	Update	
5.j. PMB [Required per NPR 7120.5]	OCFO-SID/R				Baseline	Update	Update	Update	Update		

[1] These products are developed by the Mission Directorate.
[2] These document the work of the key technical activities performed in the associated phases.
[3] The Program Plan and Project Plans may be combined with the approval of the MDAA.
[4] Single-project programs with LCC or initial capability cost of $1B or over develop high and low values for cost and schedule with corresponding JCL values at KDP B per Section 2.4.3.1.a.
[5] Single-project programs with LCC or initial capability cost of $1B or over update the JCL at CDR per Section 2.4.3.3.
[6] Projects with LCC or initial capability cost of $1B or over update the JCL at KDP D per Section 2.4.3.4 if current development costs exceed development ABC cost by 5 percent or more.
[7] The CADRe for MRR/FRR is considered the "Launch CADRe" to be completed after the launch.

Table 3-6 Single-Project Program Plan Control Plans Maturity Matrix

(See Templates in NPR 7120.5F Appendices G and H for Control Plan Details)	Product Owner/ Requirement or Best Practice	Pre-Phase A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/ FRR	DR
1. Technical, Schedule, and Cost Control Plan [Required per NPR 7120.5]	OCE/R	Approach for managing schedule and cost during Phase A[1]	Preliminary	Baseline	Update					
2. Safety and Mission Assurance Plan [Required per NPRs 8705.2 and 8705.4]	OSMA/R		Baseline	Update	Update	Update			Update (SMSR)	Update
3. Risk Management Plan [Required per NPR 8000.4]	OSMA/R	Approach for managing risks during Phase A[1]	Baseline	Update	Update					
4. Acquisition Strategy [Required per NPD 1000.5]	OCE/R	Preliminary Strategy	Baseline	Update	Update					
5. Technology Development Plan (may be part of Formulation Agreement) [additional information in NPR 7500.2, NPR 7123.1, and NPR 7120.5]	OCE/BP	Baseline	Update	Update	Update					
6. Systems Engineering Management Plan [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	Update	Update					
7. System Security Plan [Required per NPR 2810.1]	OCIO/R		Preliminary		Update	Baseline	Update	Update		
8. Software Management Plan(s) [Required per NPR 7150.2; additional information in NASA-STD-8739.8]	OCE/R		Preliminary	Baseline	Update					
9. Verification and Validation Plan [Required per NPR 7120.5, additional information in NPR 7123.1]	OCE/R	Preliminary Approach[2]		Preliminary	Baseline	Update	Update			
10. Review Plan [Required per NPR 7120.5][3]	OCE/R	Preliminary	Baseline	Update	Update					
11. Mission Operations Plan [Required per NPR 7120.5]	OCE/R						Preliminary	Baseline	Update	
12. NEPA Compliance Documentation [Required per NPR 8580.1]	OSI-EMD/ R			Baseline						
13. Integrated Logistics Support Plan [Required per NPD 7500.1]	OSI-LMD/R	Approach for managing logistics[2]	Preliminary	Preliminary	Baseline	Update				
14. Science Data Management Plan [additional information in NPD 2200.1 and NPRs 2200.2, 1441.1, and 8715.24]	SMD/BP				Preliminary			Baseline	Update	
15. Integration Plan [Required per NPR 7120.5]	OCE/R	Preliminary approach[2]		Preliminary	Baseline	Update				

(See Templates in NPR 7120.5F Appendices G and H for Control Plan Details)	Product Owner/ Requirement or Best Practice	Pre-Phase A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/ FRR	DR
16. Configuration Management Plan [Required per NPR 7120.5; additional information in NPR 7123.1 and SAE/EIA 649]	OCE/R		Baseline	Update	Update					
17. Security Plan [Required per NPR 1040.1 and NPR 1600.1]	OPS/R			Preliminary	Baseline					Update annually
18. Project Protection Plan [Required per NPR 1058.1, additional information in NASA-STD-1006]	OCE/R			Preliminary	Baseline	Update	Update	Update	Update	Update annually
19. Technology Transfer (formerly Export) Control Plan [Required per NPR 2190.1]	OIIR/R			Preliminary	Baseline	Update				
20. Knowledge Management Plan [additional information in NPD 7120.4 and NPD 7120.6]	OCE/BP	Approach for managing during Phase A[1]		Preliminary	Baseline	Update				
21. Human-Rating Certification Package [Required per NPR 8705.2]	OSMA/R	Preliminary approach[2]	Initial	Update	Update	Update		Update	Approve Certification	
22. Planetary Protection Plan [Required per NPD 8020.7 and NPR 8715.24]	OSMA/R			Planetary Protection Categorization (if applicable)	Baseline					
23. Nuclear Launch Authorization Plan [additional information in NPR 8715.26]	OSMA/R			Baseline (mission has nuclear materials)						
24. Range Safety Risk Management Process Documentation [Required per NPR 8715.5]	OSMA/R				Preliminary	Preliminary	Baseline			
25. Communications Plan [additional information in NPR 7120.5]	OComm/BP		Preliminary		Baseline	Update		Update		
26. Quality Assurance Surveillance Plan [Required per NPR 8735.2 and NASA FAR Supplement Part 1837.604]	OSMA/R		Preliminary	Baseline	Update	Update	Update			
27. Orbital Collision Avoidance Plan [Required per NID 7120.132]	OCE/R				Baseline	Update				
28. Human Systems Integration Plan [additional information in NASA/SP-20210010952 NASA HSI Handbook and NPR 7123.1]	OCE-OSMA-OCHMO/R	Preliminary	Baseline	Update	Update	Update				

[1] Not the Plan, but documentation of high-level process. May be documented in MCR briefing package.
[2] Not the Plan, but documentation of considerations that might impact the cost and schedule baselines. May be documented in MCR briefing package.
[3] Review Plan should be baselined before the first review.

4 Project Life Cycle, Oversight, and Activities by Phase

4.1 NASA Projects

Projects are the means by which NASA accomplishes the work needed to explore space, expand scientific knowledge, and perform aeronautics research on behalf of the Nation. NASA's technologically challenging projects develop the hardware and software required to deliver NASA's missions and regularly extend the Nation's scientific and technological boundaries. These complex endeavors require a disciplined approach framed by a management structure and institutional processes essential to mission success.

A space flight project is a specific investment identified in a Program Plan having defined requirements, a life-cycle cost, a beginning, and an end. A project also has a management structure and may have interfaces to other projects, agencies, and international partners. A project yields new or revised products that directly address NASA's strategic goals.

As with programs, projects vary in scope and complexity and thus have varying levels of management requirements and need varying levels of Agency attention and oversight. NASA accommodates these differences by separating projects into categories that determine both the project's oversight council and the specific approval requirements. Projects are assigned Category 1, 2, or 3 based initially on:

- The project Life-Cycle Cost Estimate (LCCE),[34]
- The inclusion of significant radioactive material,[35] and
- Whether the system being developed is for human space flight.

Secondarily, projects are assigned a category based on a priority level related to the importance of the activity to NASA, as determined by:

- The extent of international participation (or joint effort with other government agencies),
- The degree of uncertainty surrounding the application of new or untested technologies, and

[34] The project LCCE includes Phases A through F and all Work Breakdown Structure (WBS) Level 2 elements and is measured in real year (nominal) dollars. (See Section 5.9 for information about WBS elements.)
[35] Significant radioactive material is defined as levels of radioactive material onboard the spacecraft and/or launch vehicle that require nuclear launch authorization by the NASA Administrator or Executive Office of the President as described in *NPR 8715.26, Nuclear Flight Safety*.

- Spacecraft/payload development risk classification. (See *NPR 8705.4, Risk Classification for NASA Payloads*.)

The determination of the priority level is subjective based on how the Agency's senior management assesses the risk of the project to NASA's overall mission success, including the project's importance to its external stakeholders.

Guidelines for categorizing projects are shown in Table 4-1, but the Mission Directorate Associate Administrator (MDAA) may recommend a different categorization that considers additional risk factors facing the project. Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point are assigned to Category 1 unless otherwise agreed to by the Decision Authority. The NASA Associate Administrator (AA) approves the final project categorization. The project category is identified in the Formulation Authorization Document (FAD) and Project Plan and documented in the KDP B Decision Memorandum. The Office of the Chief Financial Officer (OCFO) is responsible for the official listing of all NASA projects in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy*.[36] This listing in the Metadata Manager (MdM) database provides the basis for the Agency Work Breakdown Structure (WBS). (See Section 5.9 for an explanation of how projects are documented in the MdM and how the MdM, WBS, and the financial system interrelate.)

Table 4-1 Project Categorization Guidelines

Priority Level	LCC < $365 million	LCC ≥ $365 million and ≤ $2 billion	LCC > $2 billion, significant radioactive material, or human space flight
High	Category 2	Category 2	Category 1
Medium	Category 3	Category 2	Category 1
Low	Category 3	Category 2	Category 1

[36] These data are maintained by the Office of Chief Financial Officer (OCFO) in a database called the Metadata Manager (MdM). This database is the basis for the Agency's work breakdown and forms the structure for program and project status reporting across all Mission Directorates and mission support offices.

Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, define an initial capability during Phase A and develop an initial capability cost which establishes the Agency Baseline Commitment (ABC) at KDP C. Initial capability is the first operational mission flight (or as defined in the KDP B Review Plan) and is documented in the KDP B Decision Memorandum. Initial capability cost includes operations cost for the initial capability. The Phase E cost estimate for continuing operations and production is established separately as part of the ORR and KDP E for the 5 years after initial capability and subsequently updated and documented annually for the next 5-year period. Upgrades during Phase E that meet the Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purpose of establishing their own development ABC outside the project Phase E cost estimate. The project Phase E cost estimate is updated to include production and operations costs associated with these upgrades. Development, production, and operations costs of other (i.e., non-major) upgrades are included in the project Phase E cost estimate. (See Section 5.5.4 for additional information on developing the Phase E cost estimate.)

Projects can be initiated in a variety of ways. Generally, a program initiates a project, with support and guidance from the Mission Directorate, as part of the program's overall strategy and consistent with the program's objectives and requirements. These program-initiated projects are usually either "directed" or "competed" by the Mission Directorate with support from the program.

- A "directed" mission is generated in a top-down process from the Agency strategic goals and through the strategic acquisition planning process. It is defined and directed by the Agency, assigned to a Center[37] or implementing organization by the MDAA[38] consistent with direction and guidance from the strategic acquisition planning process, and implemented through a program or project management structure. Direction may also come from outside NASA and implementing organizations may include other Government agencies.
- A "competed" mission is opened up to a larger community for conceptualization and definition through a Request for Proposal (RFP) or competitive selection process, such as an Announcement of Opportunity (AO), before entering the conventional life-cycle process. (See Section 4.3.3.) In a competed mission, a Center is generally part of the proposal.

Projects can also be initiated in other ways. In some cases, other Federal agencies ask NASA to design and develop projects. As part of the agreement with that agency, these projects are usually funded by the sponsoring agency and are known as "reimbursable" projects. For example, NASA has been supporting the National Oceanic and Atmospheric Administration (NOAA) by developing spacecraft for them and has turned the operation of

[37] For Category 1 projects, the assignment to a Center or other implementing organization is with the concurrence of the NASA Associate Administrator (AA).
[38] As part of the process of assigning projects to NASA Centers, the affected program manager may recommend project assignments to the MDAA.

those spacecraft over to NOAA after launch and on-orbit checkout. The Geostationary Operational Environmental Satellite-R Series (GOES-R) is an example of this type of project. The requirements of NPR 7120.5, including doing an ABC and Management Agreement, apply to reimbursable projects unless waived, as well as any additional requirements the sponsoring partner adds, as negotiated.

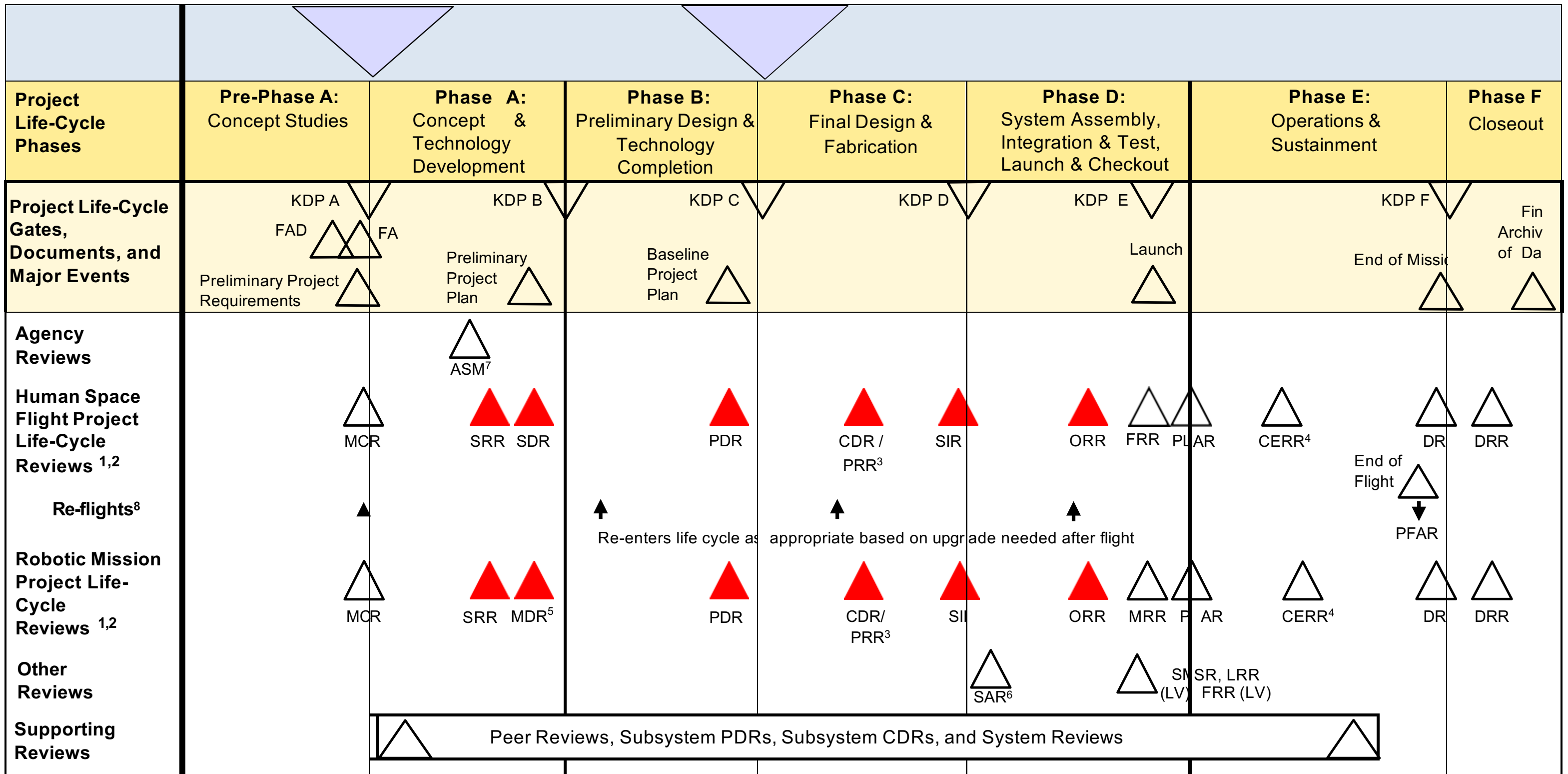
Projects can also come from other types of acquisition authorities. These authorities include, but are not limited to, grants, cooperative agreements, and Space Act Agreements (SAA). NPR 7120.5 requirements apply to contractors, grant recipients, or parties to agreements only to the extent specified or referenced in the appropriate contracts, grants, or agreements.

The National Aeronautics and Space Act of 1958, as amended (51 U.S.C. 20113(e)), authorizes NASA "to enter into and perform such ... other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate…" This authority enables NASA to enter "Space Act Agreements (SAAs)" with organizations in the public and private sector. SAA partners can be a U.S. or foreign person or entity, an academic institution, a Federal, state, or local governmental unit, a foreign government, or an international organization, for profit or not for profit.

SAAs establish a set of legally enforceable terms between NASA and the other party to the agreement and constitute Agency commitments of resources such as personnel, funding, services, equipment, expertise, information, or facilities. SAAs can be reimbursable, non-reimbursable, or funded agreements. Under reimbursable agreements, NASA's costs are reimbursed by the agreement partner, either in full or in part. Non-reimbursable agreements are those in which NASA is involved in a mutually beneficial activity that furthers the Agency's missions, with each party bearing its own costs and no exchange of funds between the parties. Funded agreements are those under which NASA transfers appropriated funds to an agreement partner to accomplish an Agency mission. (See NPD 1000.5, Policy for NASA Acquisition and http://www.nasa.gov/open/plan/space-act.html for additional information on Space Act Agreements.)

4.1.1 Project Life Cycle

Figure 4-1 illustrates the project life-cycle phases, gates, and major events, including Key Decision Points (KDPs), life-cycle reviews, and principal documents that govern the conduct of each phase. It also shows how projects recycle through Formulation when changes warrant such action.



FOOTNOTES

1. Flexibility is allowed as to the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan.
2. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5 of NPR 7120.5..
3. PRR is needed only when there are multiple copies of systems. It does not require an SRB. Timing is notional.
4. CERRs are established at the discretion of Program Offices. .
5. For robotic missions, the SRR and the MDR may be combined.
6. SAR generally applies to human space flight.
7. Timing of the ASM is determined by the MDAA or AA, as compliant with NPD 1000.5 and may take place at any time during Phase A.
8. Placement of arrows is notional. See Section 2.2.4.3 of NPR 7120.5 for more guidance on reflights.

ACRONYMS

ASM - Acquisition Strategy Meeting
CDR - Critical Design Review
CERR - Critical Events Readiness Review
DR - Decommissioning Review
DRR - Disposal Readiness Review
FA - Formulation Agreement
FAD - Formulation Authorization Document
FRR - Flight Readiness Review
KDP - Key Decision Point
LRR - Launch Readiness Review
LV - Launch Vehicle
MCR – Mission Concept Review
MDR - Mission Definition Review
MRR - Mission Readiness Review
ORR - Operational Readiness Review
PDR - Preliminary Design Review
PFAR - Post-Flight Assessment Review
PLAR - Post-Launch Assessment Review
PRR - Production Readiness Review
SAR - System Acceptance Review
SDR - System Definition Review
SIR - System Integration Review
SMSR - Safety and Mission Success Review
SRB - Standing Review Board
SRR - System Requirements Review

Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

Figure 4-1 NASA Project Life Cycle

Each project life-cycle phase includes one or more life-cycle reviews, each designed to assess a project's technical and programmatic status and health and assure that the project has completed the work required at a key point in the life cycle. Life-cycle reviews are essential elements of conducting, managing, evaluating, and approving space flight projects and are an important part of NASA's system of checks and balances. Most life-cycle reviews are conducted by the project and an independent Standing Review Board (SRB).[39] NASA accords special importance to maintaining the integrity of its independent review process to gain the value of independent technical and programmatic perspectives.

The Standing Review Board is a group of independent experts who assess and evaluate project activities, advise projects and Convening Authorities (see Table 2-2 in NPR 7120.5), and report their evaluations to the responsible organizations as identified in Figure 4-5 of this handbook. They are responsible for conducting independent reviews (life-cycle and special) of a project and providing objective, expert judgments to the Convening Authorities. The reviews are conducted in accordance with approved terms of reference and life-cycle requirements in NPR 7120.5 and NPR 7123.1. For more detail, see Section 5.10 of this handbook and NASA/SP-2016-3706, NASA Standing Review Board Handbook.

Life-cycle reviews provide the project and NASA senior management with a credible, objective assessment of how the project is progressing. The final life-cycle review in a project life-cycle phase provides essential information for the KDP, which marks the end of that life-cycle phase. A KDP is the point at which a Decision Authority determines whether and how a project proceeds through the life cycle, and authorizes key project cost, schedule, and content parameters that govern the remaining life-cycle activities. A KDP serves as a mandatory gate through which a project must pass to proceed to the next life-cycle phase. During the period between the life-cycle review and the KDP, the project continues its planned activities unless otherwise directed by the Decision Authority.

For Category 1 projects, the Decision Authority is the NASA Associate Administrator (AA). For Category 2 and 3 projects, the Decision Authority is the MDAA. KDPs for projects are labeled with capital letters, e.g., KDP A. The letter corresponds to the project phase that will be entered after successfully passing through the gate.

Figure 4-1 shows two separate life-cycle lines: one for human space flight and one for robotic space flight. These two communities have developed slightly different terms and launch approval processes over the years. Despite these subtle differences, the project management life cycles are essentially the same.

Although project life cycles are fundamentally divided between Formulation and Implementation, projects may also undergo Pre-Phase A activities before being initiated as a new project at the start of Formulation. A Mission Directorate, typically supported by a program office, provides resources for concept studies (i.e., Pre-Phase A (Concept Studies)).

[39] LCRs required to be performed by the SRB are depicted by red triangles in Figure 4-1, NASA Project Life Cycle.

These Concept Study activities involve Design Reference Mission (DRM) analysis, feasibility studies, technology needs analyses, engineering systems assessments, and analyses of alternatives that need to be performed before a specific project concept emerges.

Project Formulation comprises two sequential phases, Phase A (Concept and Technology Development) and Phase B (Preliminary Design and Technology Completion). Formulation activities include developing project requirements; assessing technology requirements; developing the system architecture; completing mission and preliminary system designs; flowing down requirements to the system and subsystem levels; planning acquisitions; assessing heritage (the applicability of designs, hardware, and software from past projects to the present one); conducting safety, performance, cost, and risk trades; identifying and mitigating development and programmatic risks; conducting engineering development activities, including developing and testing engineering prototypes and models for the higher-risk components and assemblies that have not been previously built or flown in the planned environment; and developing high-fidelity time-phased cost and schedule estimates and documenting the basis of these estimates. (See Section 4.3.4.1 for additional detail on Formulation activities.)

During Formulation, the project establishes performance metrics, explores the full range of implementation options, defines an affordable project concept to meet requirements specified in the Program Plan, and develops or acquires needed technologies. Formulation is an iterative set of activities rather than discrete linear steps. Systems engineering plays a major role during Formulation as described in *NPR 7123.1, NASA Systems Engineering Processes and Requirements*.

Formulation continues with execution of activities, normally concurrently, until Formulation output products such as the Project Plan have matured and are acceptable to the program manager, Center Director, and MDAA. For projects with LCC or initial capability cost greater than $250M, these activities allow the Agency to present to external stakeholders time-phased high-fidelity cost plans and schedule range estimates at KDP B and high-confidence cost and schedule commitments at KDP C.

Project Implementation comprises Phases C, D, E, and F. Decision Authority approval at KDP C marks the transition from Phase B of Formulation to Phase C of Implementation:

- Phase C (Final Design and Fabrication) includes completion of final system design and the fabrication, assembly, and test of components, assemblies, and subsystems.
- Phase D (System Assembly, Integration and Test, and Launch and Checkout) includes system Assembly, Integration, and Test (AI&T); verification and/or certification; prelaunch activities; launch; and checkout. Completing KDP E and authorizing launch is complex and unique because completing the KDP does not lead immediately to transition to Phase E. Transition to Phase E occurs after successful checkout of the flight system. (Section 4.4.4 provides details on the launch review and approval process and the transition to Phase E for human and robotic space flight projects.)

- The start of Phase E (Operations and Sustainment) marks the transition from system development and acquisition activities to primarily system operations and sustainment activities. (See Sustainment and Sustaining Engineering box in Section 4.4.6.1 for an explanation of sustainment activities.)
- In Phase F (Closeout), project space flight and associated ground systems are taken out of service and safely disposed of or reused for other activities, although scientific and other analyses might continue under project funding.

Independent evaluation activities occur throughout all phases.

4.1.2 Project Life-Cycle Reviews

The project life-cycle reviews identified in the project life cycle are essential elements of conducting, managing, evaluating, and approving space flight projects. The project manager is responsible for planning for and supporting the life-cycle reviews. These life-cycle reviews assess the following six assessment criteria identified in NPR 7120.5:

- **Alignment with and contribution to Agency strategic goals and the adequacy of requirements that flow down from those.** The scope of this criterion includes, but is not limited to, alignment of project requirements and designs with Agency strategic goals, project requirements and constraints, mission needs and success criteria; allocation of program requirements to projects; and proactive management of changes in project scope and shortfalls.
- **Adequacy of management approach.** The scope of this criterion includes, but is not limited to, project authorization, management framework and plans, acquisition strategies, and internal and external agreements.
- **Adequacy of technical approach** as defined by NPR 7123.1 entrance and success criteria. The scope of this criterion includes, but is not limited to, flow down of project requirements to systems and subsystems; architecture and design; and operations concepts that respond to and satisfy the requirements and mission needs.
- **Adequacy of the integrated cost and schedule estimate and funding strategy** in accordance with *NPD 1000.5, Policy for NASA Acquisition*. The scope of this criterion includes, but is not limited to, cost and schedule control plans; cost and schedule estimates (prior to KDP C) and baselines (at KDP C) that are consistent with the project requirements, assumptions, risks, and margins; Basis of Estimate (BoE); Joint Cost and Schedule Confidence Level (JCL), when required; and alignment with planned budgets.
- **Adequacy and availability of resources other than budget.** The scope of this criterion includes, but is not limited to, planning, availability, competency and stability of staffing, infrastructure, and the industrial base and supply chain requirements.
- **Adequacy of the risk management approach and risk identification and mitigation** per *NPR 8000.4, Agency Risk Management Procedural Requirements* and *NASA/SP-2011-3422, NASA Risk Management Handbook*. The scope of this criterion

includes, but is not limited to risk-management plans, processes (e.g., Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM)), open and accepted risks, risk assessments, risk mitigation plans, and resources for managing and mitigating risks.

The Joint Cost and Schedule Confidence Level (JCL) is the product of a probabilistic analysis of the coupled cost and schedule to measure the likelihood of completing all remaining work at or below the budgeted levels and on or before the planned completion of the development phase. A JCL is required for all projects with an LCC or initial capability cost greater than $250 million at KDP C. A JCL is also required for these projects in the event of a rebaseline during the Implementation phase. For projects with LCC or initial capability cost ≥ $1B, a JCL is also required at KDP B and CDR, and at KDP D if current reported development costs have exceeded the development ABC cost by 5 percent or more. The JCL calculation includes consideration of the risk associated with all elements, whether they are funded from appropriations or managed outside of the project. JCL calculations include content from the milestone at which the JCL is calculated through the completion of Phase D activities. Per NPR 7120.5, at KDP B, if applicable, and KDP C, Mission Directorates plan and budget projects with an estimated LCC or initial capability cost greater than $250 million based on a 70 percent JCL or as approved by the Decision Authority. At KDP C, Mission Directorates ensure funding for these projects is consistent with the Management Agreement and in no case less than the equivalent of a 50 percent JCL or as approved by the Decision Authority.

Life-cycle reviews are designed to provide the project with an opportunity to ensure that it has completed the work of that phase and an independent assessment of the project's technical and programmatic status and health. Life-cycle reviews are conducted under documented Agency and Center review processes. (See Section 5.10 in this handbook and *NASA/SP-2016-3706, NASA Standing Review Board Handbook*.)

A life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment and sign the Decision Memorandum.

The life-cycle review process provides:

- The project with a credible, objective independent assessment of how it is progressing.
- NASA senior management with an understanding of whether
  - The project is on track to meet objectives,
  - The project is performing according to plan, and
  - Impediments to project success are addressed.
- For a life-cycle review that immediately precedes a KDP, a credible basis for the Decision Authority to approve or disapprove the transition of the project at a KDP to the next life-cycle phase.

The independent review also provides vital assurance to external stakeholders that NASA's basis for proceeding is sound.

The project finalizes its work for the current phase during the life-cycle review. In some cases, the project uses the life-cycle review meeting(s) to make formal programmatic and technical decisions necessary to complete its work. In all cases, the project utilizes the results of the independent assessment and the resulting management decisions to finalize its work. In addition, the independent assessment serves as a basis for the project and management to determine if the project's work has been satisfactorily completed, and if the plans for the following life-cycle phases are acceptable. If the project's work has not been satisfactorily completed, or its plans are not acceptable, the project addresses the issues identified during the life-cycle review or puts in place the action plans necessary to resolve the issues.

Prior to the project life-cycle reviews, projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. These internal reviews are key components of the process used by projects to solidify their plans, technical approaches, and programmatic commitments and are part of the normal systems engineering work processes as defined in NPR 7123.1, where major technical and programmatic requirements are assessed along with the system design and other implementation plans. For both robotic and human space flight projects, these internal reviews are typically lower-level system and subsystem reviews that lead to and precede the life-cycle review. Major technical and programmatic performance metrics are reported and assessed against predictions. Figure 4-2 shows how these internal reviews relate to life-cycle reviews. (This graphic is an example based on Goddard Space Flight Center practices. Each Center may have a different approach.)

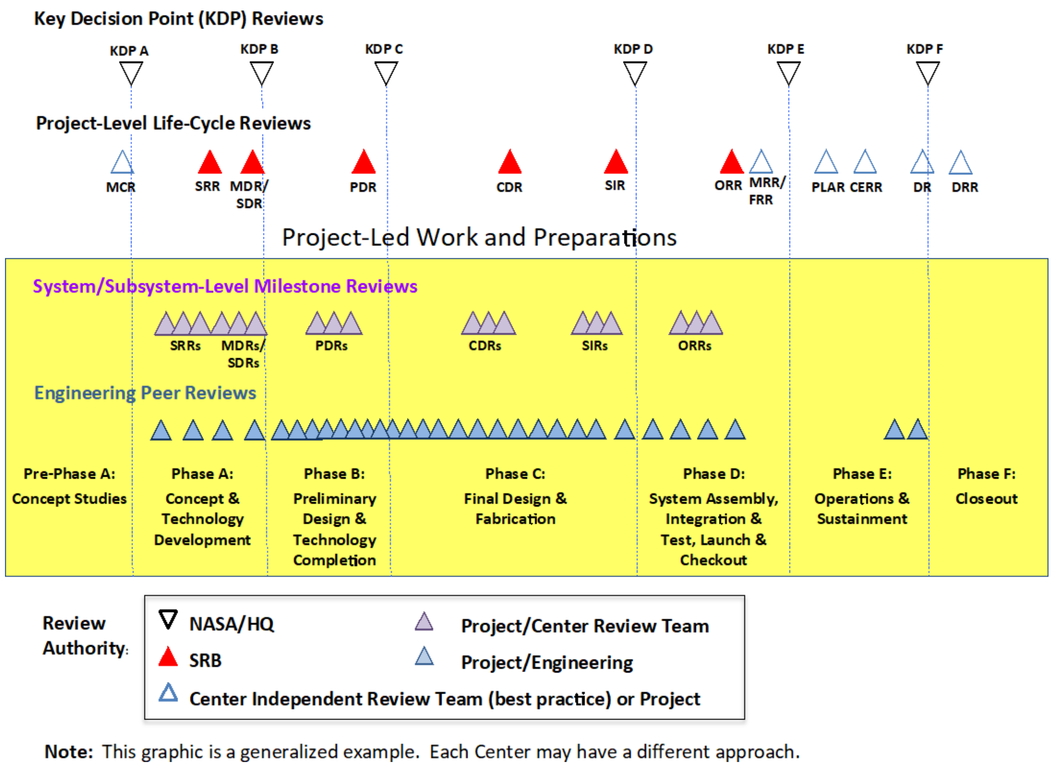


Figure 4-2 Work Led by the Project Throughout the Life Cycle

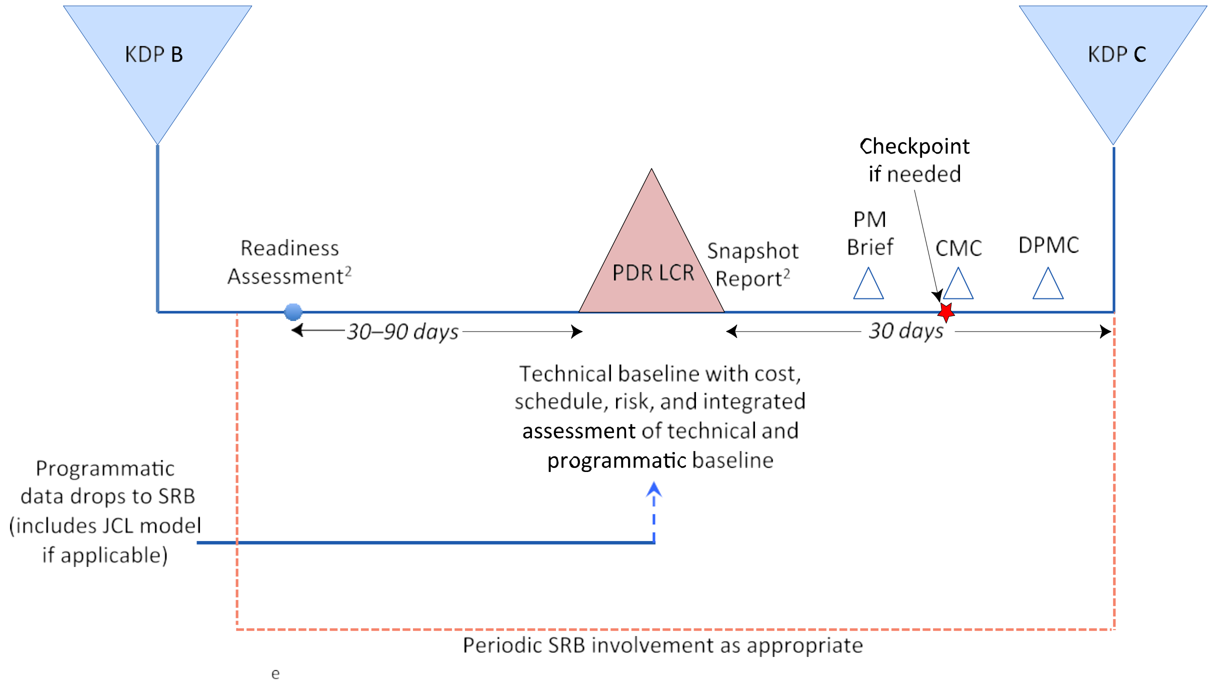
The project manager has the authority to determine whether to hold a one-step or a two-step review. This determination usually depends on the state of the project's cost and schedule maturity as described below. Any life-cycle review can be either a one-step or a two-step review. The project manager documents the project's review approach in the project **Review Plan**.

Descriptions of the one-step and two-step life-cycle review processes are provided in Figures 4-3 and 4-4. (These descriptions are written from the perspective of life-cycle reviews conducted by a project and an SRB. For life-cycle reviews that do not require an Agency-led SRB, i.e., MCR, FRR/MRR, PLAR, CERR, PFAR, DR, and DRR, the project manager will work with the Center Director or designee to prepare for and conduct the life-cycle review in accordance with Center practices and a Center-assigned independent review team. For such life-cycle reviews conducted by the project and a Center independent review team, the remaining references to SRB are replaced with Center independent review team.)

In a one-step review, the project's technical maturity and programmatic posture are assessed together against the six assessment criteria. In this case, the project has typically completed all its required technical work as defined in NPR 7123.1 life-cycle review entrance criteria and has aligned the scope of this work with its cost estimate, schedule, and risk posture before the life-cycle review. The life-cycle review is then focused on presenting this work to the SRB. Except in special cases, a one-step review is chaired by the SRB. The SRB assesses the work against the six assessment criteria and then provides an independent assessment of whether the project has met these criteria. Figure 4-3 illustrates the one-step life-cycle review process.

In a two-step review, the project typically has not fully integrated the project's cost and schedule with the technical work. In this case, the first step of the life-cycle review is focused on finalizing and assessing the technical work described in NPR 7123.1. However as noted in Figure 4-4, which illustrates the two-step life-cycle review process, the first step does consider the preliminary cost, schedule, and risk as known at the time of the review. This first step is only one half of the life-cycle review. At the end of the first step, the SRB will have fully assessed the technical approach criteria but will only be able to determine preliminary findings on the remaining criteria since the project has not yet finalized its work. Thus, the second step is conducted after the project has taken the results of the first step and fully integrated the technical scope with the cost, schedule, and risk, and has resolved any issues that may have arisen from this integration. The period between steps may take up to six months depending on the complexity of the project. In the second step, which may be referred to as the Independent Integrated Life-Cycle Review Assessment, the project typically presents the integrated technical, cost, schedule, and risk, just as is done for a one-step review, but the technical presentations may simply update information provided during the first step. The SRB then completes its assessment of whether the project has met the six assessment criteria. In a two-step life-cycle review, both steps are necessary to fulfill the life-cycle review requirements. Except in special cases, the SRB chairs both steps of the life-cycle review.

There are special cases, particularly for human space flight projects, where the project uses the life-cycle review to make formal decisions to complete the project's technical work and align it with the cost and schedule. In these cases, the project manager may co-chair the review since the project manager is using this forum to make project decisions, and the SRB will conduct the independent assessment concurrently. The project manager will need to work with the SRB chair to develop the review agenda and agree on how the review will be conducted to ensure that it enables the SRB to fully accomplish the independent assessment. The project manager and the SRB chair work together to ensure that the review Terms of Reference (ToR) reflect their agreement and the Convening Authorities approve the approach.



1. A one-or two-step review may be used for any life-cycle review.
2. The *NASA Standing Review Board Handbook* provides information on the readiness assessment, snapshot reports, and checkpoints associated with life-cycle reviews.

Figure 4-3 One-Step[1] PDR Life-Cycle Review Overview

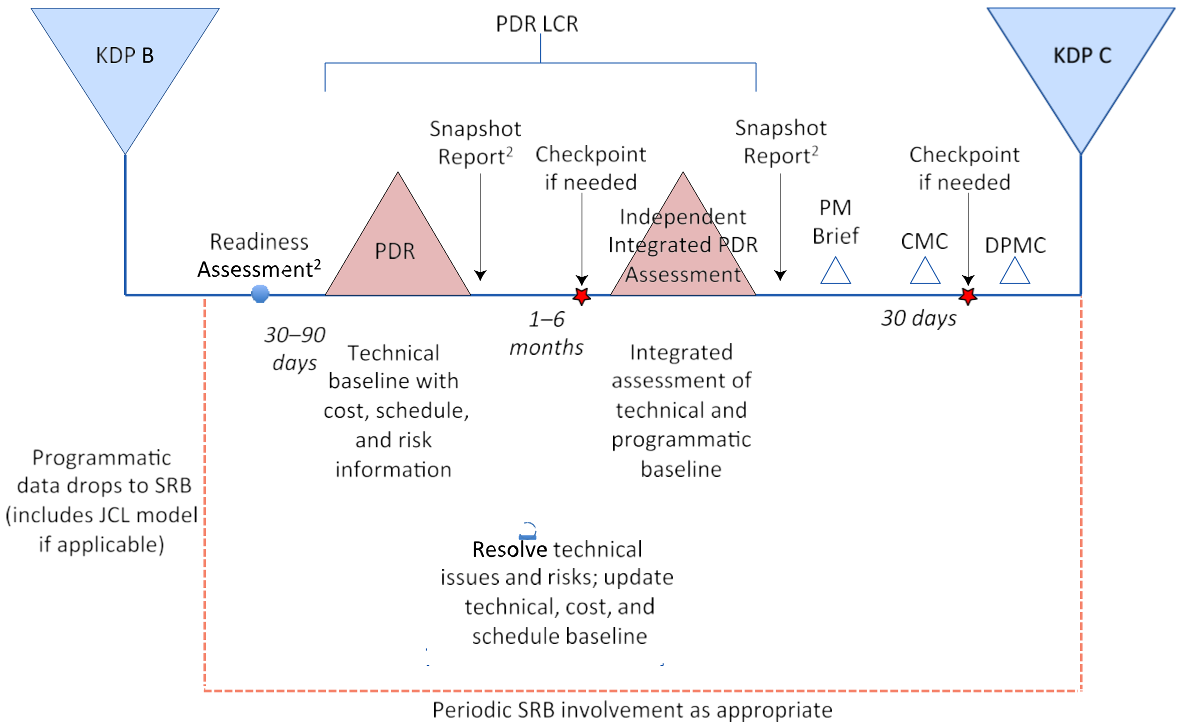


Figure 4-4 Two-Step[1] PDR Life-Cycle Review Overview

Details on project review activities by life-cycle phase are provided in the sections below. *NASA/SP-2016-3706, NASA Standing Review Board Handbook* and Section 5.10 in this handbook also contain more detailed information on conducting life-cycle reviews. NPR 7123.1 provides life-cycle review entrance and success criteria, and Appendix I in NPR 7120.5F and Appendix E in this handbook provide specifics for addressing the six assessment criteria required to demonstrate the project has met the expected maturity state to transition to the next phase.

4.1.3 Other Reviews and Resources

Special reviews may be convened by the Office of the Administrator, MDAA, Center Director, the Technical Authority (TA),[40] or other Convening Authority. Special reviews may be warranted for projects not meeting expectations for achieving safety, technical, cost, or schedule requirements; not being able to develop an enabling technology; or experiencing some unanticipated change to the project baseline. Special reviews include a

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[40] That is, individuals with specifically delegated authority in Engineering (ETA), Safety and Mission Assurance (SMA TA), and Health and Medical (HMTA). See Section 5.2 for more information on Technical Authorities.

Rebaseline Review and Termination Review. Rebaseline Reviews are conducted when the Decision Authority determines the Agency Baseline Commitment (ABC) needs to be changed. (For more detail on Rebaseline Reviews, see Section 5.5.5.1. For more detail on the ABC, see Section 4.2.4 and Section 5.5.) A Termination Review may be recommended by a Decision Authority, MDAA, or program executive if he or she believes it may not be in the Government's best interest to continue funding a project. Other reviews, such as Safety and Mission Assurance (SMA) reviews, are part of the regular management process. For example, SMA Compliance Verification reviews are spot reviews that occur on a regular basis to ensure projects are complying with NASA safety principles and requirements. (For more detail on Termination Reviews and SMA reviews, see Section 5.11.)

Other resources available to help a project manager evaluate and improve project performance include the following:

- The NASA Engineering and Safety Center (NESC), an independently funded organization with a dedicated team of technical experts, provides objective engineering and safety assessments of critical, high-risk projects. The NESC is a resource to benefit projects and organizations within the Agency, the Centers, and the people who work there by promoting safety through engineering excellence, unaffected and unbiased by the projects it is evaluating. The NESC mission is to proactively perform value-added independent testing, analysis, and assessments to ensure safety and mission success and help NASA avoid future problems. Projects seeking an independent assessment or expert advice on a particular technical problem can contact the NESC at https://www.nasa.gov/nesc or the NESC Chief Engineer at their Center.
- The NASA Independent Verification and Validation (IV&V) Facility strives to improve the software safety, reliability, and quality of NASA projects and missions through effective applications of systems and software IV&V methods, practices, and techniques. The NASA IV&V Facility applies software engineering best practices to evaluate the correctness and quality of critical and complex software systems. When applying systems and software IV&V, the NASA IV&V Facility seeks to ensure that the software exhibits behaviors exactly as intended, does not exhibit behaviors that were not intended, and exhibits expected behaviors under adverse conditions. Software IV&V has been demonstrated to be an effective technique on large, complex software systems to increase the probability that software is delivered within cost and schedule, and that software meets requirements and is safe. When performed in parallel with systems development, software IV&V provides for the early detection and identification of risk elements, enabling early mitigation of the those elements. For projects that are required or desire to do software IV&V, contact information is available on the Katherine Johnson IV&V Facility home page at http://www.nasa.gov/centers/ivv/home/index.html. (All Category 1 projects; all Category 2 projects that have Class A or Class B payload risk classification per *NPR 8705.4, Risk Classification for NASA Payloads;* and projects specifically selected by the NASA Chief, Safety and Mission Assurance (SMA) are required to do software IV&V. See NPR 7120.5F and Section 4.1 in this handbook for project categorization guidelines.)

4.1.4 Project Evolution and Recycle

A project may evolve over time in ways that make it necessary to go back and restart parts of its life cycle. A project may evolve as a result of a planned series of upgrades, when the need for new capabilities is identified, or when the project includes reflights.

When the requirements imposed on a project significantly change, it is necessary to evaluate whether the changes impact the current approved approach and/or system design and performance. In some cases, the Decision Authority may ask the project to go back through the necessary life-cycle phases and reviews and to update project documentation to ensure that the changes have been properly considered in light of the overall project and/or system performance. It may not be necessary to restart the life-cycle process at the beginning. The decision on when and where to recycle through the life-cycle reviews will be based on a discussion between the project, the program, the Mission Directorate, and the Decision Authority. For example, a project may need to refurbish operational reusable systems after each flight, or a project may be required to make modifications between flights. A project going back through a part of its life cycle is depicted in Figure 4-1 on the "Reflights" line. "Reflight" may involve updates to the **Project Plan** and other documentation.

4.1.5 Project Tailoring

Project teams are expected to tailor the requirements of NPR 7120.5 to meet the specific needs of the project. All the requirements will generally be applicable to Category 1 projects whereas only some of the more significant requirements may be applicable to Category 3 projects, for example.

When a project team and its management determine that a requirement is not needed, the process for tailoring that requirement requires getting permission from the requirement owner. Tailoring can be done using the Compliance Matrix attached to the Formulation Agreement or Project Plan. Tailoring of NPR 7120.5F requirements is approved when the proper authorities for the Formulation Agreement or Project Plan and the requirement owners (indicated in the Compliance Matrix) have signed off on the tailoring. Tailoring processes, compliance matrices, consultation and assistance, guidance, and resources to help the project manager tailor requirements can be found in Section 5.4 of this handbook, Appendix C of NPR 7120.5F, and the Agency Tailoring Website at https://appel.nasa.gov/npr-7120-5-tailoring-resources. Resources available on the Agency Tailoring Website include:

- The full Compliance Matrix.
- Pre-Customized Compliance Matrix templates that eliminate non-applicable requirements for specific types of programs and projects.

- Points of Contact provided by HQ requirements owners and some Mission Directorates for consulting with and assisting programs and projects in developing their tailoring approach and in obtaining approval for tailoring.
- Information on how the NASA Program and Project Management Board (PPMB) may assist programs and projects in tailoring requirements and provide guidance through the tailoring process.
- Guidance documents for developing a project's tailoring approach provided by some HQ requirements owners (e.g., OCE, OCFO) including guidance for small Category 3, Class D projects with a Life-Cycle Cost (LCC) under $150 million.
- Guidance documents from some Mission Directorates for developing a project's tailoring approach.

In addition, the full Compliance Matrix (*NPR 7120.5 Rev F Compliance Matrix*[41]) and tailoring guidance for small Category 3, Class D projects with a LCC under $150 million (*Guidance for Tailoring 7120.5 Requirements for Small Cat 3/Class D Projects*[42]) can be found on the OCE tab in NODIS under "Other Policy Documents."

Tailoring allows projects to perform only those activities that are needed for mission success while still meeting Agency external requirements and receiving the benefits of NASA policy, reflecting lessons learned and best practice. Project managers and their management are encouraged to thoughtfully examine and tailor requirements so projects perform only those requirements that contribute to achieving mission success. Requirements imposed by Federal law or external entities generally cannot be waived.

The Agency has established requirements and developed handbooks that discuss best practices to help project managers achieve project mission success. However, it is not possible to generate the proper requirements and guidelines for every possible scenario. Project managers and their teams need to use good common sense when developing their plans, processes, and tools so that they can be effective, efficient, and successful with acceptable risk. Project managers work with their program manager, Center, and the Mission Directorate when tailoring requirements to ensure that all parties agree with the proposed approach.

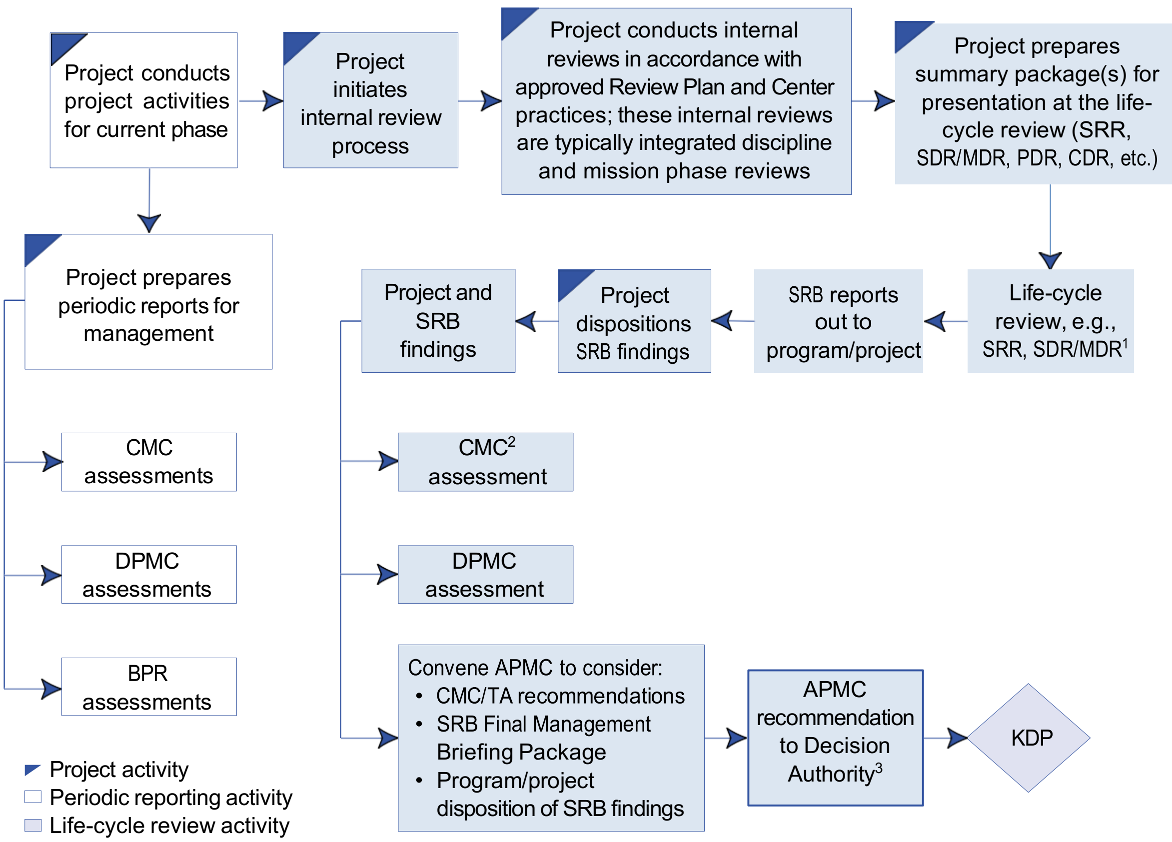
4.2 Project Oversight and Approval

NASA has established a project management oversight process to ensure that experience, diverse perspectives, and thoughtful programmatic and technical judgment at all levels are available and applied to project activities. The Agency employs management councils and management forums, such as the Baseline Performance Review (BPR), to provide insight to

[41] https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_55.docx
[42] https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_57.pdf

upper management on the status and progress of projects and their alignment with Agency goals. (See Section 4.2.5.) This section describes NASA's oversight approach and the process by which a project is approved to move forward through its life cycle. It defines and describes NASA's Decision Authority, Key Decision Points (KDPs), management councils, and the BPR.

The general flows of the project oversight and approval process for life-cycle reviews that require SRBs and for the periodic reporting activity for projects are shown in Figure 4-5. Prior to the life-cycle review, the project conducts its internal reviews. Then the project and the SRB conduct the life-cycle review. Finally, the results are reported to senior management through the management councils.



[1] See the *NASA Standing Review Board Handbook* for details.
[2] May be an Integrated Center Management Council when multiple Centers are involved.
[3] Life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment.

Figure 4-5 Project Life-Cycle Review Process and Periodic Reporting Activity

Additional insight is provided by the independent perspective of SRBs at life-cycle reviews identified in Figure 4-1. Following each life-cycle review, the chair of the independent SRB and the project manager brief the applicable management councils on the results to support the councils' assessments. These briefings are completed within 30 days of the life-cycle review. The 30 days ensure that the Decision Authority is informed in a timely manner as the project moves forward to preclude the project from taking action that the Decision Authority does not approve. These briefings cover the objectives of the review; the project's maturity compared to the maturity expected at that point in the life cycle; findings and recommendations to rectify issues or improve mission success; the project's response to these findings; and the project's proposed cost, schedule, safety, and technical plans for the follow-on life-cycle phases. This process enables a disciplined approach for developing the Agency's assessment, which informs the Decision Authority's KDP determination of project readiness to proceed to the next life-cycle phase. Life-cycle reviews are conducted under documented Agency and Center review processes.

4.2.1 Decision Authority

The Decision Authority is the Agency individual who makes the KDP determination on whether and how the project proceeds through the life cycle and authorizes the key project cost, schedule, and content parameters that govern the remaining life-cycle activities.

The Decision Authority is the individual authorized by the Agency to make important decisions on projects under his or her purview. The Decision Authority makes the KDP decision by considering factors such as technical maturity; continued relevance to Agency strategic goals; adequacy of cost and schedule estimates; associated probabilities of meeting those estimates (confidence levels); continued affordability with respect to the Agency's resources; maturity and the readiness to proceed to the next phase; and remaining project risk (safety, cost, schedule, technical, management, and programmatic).

For Category 1 projects, the Decision Authority is the NASA Associate Administrator (AA), who signs the Decision Memorandum at the KDP. The AA may delegate this authority to the MDAA for Category 1 projects. For Category 2 and 3 projects, the Decision Authority is the MDAA, who signs the Decision Memorandum at the KDP. These signatures indicate that, as the approving official, the Decision Authority has been made aware of the technical and programmatic issues within the project, approves the mitigation strategies as presented or with noted changes requested, and accepts technical and programmatic risk on behalf of the Agency. The MDAA may delegate some of his or her Programmatic Authority to appropriate Mission Directorate staff or to Center Directors. Decision authority may be delegated to a Center Director for determining whether Category 2 and 3 projects may proceed through KDPs into the next phase of the life cycle. However, the MDAA retains authority for all program-level requirements, funding limits, launch dates, and any external commitments. All delegations are documented and approved in the Program Plan.

4.2.2 Management Councils

4.2.2.1 Program Management Councils

At the Agency level, NASA Headquarters has two levels of Program Management Councils (PMCs): the Agency PMC (APMC) and the Mission Directorate PMCs (DPMCs). The PMCs evaluate the safety, technical, and programmatic performance (including cost, schedule, risk, and risk mitigation) and content of a project under their purview for the entire life cycle. These evaluations focus on whether the project is meeting its commitments to the Agency and on ensuring successful achievement of NASA strategic goals. Table 4-3 shows the governing management councils for projects (by category).

Table 4-3 Relationship Between Projects and PMCs

	Agency PMC	Mission Directorate PMC
Category 1 Projects	□	X
Category 2 Projects		□
Category 3 Projects		□

Legend: □ Governing PMC; X PMC evaluation

For all Category 1 projects, the governing PMC is the APMC. The APMC is chaired by the NASA Associate Administrator (AA) and comprises Headquarters senior managers and Center Directors. The council members advise the AA in his or her role as the PMC Chair and Decision Authority. The APMC is responsible for:

- Ensuring that NASA is meeting the commitments specified in the relevant management documents for project performance and mission assurance.
- Ensuring implementation and compliance with NASA program and project management processes and requirements.
- Reviewing projects routinely, including NASA's institutional ability to support project commitments.
- Reviewing special and out-of-cycle assessments.
- Approving the Mission Directorate strategic portfolio and its associated risk.

As the governing PMC for Category 1 projects, the APMC evaluates projects in support of KDPs. For these projects, the KDP normally occurs at the conclusion of an APMC review as depicted in Figure 4-5. The APMC makes a recommendation to the NASA AA (or delegated Decision Authority) on a Category 1 project's readiness to progress in its life cycle and provides an assessment of the project's proposed cost, schedule, and content parameters. The NASA AA (or delegate), as the Decision Authority for Category 1 projects, makes the KDP determination on whether and how the project progresses in its life cycle and authorizes the key project cost, schedule, and content parameters that govern the remaining life-cycle activities. Decisions are documented in a formal Decision Memorandum and actions are tracked in a Headquarters tracking system such as the Headquarters Action Tracking System (HATS). (See Sections 4.2.4 and 5.5 for a description of the Decision Memorandum.)

A DPMC provides oversight for the MDAA and evaluates all projects executed within that Mission Directorate. The DPMC is the governing council for all Category 2 and 3 projects. It is usually chaired by the MDAA and comprises senior Headquarters executives from that Mission Directorate. The MDAA may delegate the chairmanship to one of his or her senior executives. The activities of the DPMC are directed toward periodically (usually monthly) assessing projects' performance and conducting in-depth assessments of projects at critical milestones. The DPMC makes recommendations regarding the following:

- Initiation of new projects based on the results from advanced studies.
- Action on the results of periodic or special reviews, including rebaselining or terminating projects.
- Transition of ongoing projects from one phase of the project life cycle to the next.

As the governing PMC for Category 2 and 3 projects, the DPMC evaluates projects in support of KDPs. The KDP normally occurs at the conclusion of the DPMC as depicted in Figure 4-5. The DPMC makes a recommendation to the MDAA (or delegated Decision Authority) on a Category 2 or 3 project's readiness to progress in its life cycle and provides an assessment of the project's proposed cost, schedule, and content parameters. The MDAA (or delegate), as the Decision Authority for Category 2 and 3 projects, makes the KDP determination on whether and how the project progresses in its life cycle and authorizes the key project cost, schedule, and content parameters that govern the remaining life-cycle activities. The results of the DPMC are documented in a formal Decision Memorandum and include decisions made and actions to be addressed.

The DPMC also evaluates Category 1 projects in support of the review by the APMC and the KDP. For Category 1 projects, the MDAA carries forward the DPMC findings and recommendations to the APMC. However, the MDAA may determine in some cases that a Category 1 project is not ready to proceed to the APMC and may direct corrective action.

4.2.2.2 Center Management Council

Centers have a Center Management Council (CMC) that typically meets monthly. The CMC provides oversight and insight for the Center Director (or designee) for all project work executed at that Center. The CMC evaluation focuses on whether the project under review is following Center engineering, Safety and Mission Assurance (SMA), health and medical, and management best practices (e.g., project management, resource management, procurement, institutional); whether Center resources support project requirements; and whether the project is meeting its approved plans successfully. The Center Director (or designee), as chair of the CMC, may provide direction to the project manager to correct project deficiencies with respect to these areas. However, the Center Director does not provide direction, but only recommendations to the project manager, Mission Directorate, or Agency leadership with respect to programmatic requirements, budgets, and schedules. The CMC also assesses project risk and evaluates the status and progress of activities to identify and report trends and provide guidance to the Agency and affected projects. For example, the CMC may note a trend of increasing risk that potentially indicates a bow wave of accumulating work or may communicate industrial base issues to other programs or projects that might be affected. The Center Director, as CMC chair, provides the Center's findings and recommendations to project managers, program managers, the DPMC, and the APMC, if applicable, regarding the performance, technical, and management viability of the project prior to KDPs. This includes making recommendations to the Decision Authority at KDPs regarding the ability of the project to execute successfully. (Figure 4-5 shows this process.) These recommendations consider all aspects, including safety, technical, programmatic, and major risks and strategy for their mitigation and are supported by independent analyses, when appropriate.

In accordance with NPR 7120.5: "Center Directors are responsible and accountable for all activities assigned to their Center. They are responsible for the institutional activities and for ensuring the proper planning for and successful execution of programs and projects assigned to the Center." This means that the Center Director is responsible for ensuring that projects develop plans that are executable within the guidelines from the Mission Directorate and that these projects are executed within the approved plans. In cases where the Center Director believes a project cannot be executed within approved guidelines and plans, the Center Director will work with the project and Mission Directorate to resolve the problem. (See Section 5.1.2 for additional information on the Center Directors' responsibilities.)

The relationship of the various management councils to each other is shown in Figure 4-6.

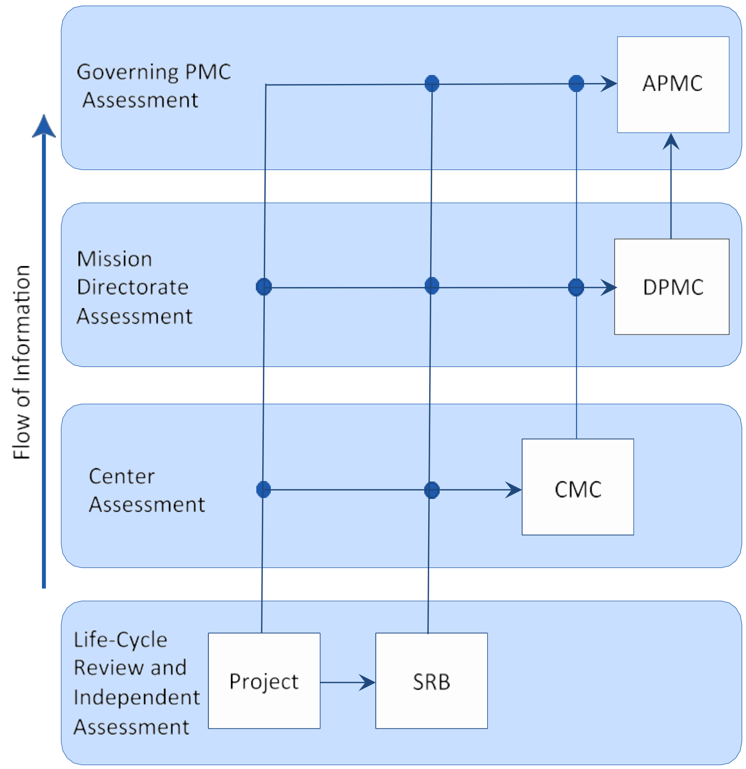


Figure 4-6 Management Council Reviews in Support of KDPs

4.2.2.3 Integrated Center Management Councils

An Integrated Center Management Council (ICMC) may be used for any project conducted by multiple Centers. The ICMC performs the same functions as the CMC but generally includes the Center Director (or representative) from each Center with a substantial project development role. The ICMC is chaired by the Center Director (or representative) of the Center responsible for the project management.

When an ICMC is used to oversee the project, the participating Centers work together to define how the ICMC will operate, when it will meet, who will participate, how decisions will be made, and how Formal Dissents will be resolved. (See Section 5.3 on Formal Dissent.) In general, final decisions are made by the chair of the ICMC. When a participating Center Director disagrees with a decision made at the ICMC, the standard Formal Dissent process is used. As an example, this would generally require that the NASA Chief Engineer resolve disagreements for engineering or project management policy issues.

4.2.3 Key Decision Points

At Key Decision Points (KDPs), the Decision Authority reviews all the materials and briefings at hand, decides whether the project is sufficiently mature and ready to progress through the life cycle, and authorizes the content, cost, and schedule parameters for the ensuing phase(s). KDPs conclude the life-cycle review at the end of a life-cycle phase. A KDP is a mandatory gate through which a project must pass to proceed to the next life-cycle phase.

A life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment and sign the Decision Memorandum.

The potential outcomes at a KDP include the following:

- Approval to enter the next project phase, with or without actions.
- Approval to enter the next phase, pending resolution of actions.
- Disapproval for continuation to the next phase. In such cases, follow-up actions may include:
  - A request for more information and/or a follow-up review that addresses significant deficiencies identified as part of the life-cycle review;
  - A request for a Termination Review for the project (Phases B, C, D, and E only);
  - Direction to continue in the current phase; or
  - Redirection of the project.

To support a KDP decision process, appropriate KDP readiness products are submitted to the Decision Authority and members of the governing PMC. These materials include the following:

- The project's proposed cost, schedule, safety, and technical plans for their follow-on phases. This includes the proposed preliminary and final project baselines at KDPs B and C, respectively.
- Summary of accepted risks and waivers.
- Project documents or updates signed or ready for signature; for example, the project Formulation Authorization Document (FAD), project Formulation Agreement, Project Plan, Memoranda of Understanding (MOUs), and Memoranda of Agreement (MOAs). (See Section 4.3.1.3.1 for more information about the FAD.)
- Summary status of action items from previous KDPs (except for KDP A).
- Draft Decision Memorandum and supporting data. (See Section 4.2.4.)
- The program manager recommendation.
- The project manager recommendation.

- The final SRB Management Briefing Package.
- The CMC or ICMC recommendation.
- The MDAA recommendation (for Category 1 projects).
- The governing PMC review recommendation.

After reviewing the supporting material and completing discussions with all parties, the Decision Authority determines whether and how the project proceeds and approves any additional actions. These decisions are summarized and recorded in the Decision Memorandum. The Decision Authority completes the KDP process by signing the Decision Memorandum. The expectation is to have the Decision Memorandum signed by concurring members as well as the Decision Authority at the conclusion of the governing PMC KDP meeting. (For more information on the Decision Memorandum, including signatories and their respective responsibilities, see Section 5.5.6.) The Decision Authority archives the KDP documents with the Agency Chief Financial Officer, and the project manager attaches the approved KDP Decision Memorandum to the Formulation Agreement or Project Plan. Any appeals of the Decision Authority's decisions go to the next higher Decision Authority. (See Section 4.3.2.1 for a detailed description of the Formulation Agreement.)

4.2.4 Decision Memorandum, Management Agreement, and Agency Baseline Commitment

The Decision Memorandum is a summary of key decisions made by the Decision Authority at a KDP, or as necessary, in between KDPs. Its purpose is to ensure that major project decisions and their basis are clearly documented and become part of the retrievable records. The Decision Memorandum supports clearly defined roles and responsibilities and a clear line of decision making and reporting documented in the official project documentation.

When the Decision Authority approves the project's entry into the next phase of its life cycle at a KDP, the Decision Memorandum describes this approval and the key project cost, schedule, and content parameters authorized by the Decision Authority that govern the remaining life-cycle activities. The Decision Memorandum also describes the constraints and parameters within which the Agency and the project manager operate; i.e., the Management Agreement, the extent to which changes in plans may be made without additional approval, and any additional actions that came out of the KDP.

The Management Agreement contained within the Decision Memorandum defines the parameters and authorities over which the project manager has management control. A project manager has the authority to manage within the Management Agreement and is accountable for compliance with the terms of the agreement. The Management Agreement, which is documented at every KDP, may be changed between KDPs as the project matures, with approval from the Decision Authority. The Management Agreement typically is viewed as a contract between the Agency and the project manager and requires renegotiation and acceptance if it changes.

During Formulation, the Decision Memorandum documents the key parameters, including LCC or initial capability cost and schedule, related to work to be accomplished during each phase of Formulation. For projects with a LCC or initial capability cost greater than $250 million, the Decision Memorandum includes a target LCC or initial capability cost range and schedule range that the Decision Authority determines is reasonable to accomplish the project. Given the project's lack of maturity during Formulation, this range reflects the broad uncertainties regarding the project's scope, technical approach, safety objectives, acquisition strategy, implementation schedule, and associated costs. The range is also the basis for coordination with the Agency's stakeholders, including the White House and Congress. At KDP B, a more refined LCC range is developed. For projects with a LCC or initial capability cost greater than $250 million and less than $1 billion, the Decision Memorandum establishes high-fidelity cost and schedule range estimates and associated confidence levels. For projects with a LCC or initial capability cost greater than or equal to $1 billion, the Decision Memorandum establishes a high and low value for cost and schedule with the corresponding JCL value.

During Implementation, the Decision Memorandum documents the parameters for the entire life cycle of the project. Projects transition from Formulation to Implementation at KDP C. At this point, the approved Life-Cycle Cost Estimate (LCCE) or initial capability cost estimate of the project is no longer documented as a range but instead as a single number. The schedule is documented as a single date. For projects with a LCC or initial capability cost greater than $250 million, the Decision Memorandum also establishes the corresponding JCL.

The LCCE includes all costs, including all Unallocated Future Expenses (UFE) and funded schedule margins for development through prime mission operations (the mission operations as defined to accomplish the prime mission objectives) to disposal, excluding extended operations.[43]

[43] Projects that are part of tightly coupled programs document their LCCE in accordance with the life-cycle scope defined in their program's Program Plan, PCA or FAD, or the project's FAD and other parameters in their Decision Memorandum and ABC at KDP C. Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point do not use extended operations.

The initial capability cost estimate includes all costs, including all UFE and funded schedule margins for development through initial capability operations.

Unallocated Future Expenses (UFE) are the portion of estimated cost required to meet the specified confidence level that cannot yet be allocated to the specific WBS sub-elements because the estimate includes probabilistic risks and specific needs that are not known until these risks are realized. (For projects that are not required to perform probabilistic analysis, the UFE should be informed by the project's unique risk posture in accordance with Mission Directorate and Center guidance and requirements. The rationale for the UFE, if not conducted via a probabilistic analysis, should be appropriately documented and be traceable, repeatable, and defendable.) UFE may be held at the project level, program level, and Mission Directorate level.

Extended operations are operations conducted after the planned prime mission operations are complete. (The planned prime mission operations period is defined in a program's FAD or PCA and in a project's FAD.) Extended operations may be anticipated when the PCA or FAD is approved, but the complexity and duration of the extended operations cannot be characterized. Examples of this case include long-duration programs, such as the space shuttle and space station programs. Alternatively, the need for extended operations may be identified later as the program or project is nearing the completion of its planned prime mission operations period. Examples include cases when extended operations contribute to the best interests of the Nation and NASA. For example, a mission may become vital to the success of programs run by another Federal agency, such as the need for mission data for terrestrial or space weather predictions by the National Oceanic and Atmospheric Administration. NASA's best interest may include continuing value to compelling science investigations that contribute to NASA's strategic goals. All extended operations periods need to be approved. The approval process is determined by the program or project's Mission Directorate and may require Agency-level approval. Program or project documentation, such as the Program or Project Plan, needs to be revised to continue the mission into extended operations.

The prime mission is approved for operations at KDP E. This mission has a defined operations span, but in many cases, the mission can be extended beyond the currently approved operational span. During the prime mission phase, the Mission Directorate may initiate consideration for approval for an extended mission:

- Generally for science missions, the Mission Directorate solicits a proposal from the project and establishes a process for proposal evaluation. This process usually includes submitting the proposal to a science theme-specific Senior Review, a peer review panel, for evaluation of the merits of the proposal. The Mission Directorate can accept, modify, or reject the proposal and can establish new budget authority for operating in the extended phase.
- For Human Space Flight (HSF) missions, the Mission Directorate asks the program office to develop a proposal for extending the mission. The Mission Directorate

evaluates the proposal and works with Agency senior management to determine the viability and cost of the extension. Extending HSF missions generally requires close coordination with the Agency stakeholders and approval of funding by Congress.

The project baseline, called the Agency Baseline Commitment (ABC), is established at approval for Implementation, KDP C. The ABC and other key parameters are documented in the Decision Memorandum.

The Agency Baseline Commitment (ABC) is an integrated set of project requirements, cost, schedule, technical content, and JCL when applicable. The ABC cost is equal to the project LCC or initial capability cost approved by the Agency at approval for Implementation. The ABC is the baseline against which the Agency's performance is measured during the Implementation Phase of a project. Only one official baseline exists for a project, and it is the ABC. The ABC for projects with a LCC or initial capability cost greater than $250 million forms the basis for the Agency's external commitment to the Office of Management and Budget (OMB) and Congress and serves as the basis by which external stakeholders measure NASA's performance for these projects. Changes to the ABC are controlled through a formal approval process. (See Section 5.5 for a detailed description of maturing, approving, and maintaining project plans, LCCs, initial capability costs, baselines, and commitments.)

4.2.5 Management Forum: Baseline Performance Review

NASA's Baseline Performance Review (BPR) serves as NASA's monthly, internal senior performance management review, integrating Agency-wide communication of performance metrics, analysis, and independent assessment for both mission and mission support projects and activities. While not a council, the Baseline Performance Review (BPR) is closely linked with the councils and integral to council operations. As an integrated review of institutional and project activities, the BPR highlights interrelated issues that impact performance and project risk enabling senior management to quickly address issues, including referral to the governing councils for decision, if needed. The BPR forum fosters communication across organizational boundaries to identify systemic issues and address mutual concerns and risks. The BPR is the culmination of the Agency's regular business rhythm performance monitoring activities, providing ongoing performance assessment between KDPs. The BPR is also used to meet requirements for quarterly progress reviews contained in the Government Performance Reporting and Accountability Modernization Act of 2010 (GPRAMA) and OMB Circular A-11 Part 6.[44]

The NASA Associate Administrator and Associate Deputy Administrator co-chair the BPR. Membership includes Agency senior management and Center Directors. The Office of the Chief Engineer (OCE) leads the project performance assessment process conducted by a

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[44] Additional information on GPRAMA can be found at https://www.congress.gov/111/plaws/publ352/PLAW-111publ352.pdf.
Additional information on A-11 Part 6 can be found at http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/s200.pdf.

team of independent assessors drawn from OCE, the Office of the Chief Financial Officer (OCFO), and the Office of Safety and Mission Assurance (OSMA).

A typical BPR agenda includes an assessment of each Mission Directorate's project performance against Management Agreements and ABCs, with rotating in-depth reviews of specific mission areas. The schedule ensures that each mission area is reviewed on a quarterly basis. Mission support functions are included in the BPR. Assessors use existing materials when possible. Table 4-4 shows typical information sources that may be used by the BPR assessors. Different emphasis may be placed on different sources depending on which mission is being assessed.

Table 4-4 Typical Information Sources Used for BPR Assessment

Program/Project Documents	FAD, Formulation Agreement, and Project Plans
Reviews	Life-cycle reviews
	Monthly, quarterly, midyear, and end-of-year Mission Directorate reviews
	Other special reviews (see Section 4.1.3)
	Monthly Center status reviews
Meetings	APMC (presentations and decision memorandums)
	DPMC (presentations and decision memorandums)
	Recurring staff and/or status meetings including project monthly status
	Project Control Board (meetings and weekly status reports)
	Biweekly tag-ups with the SMA TAs supporting and overseeing the project.
Reports	Reports from Agency assessment studies
	PPBE presentations
	Quarterly cost and schedule reports on major projects delivered to OCFO
	Center summaries presentations at BPR
	Weekly Mission Directorate report
	Weekly project reports
	Weekly reports from the NESC
	Monthly EVM data
	Project anomaly reports
	Center SMA reports
	Technical Authority reports
Databases	N2 Agency budget database
	SAP and Business Warehouse financial databases
	OMB and Congressional cost and schedule data

4.3 Project Formulation

NASA places significant emphasis on project Formulation (including activities leading to the start of Formulation) to ensure adequate preparation of project concepts and plans and mitigation of high-risk aspects of the project essential for positioning the project for the highest probability of mission success.

The following paragraphs explain the project activities chronologically by phase. In practice, the activities described for each phase are not always carried out exclusively in that phase; their timing depends on the schedule requirements of the project. For example, some projects procure long-lead flight hardware in Phase B to enable them to achieve their launch dates.

4.3.1 Concept Studies (Pre-Phase A) Activities

4.3.1.1 Project Activities Leading to the Start of Formulation (Pre-Phase A)

The process for initiating projects begins at the senior NASA management level with the strategic acquisition process. This process enables NASA management to consider the full spectrum of acquisition approaches for its projects from Commercial Off-the-Shelf (COTS) buys to total in-house design and build efforts where NASA has a unique capability and capacity or the need to maintain or develop such capability and capacity. The Agency decides whether to acquire a needed capability in-house, acquire it from outside the Agency, or acquire it by a combination of the two. Strategic acquisition is used to promote best-value approaches (considering the Agency as a whole), encourage innovation and efficiency, and take advantage of state-of-the-art solutions available within NASA and from industry, academia, other Federal agencies, and international partners.

The strategic acquisition process is the Agency process for ensuring that NASA's strategic vision, programs, projects, and resources are properly developed and aligned throughout the mission and life cycle. (See NPD 1000.0, NASA Governance and Strategic Management Handbook and NPD 1000.5, Policy for NASA Acquisition for additional information on the strategic acquisition process.)

Many processes support acquisition, including the program and project management system, the budget process, and the procurement system. The NASA Planning, Programming, Budgeting, and Execution (PPBE) process supports allocating the resources of programs to projects through the Agency's annual budgeting process. (See *NPR 9420.1, Budget Formulation* and *NPR 9470.1, Budget Execution*.) The NASA procurement system supports the acquisition of assets and services from external sources. (See *NPD 1000.5, NASA Policy for Acquisition*, the Federal Acquisition Regulation (FAR), and the NASA FAR Supplement (NFS) for NASA's specific implementation of the FAR.)

4.3.1.2 Project Pre-Phase A Life-Cycle Activities

An MDAA has the authority to begin project pre-Formulation activities. Prior to initiating a new project, a Mission Directorate, typically supported by a program office, provides resources for concept studies (i.e., Pre-Phase A Concept Studies) along with the mission objectives and ground rules and assumptions to be used by the study team. While not formally a part of Formulation, some formulation-type activities naturally occur as part of earlier advanced studies.

These pre-Formulation activities involve Design Reference Mission (DRM) analysis, feasibility studies, **technology needs analyses, engineering systems assessments**[45], human systems assessments, and analyses of alternatives that need to be performed before a specific project concept emerges. These trade studies are not considered part of formal project planning since there is no certainty that a specific project proposal will emerge. Pre-Formulation activities also involve identification of risks that are likely to drive the project's cost and schedule estimates, or cost and schedule range estimates (projects with an LCC or initial capability cost greater than $250 million), at KDP B and cost and schedule commitments at KDP C and include development of mitigation plans for those risks.

During Pre-Phase A, a pre-project team studies a broad range of mission concepts that contribute to program and Mission Directorate goals and objectives. These advance studies, along with interactions with customers and other potential stakeholders, help the team to identify promising mission concept(s) and to draft project-level requirements. The Mission Directorate uses the results of this work to determine if the mission concepts warrant continued development.

A major focus of Pre-Phase A is to conduct **technology and engineering system assessments** to identify risks that are likely to drive the project's cost and schedule estimates, or cost and schedule range estimates (projects with an LCC or initial capability cost greater than $250 million), at KDP B:

- The team identifies potential technology needs (based on the best mission concepts) and assesses the gaps between the needed technology and current or planned technology, the Technology Readiness Levels (TRLs), and the technology risks. (See NPR 7123.1, Appendix E for TRL definitions and *SP-20205003605, Technology Readiness Assessment Best Practices Guide* for technology readiness assessment best practices.)
- The team also identifies risks in engineering development, payload, supply chain, and heritage hardware and software. The team defines risk mitigation plans and resource requirements for the top risks. These activities are focused toward the Mission Concept Review (MCR) and KDP A. These activities also inform development of the **Formulation Agreement** in response to the **Formulation Authorization Document (FAD)** generated by the Mission Directorate to authorize formulation of the mission. (See the

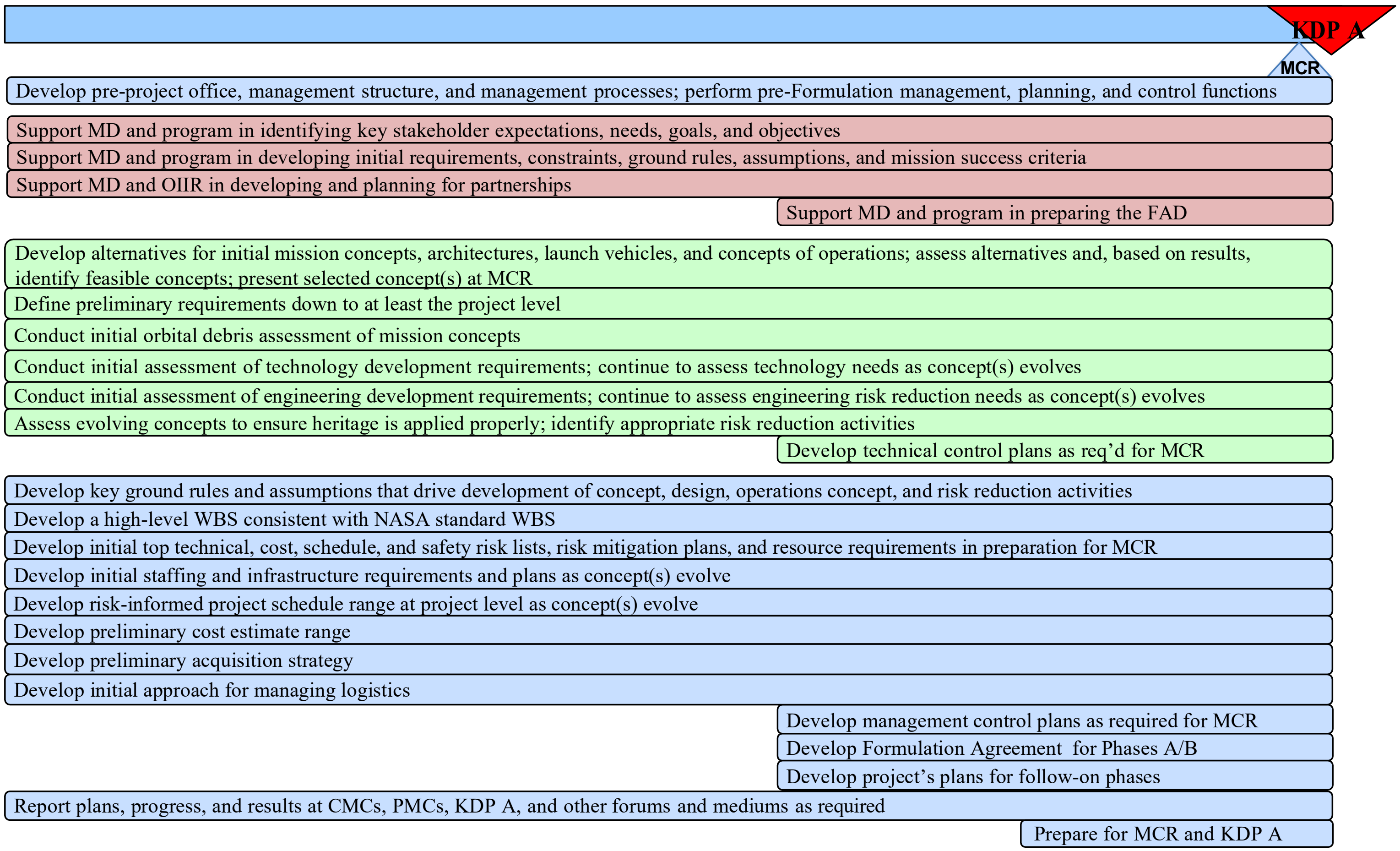
[45] In this chapter, the name of a product or control plan in bold type indicates a requirement. (Repeated references in the same paragraph are not in bold.)

following Section 4.3.1.3 for information about the FAD. See Section 4.3.2.1 for a detailed description of the Formulation Agreement.)

At the conclusion of pre-Formulation, a FAD is issued authorizing Formulation to begin, and a Formulation Agreement is developed and approved to document the plans and resources required for Formulation. (See NPR 7120.5, Appendix E for the FAD template).

The following paragraphs describe the activities a project needs to accomplish to develop one or more sound concepts, conduct a successful Mission Concept Review (MCR), and get approval at KDP A to enter project Formulation. The MCR is the first major Life-Cycle Review (LCR) in a project life cycle. The **purpose of the MCR** is to evaluate the feasibility of the proposed mission concept(s) and how well the concept(s) fulfill the project's needs and objectives. After the MCR, the project proceeds to KDP A where the project demonstrates that it has addressed critical NASA needs; the proposed mission concept(s) is feasible; the associated planning is sufficiently mature to begin Phase A; and the mission can probably be achieved as conceived.

The general flow of activities for a project in pre-Formulation is shown in Figure 4-7.



Program management, planning, and control tasks

Technical work the program is doing

Work for which Headquarters is responsible but the program helps accomplish (e.g., International partnerships are a Headquarters responsibility, but the programs help develop and finalize those partnerships)

MD = Mission Directorate
OIIR = Office of International and Interagency Relations

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 4-7 Project Pre-Phase A Flow of Activities

4.3.1.3 Project Pre-Phase A Management, Planning, and Control Activities

4.3.1.3.1 Supporting Headquarters Planning

Once the Mission Directorate decides to begin pre-Formulation, the project manager and project team (designated as the pre-project manager and pre-project team until the project is formalized) support the Mission Directorate in developing the concept for the project. When requested, the team helps identify the main stakeholders of the project (e.g., principal investigator, science community, technology community, public, education community, Mission Directorate sponsor) and gathers and documents key external stakeholder expectations, needs, goals, and objectives. The project team supports the program manager and the MDAA in the development of the preliminary program requirements, constraints, ground rules and assumptions on the project, and stakeholder expectations, including preliminary mission objectives and goals and mission success criteria. The project also supports the program manager and the MDAA in ensuring alignment of the project requirements with the Program Plan and applicable Agency strategic goals. These requirements are eventually documented in the Program Plan. The MDAA uses this information in developing and obtaining approval of the FAD. The project also develops the process to be used within the project to ensure stakeholder advocacy.

One of the first activities is to select the management team. The MDAA issues the **Formulation Authorization Document** (FAD) to authorize the formulation of a project whose goals fulfill part of the Agency's Strategic Plan and Mission Directorate strategies. The FAD describes the purpose of the project, including a clear traceability from the goals and objectives in the Mission Directorate strategies and/or Program Plan. It describes the level or scope of work, and the goals and objectives to be accomplished in the Formulation Phase. It also describes the structure for managing the Formulation process from the MDAA to the NASA Center program or project managers, as applicable, and includes lines of authority, coordination, and reporting. It identifies the Decision Authority and the governing PMC for oversight of the project, and the project category (Category 1, 2, or 3). It identifies Mission Directorates, mission support offices, and Centers to be involved in the activity, their scope of work, and any known constraints related to their efforts (e.g., the project is cofunded by a different Mission Directorate). It identifies any known participation by organizations external to NASA, their scope of work, and any known constraints related to their efforts. It identifies the funding to be committed to the project during each year of Formulation. Finally, it specifies the project LCRs planned during the Formulation Phase and includes any other requirements (e.g., the Pre-ASM, ASM) and any known unique considerations such as innovative acquisition approaches, tailoring to accommodate aspects of innovative acquisition approaches, and when the tailoring approach will be defined.

4.3.1.3.2 Initial Project Structure and Management Framework

The project team works with the Center to develop and implement an initial management framework, including the project team, organizational structure, and initial management processes consistent with the direction from the MDAA and program identifying the roles and responsibilities of each organization (e.g., Headquarters, Centers, other Government agencies, academia, industry, and international partners).

The project team supports the MDAA and the NASA Headquarters Office of International and Interagency Relations (OIIR) in identifying and planning for any preliminary **partnerships and interagency and international agreements** as they are known at the time.

4.3.1.3.3 Management Control Processes and Products

The project team conducts planning that enables formulation and implementation of the mission concept(s), architectures, scenarios or DRMs, and requirements. The results of this planning, much of which is described below, supports the MCR and KDP A by demonstrating how the project plans to implement the mission concept(s) being proposed.

As the project team develops its planning, management processes are documented in control plans, which are designed to keep the project activities aligned, on track, and accounted for as the project moves forward. These control plans are described in this and subsequent sections of this handbook in conjunction with the phase where they are required. Control plans can be either incorporated into the central planning document, which is the **Project Plan,** or developed as separate stand-alone documents referenced in the appropriate part of the Project Plan. NPR 7120.5F, Appendices H and I and Section 4.5.4 in this handbook provide considerations for determining if a control plan should be a stand-alone document. NPR 7120.5F, Appendix I, Table I-5 and Table 4-7 at the end of this chapter identify, for each control plan, whether it is a requirement or a best practice and what the maturation expectations for the control plan are, i.e., when the preliminary and baseline versions are expected and when updates are expected. Centers may have existing plans that projects can use to satisfy requirements for some of the control plans.

The project supports the MDAA and the program in the development of preliminary **driving mission, technical, and programmatic ground rules and assumptions**. The project also responds to the FAD and assists the program manager as necessary in preparing the FAD for baselining at the MCR/KDP A.

The project team develops a high-level product-oriented Work Breakdown Structure (WBS) that is consistent with the NASA standard space flight project WBS. (See Section 5.9.)

As the concepts mature and for each concept being considered, the team iteratively performs an assessment of potential infrastructure and workforce needs as well as opportunities to use that infrastructure and workforce in other Government agencies, industry, academia, and international organizations. This includes identifying and documenting concurrence for any investments, divestments, acquisition strategies, procurements, agreements, and changes to capability portfolio capability components in accordance with requirements and strategic guidance included in *NPR 8600.1, NASA Capability Portfolio Management Requirements*. Based on this assessment, the project team develops the initial **requirements and plans for staffing and infrastructure**.

Additionally, the team develops the preliminary **strategy for acquisition**, including:

- A preliminary assessment of supply chain risks, including potential critical or single-source suppliers needed to design, develop, produce, and support required capabilities at planned cost and schedule.
- An approach for managing logistics.
- Plans for in-house work versus procurements, including major proposed procurements, types of procurements, and "no later than" procurement schedules.
- Preliminary plans for partners (i.e., other Government agencies, domestic and international), their roles and anticipated contributions, and plans for obtaining commitments for these contributions.

Consistent with the technical team's work, the project develops the initial **top safety, technical, cost, and schedule risks**, including technology development, engineering development, payload (robotic space flight), and procurement risks; risks associated with the use of heritage hardware and software; and risks that are likely to drive the project's cost and schedule estimates or cost and schedule range estimates (projects with an LCC or initial capability cost greater than $250 million) at KDP B. The project identifies the initial risk mitigation plans and associated resources and the approach for managing risks during Phase A. This activity forms the foundation for the **Risk Management Plan.**

Based on the concepts that are to be carried forward, the project team develops a **risk-informed schedule** at the project level (as a minimum) with a preliminary date or a preliminary range for Phase D completion. In addition, the team develops project cost and schedule estimates or cost and schedule range estimates covering Phase A (excluding Pre-Phase A) through completion of Phase D. These cost and schedule estimates typically are informed by technology needs; initial **engineering development and heritage assessments** using *NASA/SP-2016-6105, Systems Engineering Handbook,* Appendix G, Technology Assessment/Insertion; acquisition strategies; infrastructure and workforce requirements; and the need to accommodate resolution of identified risks. The project typically also identifies the initial phased LCC, or initial capability cost and schedule estimates, or cost and schedule range estimates. (LCC and schedule cover Phase A through Phase F excluding any extended operations whereas initial capability cost and schedule cover Phase A through the first operational mission flight or as defined in the KDP B **Review Plan**.) These estimates need to be consistent with the preliminary Phase D completion estimate. The project documents the basis for initial cost and schedule estimates and develops the initial approach for managing schedule and cost during Phase A. This is the first effort in developing the **Technical, Schedule, and Cost Control Plan**, which eventually becomes part of the **Project Plan**.

The project develops an approach for knowledge management and managing the identification and documentation of lessons learned during Phase A. This includes the project's knowledge management strategy; how the project will take advantage of lessons learned identified by others; and how the project will continuously capture and use lessons learned during Formulation and Implementation. This approach evolves into a formal Knowledge Management Plan that is one of the Control Plans in the **Project Plan**. (The Knowledge Management Plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

4.3.1.4 Project Pre-Phase A Technical Activities and Products

The project team performs the technical activities required in NPR 7123.1 for this phase, starting with gathering key internal stakeholder expectations, needs, goals, and objectives. Based on these and the program-level requirements, constraints, and ground rules and assumptions, the project begins to develop concepts and architectures that satisfy the key expectations and project requirements. This process usually considers several alternative approaches to both the architecture and the **Concept Documentation**, and the project develops candidate (preliminary) **mission, spacecraft, and ground systems architectures**. The architecture includes how the major project components (hardware, software, human systems) will be integrated and are intended to operate together and with heritage systems, as applicable, to achieve project goals and objectives. By implication, the architecture defines the system-level processes necessary for development, production, human systems integration, verification, deployment, operations, support, disposal, and training. The architecture also includes facilities, logistics concepts, and planned mission results and data analysis, archiving, and reporting. The Concept Documentation includes all activities such as integration and test, launch integration, launch, deployment, and on-orbit checkout (robotic projects) or initial operations (human space flight projects), in-space operations, landing and recovery, if applicable, and decommissioning and disposal.

If the architecture and **Concept Documentation** require a launch service, the project will begin to work with the NASA Launch Services Program (LSP) to develop and assess the mission's launch options. (Launch options can include any methods specified in *NPD 8610.12, Orbital Space Transportation Services*; however, most missions use a launch service procured and managed by the LSP to facilitate the application of the launch services risk mitigation and technical oversight policies as described in *NPD 8610.7, Launch Services Risk Mitigation Policy for NASA-Owned and/or NASA-Sponsored Payloads/Missions* and *NPD 8610.23, Launch Vehicle Technical Oversight Policy*.) LSP evaluates the project's spacecraft needs and pairs the requirements of the project with an appropriate launch service. Early interaction and involvement help to ensure that the potential viable launch options are encompassed and accommodated in the spacecraft design and test plans. LSP acquires the launch service through a competitive process whenever possible, awarding based on best value to the government. The project is typically part of the proposal evaluation team. The project funds LSP's acquisition efforts required to perform preliminary studies, if necessary, and ultimately to procure the launch service. LSP provides the launch service management as well as mission assurance activities, payload launch site processing services, payload integration activities and launch phase telemetry and command services. LSP works diligently to ensure mission success, providing technical guidance through the entire process from the pre-mission planning to the post-launch phase of the project's spacecraft. The interaction with LSP will also include coordination with the project's Mission Directorate, e.g., the Science Mission Directorate (SMD) and the Space Operations Mission Directorate (SOMD), which oversees the LSP. Figure 4-8 shows the interaction of the project and the LSP throughout the project's life cycle and provides a summary of the end-to-end support that LSP provides, beginning years before the spacecraft is created and continuing until well after the spacecraft is launched.

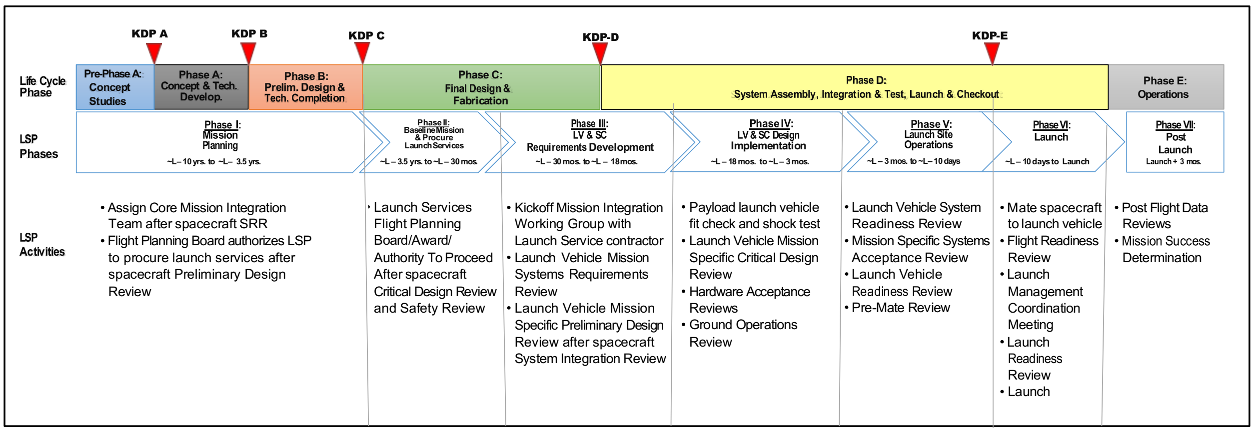


Figure 4-8 Summary of the Mission Life Cycle for Project/LSP Interaction

In addition, the project develops a **preliminary assessment of orbital debris** in accordance with *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* and identifies the planned orbital lifetime, any potential nonconformance to orbital debris requirements for planned intentional breakups, reentry of major components that potentially could reach the surface, and the use of tethers. Any deviations are submitted to the Chief, SMA for approval prior to the Acquisition Strategy Meeting (ASM).

In accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects*, the project also develops the preliminary **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status**; the preliminary **Criticality Identification Method for Hardware**; and the preliminary Hardware Quality Data Management Analytics. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

In analyzing the **Concept Documentation**, the project develops the preliminary approach to V&V, system integration, and human rating, if applicable. Identifying these at this point enables the project to assess unique workforce and infrastructure needs early enough to include the requirements for these in the initial concept(s).

As the Pre-Phase A work approaches the MCR, the project develops and documents at least one **feasible preliminary concept** (included as part of **Concept Documentation** in NPR 7120.5, Table I-4, and Table 4-6 at the end of this chapter), including the key preliminary ground rules and assumptions that drive the concept(s). A feasible concept is one that is probably achievable technically within the cost and schedule resources allocated by the program in the project's FAD. This preliminary concept includes key drivers, preliminary estimates of technical margins for candidate architectures, and a preliminary Master Equipment List (MEL). This concept is sometimes referred to as the concept of operations (ConOps) or mission concept. As a minimum, the principal concept will be approved following the MCR and KDP A. Future changes to this concept (and others, if approved for further study) will be identified at each follow-on LCR and KDP so that management understands how the concept is evolving as the formulation process progresses.

The term "concept documentation" used in NPR 7120.5 is the documentation that captures and communicates a feasible concept at MCR that meets the goals and objectives of the mission, including results of analyses of alternative concepts, the concept of operations (baselined at MCR per NPR 7123.1), preliminary risks, and potential descopes. (Descope is a particular kind of risk mitigation that addresses risks early in the project Formulation Phase.)

Based on the leading concept, the project develops the initial recommendations for mission objectives and requirements and preliminary **project-level requirements** and typically develops a mission or science traceability matrix that shows how the requirements flow from the objectives of the mission through the operational requirements (such as science measurement requirements) to the top-level infrastructure implementation requirements (such as orbit characteristics and pointing stability).

Each requirement is stated in objective, quantifiable, and verifiable terms. Requirements can identify the project's principal schedule milestones, including Preliminary Design Review (PDR), Critical Design Review (CDR), launch, mission operations critical milestones, and the planned decommissioning date. They can state the development and/or total Life-Cycle Cost (LCC) or initial capability cost constraints on the project and set forth any budget constraints by fiscal year. They can state the specific conditions under which a Termination Review would be triggered. They can also describe any additional requirements on the project such as international partners. If the mission characteristics indicate a greater emphasis is necessary on maintaining technical, cost, or schedule, then the requirements can identify which is most important, e.g., state if the mission is cost-capped, or if schedule is paramount as for a planetary mission, or if it is critical to accomplish the technical objectives as for a technology demonstration mission.

For each known project, the program team documents in the Program Plan a top-level description of the project, including the mission's science or exploration objectives; the project's category, governing PMC, and risk classification; the project's mission, performance, and safety requirements; and if there are plans for continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point. For science missions, it includes both baseline and threshold science requirements (see Appendix A for definitions) and identifies the mission success criteria for each project based on the threshold science requirements.

Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, define an initial capability during Phase A and develop an initial capability cost which establishes the Agency Baseline Commitment (ABC) at KDP C. Initial capability is the first operational mission flight (or as defined in the KDP B Review Plan) and is documented in the KDP B Decision Memorandum. Initial capability cost includes operations cost for the initial capability. The Phase E cost estimate for continuing operations and production is established separately as part of the ORR and KDP E for the 5 years after initial capability and subsequently updated and documented annually for the next 5-year period. Upgrades during Phase E that meet the Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purposes of establishing their own development ABC outside the project Phase E cost estimate. The project Phase E cost estimate is updated to include production and operations costs associated with these upgrades. Development, production, and operations costs of other (i.e., non-major) upgrades are included in the project Phase E cost estimate. (See Section 5.5.4 for additional information on developing the Phase E cost estimate.)

At this point, with guidance from its stakeholders, the project begins to select technical standards for use as project requirements in accordance with *NPR 7120.10, Technical Standards for NASA Programs and Projects*. Based on currency and applicability, technical standards required by law and those mandated by NPDs and NPRs are selected first. When all other factors are the same, NASA promotes the use of voluntary consensus standards over NASA and other Government agency technical standards when they meet or can be tailored to meet NASA's needs.

During Pre-Phase A, the project develops multiple assessments and products, described below, that may be documented in the project's **Formulation Agreement**, as opposed to developing separate plans. (See Section 4.3.2.1 for a detailed description of the Formulation Agreement.)

For each of the candidate concepts that will be carried forward into Phase A, the project develops an initial **assessment of potential technology** needs and their current Technology Readiness Level (TRL) as well as potential opportunities to use commercial, academic, and other Government agency sources of technology. The project team develops and baselines the Technology Development Plan[46] so that the needed technology development can be initiated once formal Formulation starts after KDP A. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.) This plan describes:

[46] At this point in its development, the Technology Development Plan may be part of the Formulation Agreement.

- The technology assessment, development, management, and acquisition strategies (including intellectual property considerations) needed to achieve the project's mission objectives.
- How the project will assess its technology development requirements, including how the project will evaluate the feasibility, availability, readiness, cost, risk, and benefit of the new technologies, and ensure timely reporting of new technologies to the Center Technology Transfer Office and supporting technology transfer activities as described in *NPR 7500.2, NASA Technology Transfer Requirements*.
- How the project will identify opportunities for leveraging on-going technology efforts.
- How the project will transition technologies from the development stage to the manufacturing and production phases.
- The supply chain needed to manufacture the technology and any costs and risks associated with the transition to the manufacturing and production phases; including appropriate mitigation plans for the identified risks.
- The project's strategy for ensuring that there are alternative development paths available in case technologies do not mature as expected. (Refer to NPR 7123.1 for TRL definitions and *SP-20205003605, Technology Readiness Assessment Best Practices Guide*. The Technology Readiness Assessment Best Practices Guide can be found in NODIS on the OCE tab under the "Other NASA-Level Documents" menu.)
- How the project will remove technology gaps, including maturation, validation, and insertion plans, performance measurement at quantifiable milestones, off-ramp decision gates, and resources required.
- How the project will ensure that all planned technology exchanges, contracts, and partnership agreements comply with all laws and regulations regarding export control and the transfer of sensitive and proprietary information.
- How the project will transition technologies from the development stage to manufacturing, production, and insertion into the end system, including any potential costs and risks associated with the transition to manufacturing, production, and insertion and appropriate mitigation plans for the identified risks.

In addition, the project develops an initial **assessment of engineering development** needs, including defining the need for engineering prototypes and models for the higher-risk components and assemblies that have not been previously built or flown in the planned environment and testing them to demonstrate adequate performance. As with technology development, identification at this point will enable the project to plan and initiate engineering development activities early in Formulation knowing that the funding has been planned for these activities.

A project that plans to use heritage systems outside of environments and configurations for which they were originally designed and used develops an initial **assessment of heritage**

hardware and software systems based on Appendix G, Technology Assessment/Insertion of *NASA/SP-2016-6105, Systems Engineering Handbook.*

All these activities help the project develop an initial **assessment of preliminary technical risks** for candidate architectures, including engineering development risks.

The project team develops a preliminary **Systems Engineering Management Plan** (SEMP) prior to MCR. The SEMP summarizes the key systems engineering elements and enables the project to initiate system engineering activities once Formulation has been started following KDP A. It includes descriptions of the project's overall approach for systems engineering to include system design and product realization processes (implementation and/or integration, V&V, and transition) as well as the technical management processes.

If applicable in accordance with NPR 7120.5 and NPR 7123.1, the project develops a preliminary **Human Systems Integration (HSI) Plan**. This plan describes how human systems integration and human-centered design will be integrated into the project design process and life cycle, including what types of human systems integration resources, tools, analysis, testing, and products will be employed or developed to ensure successful human systems integration, thereby reducing mission risk and total life-cycle cost while increasing overall safety. The plan also describes roles and responsibilities related to implementation of HSI. (See *NASA/SP-20210010952, NASA Human Systems Integration Handbook*[47] for additional information.)

The project also develops the preliminary **Review Plan** and identifies preliminary plans, if any, for combining LCRs in future life-cycle phases. (See Section 4.3.4.3 for a description of the Review Plan.)

4.3.2 Completing Pre-Phase A (Concept Studies) Activities and Preparing for Phase A (Concept and Technology Development)

4.3.2.1 Finalizing Plans for Phase A

As the project **FAD** is being developed at Headquarters, the project concurrently begins to develop its project **Formulation Agreement**.

[47] https://ntrs.nasa.gov/citations/20210010952

Formulation Agreement

The Formulation Agreement serves as a tool for communicating and negotiating the project's schedule and funding requirements during Phase A and Phase B with the Mission Directorate. It identifies and prioritizes the technical and acquisition activities that will have the most value during Formulation and informs follow-on plans.

The Formulation Agreement focuses on the work necessary to accurately characterize the complexity and scope of the project; increase understanding of requirements; identify and mitigate safety, technical, cost, and schedule risks; and develop high quality cost and schedule estimates. For projects with a LCC or initial capability cost greater than $250 million, this work enables the project to develop high-fidelity cost and schedule range estimates and associated confidence levels (if LCC or initial capability cost is under $1 billion) or associated JCL (if LCC or initial capability cost is greater than or equal to $1 billion) at KDP B and high-fidelity cost and schedule commitments and associated JCL at KDP C, and to commit to a successful plan for Implementation at KDP C. These activities include establishing the internal management control functions that will be used throughout the life of the project.

The Agreement is approved and signed at KDP A (baselined for Phase A and preliminary for Phase B). The Agreement is updated in preparation for the System Definition Review (SDR)/Mission Definition Review (MDR) and resubmitted for signature at KDP B (baselined for Phase B). The Formulation Agreement for KDP A includes detailed Phase A information, preliminary Phase B information, and the Formulation Cost, which is based on the estimated costs for Phase A and Phase B. The Formulation Agreement for KDP B identifies the progress made during Phase A, updates and details Phase B information, and updates the Formulation Cost, which is based on the actual cost for Phase A and an updated cost for Phase B. The Formulation Cost at KDP B is the total authorized cost for Formulation activities required to get to KDP C.

In practice, the FAD and the Formulation Agreement are developed concurrently so that both documents can be approved at KDP A. Documentation products developed as part of or as a result of the Formulation Agreement may be incorporated into the Project Plan, if appropriate, as the Project Plan is developed during Formulation.

In preparation for completing the Pre-Phase A activities, the project documents the results of its efforts in this period. The project team generates the documentation specified in NPR 7123.1 and the product Tables I-4 and I-5 in NPR 7120.5F and Tables 4-6 and 4-7 at the end of this chapter. Most of these documents have been described above. Inclusion of information in the **Formulation Agreement**, the basis of cost and schedule estimates, draft and preliminary versions of project documents and plans, and/or the Mission Concept Review (MCR) briefing package may satisfy some of the documentation requirements.

4.3.2.2 Project Pre-Phase A Reporting Activities and Preparing for Major Milestones

4.3.2.2.1 Project Reporting

The project reports to the Center, as requested by the Center, to enable the Center Director to evaluate whether engineering, SMA, health and medical, and management best practices (e.g., project management, resource management, procurement, and institutional best practices) are being followed, and whether Center resources support project requirements. The project provides project risks and the status and progress of activities so the Center can identify and report trends and provide guidance to the Agency and affected programs and projects. The CMC (or equivalent) provides its findings and recommendations to project managers and to the appropriate PMCs regarding the performance and technical and management viability of the project prior to KDPs.

Aside from the Center and Agency reporting already mentioned, many stakeholders are interested in the status of the project from Congress on down. The project manager supports the program executive in reporting the status of project Formulation at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly BPR. (See Section 4.2.5 for more information on BPRs and Section 5.12 for more information on external reporting.)

4.3.2.2.2 Project Internal Reviews

Prior to Life-Cycle Reviews (LCRs), projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. These internal reviews are the decisional meetings wherein the projects solidify their plans, technical approaches, and programmatic commitments. This is accomplished as part of the normal systems engineering work processes as defined in NPR 7123.1 wherein major technical and programmatic requirements are assessed along with the system design and other implementation plans. For both robotic and human space flight projects, these internal reviews are typically lower-level system and subsystem reviews that lead to and precede the LCR. Major technical and programmatic performance metrics are reported and assessed against predictions.

Non-SRB project technical reviews are divided into several categories: major systems reviews (one or two levels down from the project), Engineering Peer Reviews (EPRs), internal reviews, and tabletop reviews.

Project systems reviews are major technical milestones of the project that typically precede the LCR, covering major systems milestones. The technical progress of the project is assessed at key milestones such as these systems reviews to ensure that the project's maturity is progressing as required. In many cases, these reviews are conducted by the project in coordination with a Center-sponsored independent review panel if the Center is using these reviews as one means to oversee the project's work. In these cases, the project manager works with the Center to ensure that there is a suitable independent review panel in place for each such review and works with systems engineering to ensure that clear technical criteria and an agreed agenda have been established well in advance of each such review.

Systems engineering collects and reviews the documentation that demonstrates the technical progress planned for the major systems review and submits the materials as a data package to the review team prior to the review. This allows the selected technical representatives to identify problems and issues that can be discussed at the review. Systems engineering is responsible for the agenda, organization, and conduct of the systems review as well as for obtaining closure on any action items and corrective actions. Systems engineering acts as recorder, noting all comments and questions that are not adequately addressed during the presentations. At the conclusion of a major systems review, the independent review panel, if in place, makes a determination on whether the predetermined criteria for a successful review have been met and makes a recommendation on whether the system is ready to proceed into the next phase of its development.

An Engineering Peer Review (EPR) is a focused, in-depth technical review of a subsystem, lower-level assembly, or component. An EPR can address an entire system or subsystem, but more typically addresses a lower level. The EPR adds value and reduces risk through expert knowledge infusion, confirmation of approach, and specific recommendations. The key difference between an EPR and a major subsystem review is that the review panel is selected by personnel supporting the project and not by the Center. The mission systems engineer works with the respective product manager (project manager, project formulation manager, instrument manager, or principal investigator) to ensure that the EPR review panel comprises technical experts with significant practical experience relevant to the technology and requirements of the subsystem, lower-level assembly, or component to be reviewed. They also work together to produce an EPR plan, which lists the subsystems, lower-level assemblies, and components to be reviewed and the associated life-cycle milestones for the reviews. A summary of results of the EPRs is presented at each major subsystem review and/or at each LCR.

Additional informal project technical reviews, sometimes called "table top reviews," are conducted by project team members as necessary and are one of the primary mechanisms for internal technical project control. These reviews follow the general protocols described above for subsystem reviews and EPRs.

4.3.2.3 Preparing for Approval to Enter Formulation (Phase A)

Projects support the Mission Concept Review (MCR) LCR in accordance with NPR 7123.1, Center practices, and NPR 7120.5, including ensuring that the LCR objectives and expected maturity states defined in NPR 7120.5 have been satisfactorily met. LCR entrance and success criteria in Appendix G of NPR 7123.1 and the expected maturity states in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate that the project has met its expected maturity state. MCRs are generally conducted by the Center, but the Decision Authority may request an SRB to perform this review. If this is the case, Section 5.10 of this handbook and *NASA/SP-2016-3706, NASA Standing Review Board Handbook* provide guidance.

Projects plan, prepare for, and support the governing PMC review prior to KDP A and provide or obtain the KDP readiness products listed in Section 4.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the project updates its documents and plans as required to reflect the decisions made and actions assigned at the KDP.

4.3.3 Initiation of Competed Mission Projects

For competed or "Announcement of Opportunity (AO)-driven" missions, some Mission Directorates, primarily the Science Mission Directorate (SMD), choose to use either a one- or two-step process to initiate projects within a space flight program:

- In a one-step AO process, projects are competed and selected for Formulation in a single step.
- In two-step competitions, several projects may be selected in Step 1 and given time to mature their concepts in a funded concept study before the Step 2 down-selection. Program resources are invested (following Step 1 selections) to bring these projects to a state in which their science content, cost, schedule, technical performance, project implementation strategies, SMA strategies, heritage, technology requirements and plans, partnerships, and management approach can be better judged.

From the point of view of the selected AO-driven project, the proposing teams are clearly doing preparatory work and formal project Formulation (e.g., typical Pre-Phase A and Phase A tasks, such as putting together a detailed WBS, schedules, cost estimates, and implementation plan) during the concept study and the preparation of the Step 2 concept study report. From the point of view of the program, no specific project has been chosen, the total cost is not yet known, and project requirements are not yet finalized, yet Formulation has begun. Therefore, for competed missions, the selection of a proposal for concept development is the equivalent of KDP A. In a one-step AO process, projects enter Phase A after selection (KDP A) and the process becomes the conventional process for directed missions. In a two-step AO process, projects perform concept development in the equivalent of Phase A and go through evaluation for down-selection at the equivalent of KDP B. Following this selection, the process becomes conventional—with the exception that KDP B products requiring Mission Directorate input are finished as early in Phase B as feasible.

4.3.4 Project Phase A, Concept and Technology Development Activities

4.3.4.1 Project Phase A Life-Cycle Activities

Project Formulation comprises two sequential phases, Phase A (Concept and Technology Development) and Phase B (Preliminary Design and Technology Completion). Formulation is an iterative set of activities rather than discrete linear steps. The purpose of Phase A is to develop a proposed mission/system architecture that is credible and responsive to program requirements and constraints on the project, including resources. The Phase A work products need to demonstrate that the maturity of the project's mission/system definition and associated plans are sufficient to begin Phase B, and the mission can probably be achieved within available resources with acceptable risk.

During Phase A, a project team is formed or expanded (if already formed in Pre-Phase A) to update and fully develop the mission concept and begin or assume responsibility for the technology development; engineering prototyping; **heritage hardware and software assessments** using *NASA/SP-2016-6105, Systems Engineering Handbook*, Appendix G, Technology Assessment/Insertion; and other risk-mitigation activities identified in the project's **Formulation Agreement**. The project establishes performance metrics, explores the full range of implementation options, defines an affordable project concept to meet requirements specified in the Program Plan, and develops needed technologies. The primary activities in these phases include:

- Developing and defining the project requirements down to at least the system level.
- Flowing down requirements to the system and preliminary requirements to the subsystem level.
- Assessing the technology requirements, developing the plans to achieve them, and initiating development of the technology.
- Developing the project's knowledge management strategy and processes.
- Examining the Lessons Learned database for lessons that might apply to the current project's planning.
- Developing the system architecture.
- Conducting acquisition planning, including an analysis of the industrial base capability to design, develop, produce, support, and if appropriate, restart an acquisition project.
- Assessing heritage (i.e., the applicability of designs, hardware, and software in past projects to the present one) using *NASA/SP-2016-6105, Systems Engineering Handbook*, Appendix G, Technology Assessment/Insertion.
- Conducting safety, performance, cost, and risk trades.
- Identifying and mitigating development and programmatic risks, including supply chain risks.
- Conducting engineering development activities, including initiating development of engineering prototypes and models for the higher-risk components and assemblies that have not been previously built or flown in the planned environment and initiating testing of them to demonstrate adequate performance.
- Completing mission and preliminary system-level designs.
- Evaluating and refining subsystem interfaces.
- Developing time-phased cost and schedule estimates and documenting the basis of these estimates.

Finally, the project team develops the preliminary **Project Plan** and the preliminary project technical baselines, and cost and schedule estimates. Projects with an LCC or initial capability cost greater than $250 million and under $1 billion develop cost range estimates with confidence levels and schedule range estimates with confidence levels. Projects with an LCC or initial capability cost greater than or equal to $1 billion develop a JCL and provide a high and low value for cost and schedule with the corresponding JCL value (e.g., 50 percent, 70 percent).[48] The JCL is informed by a probabilistic analysis of development cost and schedule duration.[49] Formulation activities continue, normally concurrently, until Formulation output products such as the Project Plan have matured and are acceptable to the program manager, Center Director, MDAA, and NASA Associate Administrator (AA) if the AA is the Decision Authority. When applicable, these activities allow the Agency to present external stakeholders with time-phased, high-fidelity cost plans and schedule range estimates at KDP B and high-confidence cost and schedule commitments at KDP C.

Phase A completes when the Decision Authority approves transition from Phase A to Phase B at KDP B. Major project and LCRs leading to approval at KDP B are the Acquisition Strategy Meeting (ASM), the System Requirements Review (SRR), and the System Definition Review (SDR)/Mission Definition Review (MDR),[50] and the governing PMC review.

The MDAA or NASA AA determine when and whether a Pre-ASM is required and when and whether an ASM is required[51]. The purpose of the **Aquisition Strategy Meeting** (ASM) is for senior Agency management to review and agree on the acquisition strategy before authorizing resource expenditures for major acquisitions. The ASM review is based on information provided by the associated Mission Directorate or mission support office and results in approval of plans for Formulation and Implementation. Decisions are documented in the **ASM Decision Memorandum** or **ASM meeting summary**. The results of the ASM are used to finalize the **Acquisition Strategy**.

[48] This requirement is not applicable to two-step Announcement of Opportunity missions due to acquisition down-selection serving as KDP B.
[49] The methodology for JCL analysis at KDP B is not limited to a probabilistic analysis of the coupled cost and schedule specified for KDP C. Other parametric and bivariate methodologies may be applied.
[50] The SDR and MDR are the same review: robotic programs tend to use the terminology MDR and human programs tend to use SDR.
[51] Information on Pre-ASMs and ASMs, the associated Convening Authorities, and criteria for determining the Convening Authority is provided in *NPD 1000.5, Policy for NASA Acquisition* and its NASA Advisory Implementing Instructions (*NAII 1000.1, Pre-Acquisition Strategy Meeting (Pre-ASM) Guide* and *NAII 1000.2, Acquisition Strategy Meeting (ASM) Guide*).

The Acquisition Strategy Meeting (ASM) is a decision-making forum where senior Agency management reviews and approves project acquisition strategies. The ASM focuses on considerations such as impacting the Agency workforce, maintaining core capabilities, make-or-buy decisions, supporting Center assignments, potential partnerships, and risk. The ASM is held at the Agency level, implementing the decisions that flow out of the earlier Strategy Implementation Planning (SIP) process. (See Section 5.8.3.1 for information on the SIP process.)

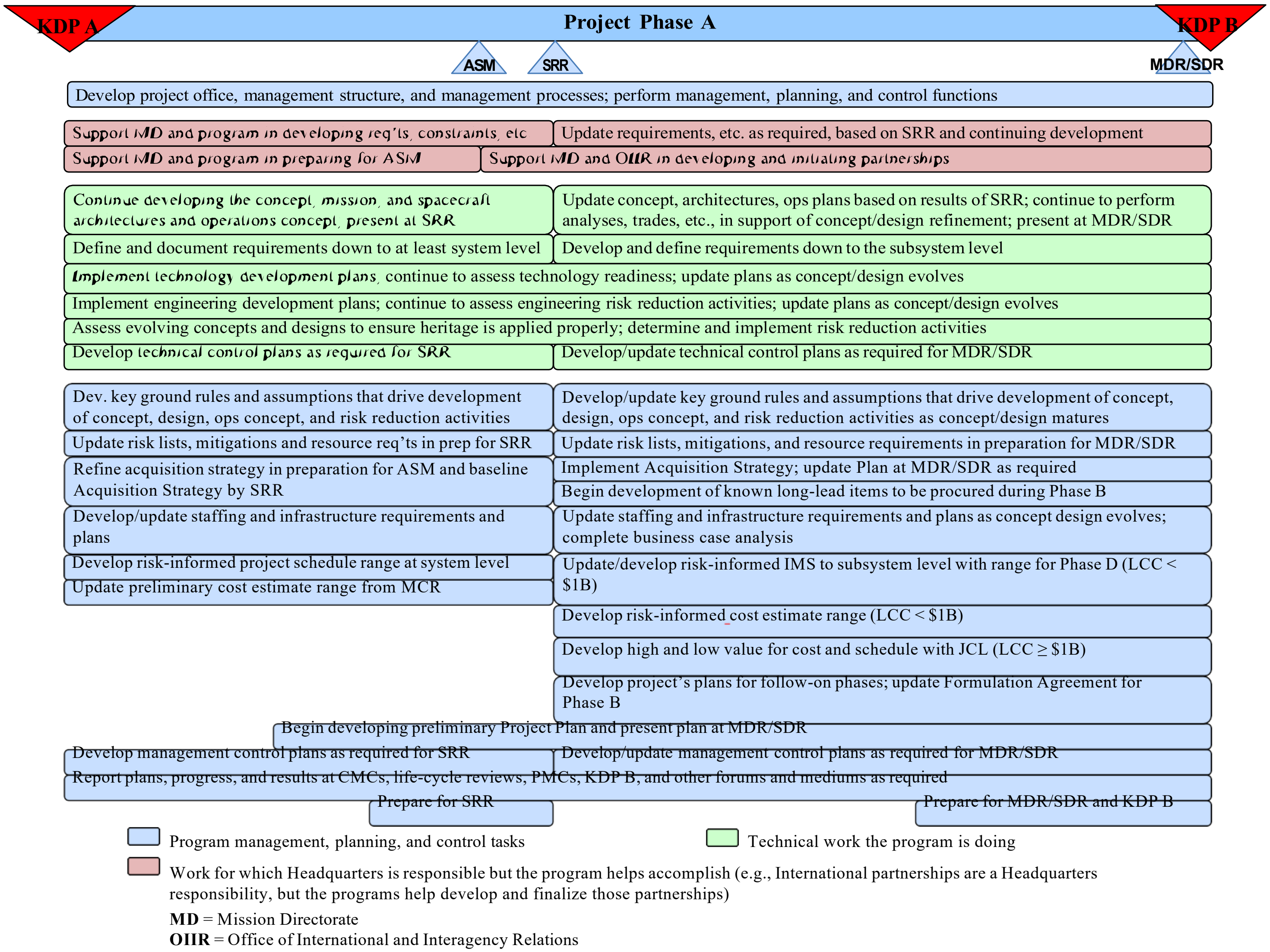
Major acquisitions are directed at and critical to fulfilling the Agency's mission, entail the allocation of relatively large resources, or warrant special management attention.

The **purpose** of the System Requirements Review (SRR) is to evaluate whether the functional and performance requirements defined for the system are responsive to the program's requirements on the project and represent achievable capabilities.

The **purpose** of the System Definition Review (SDR)/Mission Definition Review (MDR) is to evaluate the credibility and responsiveness of the proposed system/mission architecture to the program requirements and constraints on the project, including available resources, and to determine whether the maturity of the project's system/mission definition and associated plans are sufficient to begin Phase B.

At KDP B, the project is expected to demonstrate its credibility and maturity to begin Phase B and to have shown that the mission can probably be achieved within available resources with acceptable risk.

The general flow of activities for a project in Phase A is shown in Figure 4-9.



Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 4-9 Project Phase A Flow of Activities

4.3.4.2 Project Phase A Management, Planning, and Control Activities

4.3.4.2.1 Supporting Headquarters Planning

During Phase A, the project manager and project team support the program manager and the MDAA in developing the baseline **program requirements** on the project, selection and use of technical standards products, and **constraints on the project, including mission objectives, goals, and success criteria**.[52] The applicable Agency strategic goals are updated as needed. The program and the project also document any important **driving mission, technical, and programmatic ground rules and assumptions** imposed by the Mission Directorate or program. These ground rules and assumptions are baselined at System Definition Review (SDR)/Mission Definition Review (MDR). In doing this, the project supports the program manager and the MDAA in ensuring continuing alignment of the project requirements with applicable Agency strategic goals.

Early in Phase A, the Mission Directorate, with support from both the program and the project, begins to plan and prepare for the Pre-ASM and ASM, if required. This is done prior to partnership agreements so the Agency can ensure that all elements are engaged in the project in accordance with the Agency's strategic planning. The project obtains the **ASM Decision Memorandum or ASM meeting summary** after the meeting and uses it as guidance and direction to finalize the project's acquisition strategy.

Once the Agency has completed its strategic planning and has held the ASM, the project supports the program manager, the MDAA, and the NASA Headquarters Office of International and Interagency Relations (OIIR) in initiating **interagency and international agreements**, including planning and negotiating agreements and making recommendations on joint participation in reviews, integration and test, and risk management, if applicable. The project works with the appropriate NASA Headquarters offices to initiate the development of Memoranda of Understanding (MOUs) and/or Memoranda of Agreement (MOAs) with external partners as needed. U.S. partnerships and agreements are baselined at SDR/MDR.

4.3.4.2.2 Management Control Processes and Products

The project team conducts planning that enables formulation and implementation of the mission concept(s), architectures, scenarios or DRMs and requirements and implements the **Formulation Agreement**. The results of this planning, much of which is described below, support the System Requirements Review (SRR), the System Definition Review (SDR)/Mission Definition Review (MDR), and KDP B by demonstrating how the project plans to implement the mission concept(s) being proposed.

The project team continues to work with the Center to further develop and implement the management framework, fill out the project team and organizational structure, and define

[52] Program requirements on the project are contained in the Program Plan.

the initial management processes consistent with the direction from the MDAA and the program.

The project develops a preliminary **Technical, Schedule, and Cost Control Plan** by SRR and baselines the plan by SDR/MDR. This plan describes how the project monitors and controls the project requirements, technical design, schedule, and cost to ensure that the high-level requirements levied on the project are met. It describes the project's performance measures in objective, quantifiable, and measurable terms and documents how the measures are traced from the program requirements on the project. In addition, it documents the minimum mission success criteria associated with the program requirements on the project that, if not met, trigger consideration of a Termination Review. The minimum success criteria are generally defined by the project's threshold science requirements. The project also develops and maintains the status of a set of programmatic and technical leading indicators to ensure proper progress and management of the project. (See the Required and Recommended Programmatic and Technical Leading Indicators box for more information.) Per NPR 7123.1, three indicators are required: mass margins, power margins, and Request for Action (RFA) (or other means used by the project to track review comments). The status and trend of leading indicators should be presented at LCRs and KDPs. In addition to these required indicators, NASA highly recommends the use of a common set of programmatic and technical indicators to support trend analysis throughout the life cycle. Projects may also identify unique programmatic and technical leading indicators. (See Section 5.13 and the *NASA Common Leading Indicators Detailed Reference Guide* located at https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_52.pdf for additional information on leading indicators, and for specific details and examples of the three required and set of recommended indicators.)

Margins are the allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, or memory) to account for uncertainties and risks. Margins are allocated in the formulation process, based on assessments of risks, and are typically consumed as the program or project proceeds through the life cycle.

Required and Recommended
Programmatic and Technical Leading Indicators

Required (per NPR 7123.1)

1. Technical Performance Measures (mass margin, power margin)
2. Review Trends (Review Item Discrepancy (RID)/Request for Action (RFA)/action item burndown per review)

Recommended

1. Requirement Trends (percent growth, To Be Determined (TBD) and To Be Resolved (TBR) closures, # requirement changes)
2. Interface Trends (percent Interface Control Document (ICD) approval, TBD and TBR burndown, # interface requirement changes)
3. Verification Trends (closure burndown, # deviations and waivers approved and open)
4. Software Unique Trends (# software requirements per build or release versus plan)[53]
5. Problem Report and/or Discrepancy Report Trends (# open, # closed)
6. Manufacturing Trends (# nonconformance and/or corrective actions)
7. Cost Trends (plan versus actual, Unallocated Future Expenses (UFE), Earned Value Management (EVM), New Obligation Authority (NOA))
8. Schedule Trends (critical path slack or float, critical milestones, EVM schedule metrics, etc.)
9. Staffing Trends (Full-Time Equivalent (FTE) and Work-Year Equivalent (WYE) plan versus actual)
10. Manufacturing Trends (# nonconformance and/or corrective actions (open, closed, or resolved))
11. Additional project-specific indicators as needed (e.g., human system integration compliance)

The plan describes the following:

- How the project will monitor and control its ABC.
- How the project will periodically report performance.
- How the project will mitigate exceeding the development cost documented in the ABC and take corrective action prior to triggering the 30 percent breach threshold.[54]
- How the project will support a Rebaseline Review in the event the Decision Authority directs one. (For more information on Rebaseline Reviews, see Section 5.5.5.1.)
- How the project will implement Technical Authority (engineering, health and medical, and safety and mission assurance).

[53] Note that there are software measurement requirements other than Technical Leading Indicators in *NPR 7150.2, NASA Software Engineering Requirements* (e.g., SWE-091) which have implementation guidance in *NASA-HDBK-2203, NASA Software Engineering and Assurance Handbook* (http://swehb.nasa.gov).
[54] A breach occurs when the projected cost estimate for development cost exceeds the ABC cost for Phase C through D by 30 percent or more. See Section 5.5 for additional information.

- How the project will implement metric (International System of Units (SI), commonly known as the Système Internationale (SI) or metric system of measurement) and nonmetric systems of measurement and identify units of measure in all product documentation. (See Section 4.3.4.3 for more details.)
- How the project will implement Earned Value Management (EVM), including:
  - How the **Performance Measurement Baseline (PMB)** will be developed and maintained and how Unallocated Future Expenses (UFE) will be established and controlled.

    The Performance Measurement Baseline is a time-phased budget plan for accomplishing all authorized work scope in a project's life cycle, which includes both NASA internal costs and supplier costs. The project's performance against the PMB is measured using EVM if EVM is required, or other performance measurement techniques if EVM is not required. The PMB does not include UFE.

  - What methods the project will use to authorize work and to communicate changes to the scope, schedule, and budget of all suppliers; how the plan is updated as make-or-buy decisions and agreements are made.
  - How the project team will communicate the time-phased levels of funding that have been forecast to be made available to each supplier.
  - For the class of suppliers not required to use EVM, what schedule and resource information will be required of the suppliers to establish and maintain a baseline and to quantify schedule and cost variances; how contractor performance reports will be required.
  - How the cost and schedule data from all partners and/or suppliers will be integrated to form a total project-level assessment of cost and schedule performance.
- What if any additional specific tools will be necessary to implement the project's control processes; e.g., the requirements management system, project scheduling system, project information management systems, budgeting, and cost accounting system.
- How the project will monitor and control the Integrated Master Schedule (IMS). The project develops a summary of its IMS, including all critical milestones, major events, life-cycle reviews, and KDPs throughout the project life cycle. The summary of the IMS includes the logical relationships (interdependencies) for the various project elements and projects and critical paths as appropriate and identifies **driving ground rules and assumptions** and constraints affecting the schedule. The summary of the IMS is included in the **Project Plan**.
- How the project will use its technical and schedule margins and UFE to stay within the terms of the Management Agreement and ABC.

- How the project plans to report technical, schedule, and cost status to the program manager, including the frequency and level of detail of reporting.
- How the project will request technical waivers and deviations and handle Formal Dissents.
- What the project's descope plans will be, including key decision dates, savings in cost and schedule, and how the descopes will be related to the project's threshold performance requirements.
- What the project's systems engineering organization and structure will be, and how the project chief engineer will execute the overall systems engineering functions.

The project team expands the WBS, consistent with the NASA standard space flight project WBS (see Section 5.9) and provides the project's WBS and WBS dictionary to the Level 2 elements in accordance with the standard template in Figure 4-10. The WBS supports cost and schedule allocation down to a work package level; integrates both Government and contracted work; integrates with the Earned Value Management System (EVMS) approach; allows for unambiguous cost reporting; and is designed to allow project managers to monitor and control work package/product deliverable costs and schedule.

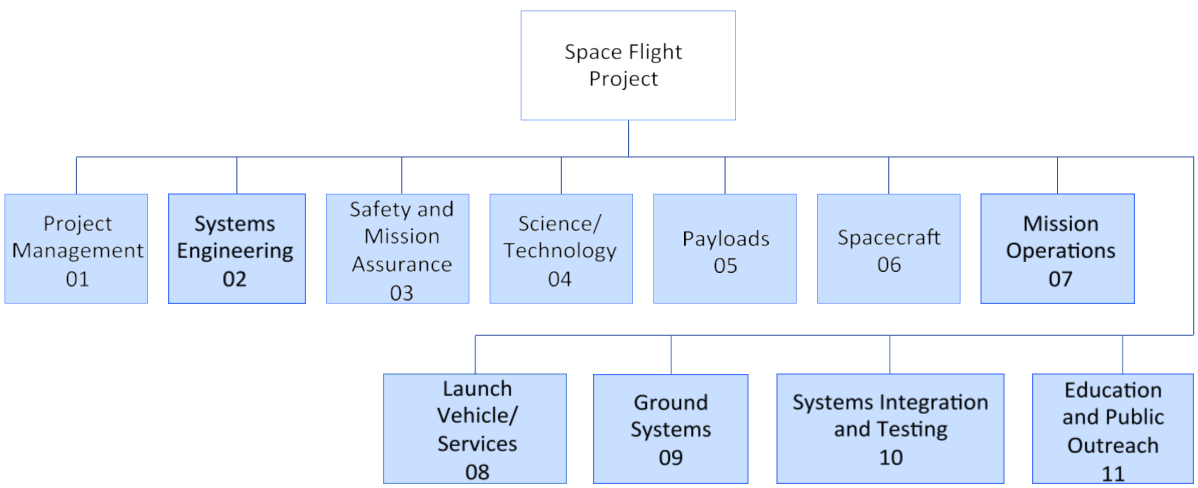


Figure 4-10 Standard Level 2 WBS Elements for Space Flight Projects

A work package is a natural subdivision of control accounts. A work package is simply a task/activity or grouping of work. A work package is the point at which work is planned, progress is measured, and earned value is computed.

The project team develops its resource baseline, which includes funding requirements by fiscal year and the New Obligation Authority (NOA) in real-year dollars for all years: prior, current, and remaining. The funding requirements are consistent with the project's WBS and include funding for all cost elements required by the Agency's full-cost accounting procedures. Funding requirements are consistent with the budget. The resource baseline provides a breakdown of the project's funding requirements to the WBS Level 2 elements. The resource baseline provides the workforce requirements by fiscal year, consistent with the project's funding requirements and WBS. Throughout the Implementation Phase, for projects with a LCC or initial capability cost greater than $250M, baselines are based on and maintained consistent with the approved JCL in accordance with *NPD 1000.5, Policy for NASA Acquisition* and NPR 7120.5. (The resource baseline also includes the **infrastructure requirements**, discussed elsewhere in this section.)

The project further develops and baselines the key ground rules and assumptions that drive development of the mission concept, engineering prototyping plans and status, required funding profiles and schedules for Phases A and B, results of **technology heritage assessments** and key subsystem trade studies, technical requirements, and the programmatic preliminary baseline. Once the project has defined the ground rules and assumptions, it tracks them through Formulation to determine if they are being realized (i.e., remain valid) or if they need to be modified.

As the concepts mature, the project team updates its assessment of potential infrastructure and workforce needs versus current plans, as well as opportunities to use infrastructure and workforce in other Government agencies, industry, academia, and international organizations for each concept being considered. (**Infrastructure requirements** and plans are developed in accordance with *NPR 9250.1, Property, Plant, and Equipment and Operating Materials and Supplies*, *NPD 8800.14, Policy for Real Estate Management*, and *NPR 8820.2, Facility Project Requirements (FPR)*.) Based on this assessment, the project team updates the initial requirements and plans for staffing and infrastructure at both the SRR and the SDR/MDR. As part of this activity, the project completes a preliminary **business case analysis** for infrastructure for each proposed real property infrastructure investment consistent with *NPR 8800.15, Real Estate Management Program* and the *NASA Business Case Guide for Real Property and Facilities Project Investments.*[55] The **business case analysis** needs to be initiated in sufficient time to allow the analysis, documentation, review, approval, and funding of the infrastructure to support the mission requirements. Also, in coordination with the OCFO and in accordance with *NPR 9250.1, Property, Plant, and Equipment and Operating Materials and Supplies*, the project team updates the **Capitalization Determination Form (CDF)** (Form NF 1739)[56] to determine the appropriate accounting treatment of capital assets. Once it has completed the questionnaire, the project team forwards it to the OCFO, Property Branch.

The project team expands the preliminary strategy for acquisition developed in Pre-Phase A and develops its **Acquisition Strategy**. The Acquisition Strategy is the plan or approach for using NASA's acquisition authorities to achieve the project's mission. The strategy includes recommendations from make versus buy analyses, the recommendations from competed versus directed analyses, proposed partnerships and contributions, proposed

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[55] https://www.hq.nasa.gov/office/codej/codejx/Assets/Docs/NASA_Business_Case_Guide_11_29_10.pdf
[56] The questionnaire can be found in NASA's Electronics Forms Database website: https://nef.nasa.gov/

infrastructure use and needs, budget, and any other applicable considerations. This strategy addresses the project's initial plans for obtaining the systems, research, services, construction, and supplies that it needs to fulfill its mission, including any known procurement(s), the availability of the industrial base capability and necessary supply chain, and attendant risks.

The project team works with the Mission Directorate and the program to prepare for the Pre-ASM and ASM, if required. Once the ASM is completed, the project team obtains a copy of the **ASM Decision Memorandum** or **ASM meeting summary** and finalizes the **Acquisition Strategy** based on the ASM direction. The Acquisition Strategy is baselined by SRR and updated at SDR/MDR. The project Acquisition Strategy:

- Is developed by the project manager, supported by the host Center's Procurement Officer, and needs to be consistent with *NPD 1000.5, Policy for NASA Acquisition*, the results of the Agency strategic acquisition process, and the ASM.
- Documents an integrated acquisition strategy that enables the project to meet its mission objectives and provides the best value to NASA.
- Identifies all major proposed acquisitions (such as engineering design study, hardware and software development, mission and data operations support, and sustainment) in relation to the project WBS and provides summary information on each proposed acquisition, including a contract WBS; major deliverable items; recommended type of procurement (e.g., competitive, Announcement of Opportunity (AO) for instruments); type of contract (e.g., cost-reimbursable, fixed-price); source (e.g., institutional, contractor, other Government agency, or international organization); procuring activity; and surveillance approach.
- Identifies the major procurements that require a Procurement Strategy Meeting (PSM).
- Describes completed or planned studies supporting make-or-buy decisions, considering NASA's in-house capabilities and the maintenance of NASA's core competencies as well as cost and best overall value to NASA.
- Describes the supply chain and identifies potential critical and single-source suppliers needed to design, develop, produce, support, and if appropriate, restart an acquisition project.
- Promotes sufficient project stability to encourage industry to invest in, plan for, and bear its share of risk.
- Describes the internal and external mechanisms and procedures used to identify, monitor, and mitigate supply chain risks and includes data reporting relationships that allow continuous surveillance of the supply chain and provide for timely notification and mitigation of potential risks.
- Describes the process for reporting supply chain risks to the program.
- Identifies the project's approach to strengthening SMA in contracts.

- Describes all agreements, MOUs, barters, in-kind contributions, and other arrangements for collaborative and/or cooperative relationships, including partnerships created through mechanisms other than those prescribed in the FAR and NFS. It lists all such agreements (the configuration control numbers, the date signed or projected dates of approval, and associated record requirements) necessary for project success. It includes or references all agreements concluded with the authority of the project manager and references agreements concluded with the authority of the program manager and above. These include (1) NASA agreements (e.g., space communications, launch services, inter-Center MOAs) and (2) non-NASA agreements, both domestic (e.g., U.S. Government agencies) and international (e.g., MOUs).
- Describes intellectual property considerations and goals for advanced technologies to protect core NASA interests during the project life cycle; the process for respecting and protecting privately developed intellectual property; the process for ensuring that acquisition strategies, proposals, and contract awards reflect intellectual property considerations established for the project; the approach for ensuring that the intellectual property strategy promotes competition for post-production sustainment and/or modernization contracts; the approach for seeking flexible and creative solutions to intellectual property issues that meet the desires of the parties and reflect NASA's investment; the approach for ensuring procurement contracts specify both (1) the delivery of necessary technical data and computer software and (2) the license rights necessary for technical data and computer software; and the approach for ensuring the delivery of technical data and computer software under procurement contracts is marked in accordance with the contract at the time of delivery.

The Procurement Strategy Meeting (PSM) provides the basis for approval of the approach for major procurements for programs and projects and ensures they are following the law including the Federal Acquisition Regulation (FAR). Detailed PSM requirements and processes, prescribed by the FAR and the NASA FAR Supplement (NFS) and formulated by the Office of Procurement, ensure the alignment of portfolio, mission acquisition, and subsequent procurement decisions. The contents of written acquisition plans and PSMs are delineated in FAR Subpart 7.1, Acquisition Plans, and NFS Subpart 1807.1, Acquisition Plans, and in the Guide for Successful Headquarters Procurement Strategy Meetings at https://ooptechportal.hq.nasa.gov/Documents/NASA%20PSM%20Guide.pdf

During this period, projects with contracts requiring EVM will conduct the required Integrated Baseline Reviews (IBRs) focusing on EVM system planning. (Refer to NFS Subpart 1834.2, Earned Value Management System.)

By SRR, the project team baselines a **Risk Management Plan** that includes the content required by *NPR 8000.4, Agency Risk Management Procedural Requirements*. The plan summarizes how the project will implement a risk management process (including Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM)) in accordance with NPR 8000.4. It includes the initial Significant Risk List and appropriate actions to mitigate each risk. Projects with international or other U. S. Government agency contributions need to plan for, assess, and report on risks due to international or other government partners and plan for contingencies. Consistent with the technical team's work, the project continues to identify, assess, and update the technical, cost, schedule, and safety risks that threaten the system requirements, mission concept, operations concept, and technology development. Risks include, but are not limited to, technology development, engineering development, payload (robotic space flight), and procurement risks; risks associated with use of heritage hardware and software; and risks that are likely to drive the project's cost and schedule, or cost and schedule ranges (projects with an LCC or initial capability cost greater than $250 million) at KDP B. The project team updates, identifies, assesses, and mitigates (if feasible) supply chain risks, including potential critical or single-source suppliers needed to design, develop, produce, and support required capabilities at planned cost and schedule. The project team reports risks to the program in accordance with the approved **Acquisition Strategy**. The project team identifies risk mitigation plans and associated resources for managing and mitigating risks in accordance with the Risk Management Plan.

Projects develop a preliminary Communications Plan by SRR (the plan is baselined at PDR). (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.) The plan is developed in collaboration with the Associate Administrator (AA) for the Office of Communications or designee. It identifies key project milestones that will be of interest to the general public, the media, and other key stakeholders and plans to engage these audiences via audio and real and/or near real-time high-resolution video and/or imagery for each milestone including during full mission operations. The plan summarizes how these efforts will promote understanding of and engagement with project objectives, elements, benefits, and contributions to overarching NASA goals. Resources and technical requirements for implementation of communications for the general public, media, and other key stakeholders are identified in collaboration with the Office of Communications AA or designee. (See the Communications Plan Template (on the website for the Office of Communications, http://communications.nasa.gov/content/nasa-comm-guidelines.)

By the SDR/MDR, all projects prepare a preliminary **Project Plan** that follows the template in NPR 7120.5F, Appendix H. The Project Plan contains a number of required control plans. NPR 7120.5F, Appendix I, Table I-5, and Table 4-7 at the end of this chapter show which of the control plans are required during this phase and describe when the control plans are required to be developed. Each of these control plans is described in this chapter, and some of them are required to be baselined before the Project Plan is fully finished and baselined at PDR. These early control plans help the project team manage its early work and become part of the preliminary Project Plan. During Phase B, there is an overlap between the **Formulation Agreement** and the preliminary Project Plan. The Formulation Agreement is the agreement between the Mission Directorate and the project that governs the work during Phase B; however, the control plans that are baselined govern the management and technical control processes used during this phase.

All project teams prepare **cost and schedule estimates** for both SRR and SDR/MDR consistent with **driving ground rules and assumptions, risks, requirements**, and available funding and schedule constraints:

- Based on the refined concept or design and its risks at SRR, the project team develops a **risk-informed schedule at the system level** (as a minimum) with a preliminary Phase D completion date estimate or range by SRR**.** In addition, the project team updates the initial **project cost estimate** or range, prepared for the MCR/KDP A, by SRR. For projects with a LCC or initial capability cost greater than $250 million, these cost and schedule estimates are ranges that represent optimistic outcomes and pessimistic outcomes if all risks and unknown-unknowns materialize. In other words, the ranges ensure the upper limits will not be exceeded by the final cost and schedule commitments made at KDP C. The costs need to include institutional funding requirements, technology investments, and multi-Center operations; costs associated with Agency constraints (e.g., workforce allocations at Centers); and costs associated with efficient use of Agency capital investments, facilities, and workforce.
- As the project approaches SDR/MDR and KDP B, the project team prepares its **project preliminary baselines**. The project develops and documents preliminary project baselines and a proposed Management Agreement for all work to be performed by the project. All preliminary baselines are consistent with the program requirements and constraints levied on the project, key assumptions, workforce estimates, key acquisitions, and significant risks. The preliminary project baselines support the Decision Authority in establishing cost and schedule estimates, or cost and schedule range estimates that can be provided to external stakeholders, if applicable. The preliminary project baseline cost and schedule estimates include:
  - A risk-informed life-cycle cost or initial capability cost estimate or cost range estimate based on the project's preliminary baselines and mission concept. (This product includes phased LCC or initial capability costs and is developed using the latest accounting guidance and practices.) The project team develops its cost estimates using many different techniques. These include, but are not limited to, bottoms-up estimates where specific work items are estimated by the performing organization using historical data or engineering estimates; vendor quotes; analogies; and parametric cost models. (See Section 5.6 for a discussion of probabilistic cost estimating.)
  - Proposed annual budgeted costs or range of annual budgeted costs by Government fiscal year and by the project's WBS.
  - Proposed annual UFE or range of annual UFE.
  - A risk-informed, preliminary **Integrated Master Schedule** (IMS) that contains the following key data elements: all task and/or milestone sequence interdependency assignments, WBS code assignment on all tasks and/or milestones, current task and/or milestone progress, and clearly identifiable schedule margin.

- Projects with an LCCE or initial capability cost estimate greater than $250 million and less than $1 billion develop their range of cost and range for schedule estimates with confidence levels identified for the low and high values of the range. These confidence levels are established by a probabilistic analysis and are based on identified resources and associated uncertainties by fiscal year. These analyses can be separate analyses of cost and schedule; a JCL is not required at this point but may be used.
- Projects with a LCCE or initial capability cost estimate greater than or equal to $1 billion develop a high and low value for cost and schedule with the corresponding JCL value.[57] The JCL is informed by a probabilistic analysis of development cost and schedule duration.[58]
- These cost and schedule range estimates typically are informed by technology needs, **engineering development and heritage assessments**, acquisition strategies, infrastructure and workforce requirements, and identified risks.

Projects document the **Basis of Estimate** (BoE) for initial cost and schedule estimates at both SRR and SDR/MDR.

The Basis of Estimate (BoE) documents the ground rules and assumptions and drivers used in developing the cost and schedule estimates, including applicable model inputs, rationale or justification for analogies, and details supporting cost and schedule estimates. The BoE is contained in material available to the Standing Review Board (SRB) and management as part of the Life-Cycle Review (LCR) and Key Decision Point (KDP) process. Good BoEs are well-documented, comprehensive, accurate, credible, traceable, and executable. Sufficient information on how the estimate was developed needs to be included to allow review team members, including independent cost analysts, to reproduce the estimate if required. Types of information can include estimating techniques (e.g., bottoms-up, vendor quotes, analogies, parametric cost models), data sources, inflation, labor rates, new facilities costs, operations costs, sunk costs, etc.

All flight projects baseline the **Cost Analysis Data Requirement** (CADRe) parts A, B, and C consistent with the *NASA Cost Estimating Handbook*[59] 30 to 45 days after the KDP event to reflect any decisions from the KDP. This CADRe is based on the project's baseline presented at the SRR or update presented at SDR/MDR.

4.3.4.3 Project Phase A Technical Activities and Products

The project team continues developing the project's concept and architecture, its major components and how they will be integrated, and the concept of operations, and continues working with the Launch Services Program (LSP) to refine the viable launch service

[57] This requirement is not applicable to two-step Announcement of Opportunity missions due to acquisition down-selection serving as KDP B.
[58] The methodology for JCL analysis at KDP B is not limited to a probabilistic analysis of the coupled cost and schedule specified for KDP C. Other parametric and bivariate methodologies may be applied.
[59] https://www.nasa.gov/content/cost-estimating-handbook

options, if applicable. In this phase, the LSP works with the project to refine spacecraft customer requirements, prepare the acquisition strategy for the launch service, identify support services and estimated costs, establish dates for spacecraft delivery, and complete a launch service assessment. System engineering plays a major role during Formulation as described in NPR 7123.1. The project performs the iterative and recursive process of functional analysis, requirements allocation, trade studies, preliminary synthesis, evaluation, and requirements analysis. As the project approaches the SRR, the project documents the updated concept, baselines the mission and spacecraft architecture, and defines and documents the preliminary ground and payload architectures and preliminary concepts of operations. As the project approached SDR/MDR, it updates the mission and spacecraft architecture and baselines the ground and payload architecture.

Based on the leading concept, the project baselines the mission objectives and **project-level and system-level requirements** at SRR, including allocated and derived requirements down to at least the system level. If not already defined, the project team identifies the payload risk classification as described in *NPR 8705.4, Risk Classification for NASA Payloads*. The project needs to continue to update and maintain the requirements traceability matrix initially developed in Pre-Phase A. The project updates the project-level and system-level requirements and develops and documents the preliminary subsystem requirements at SDR/MDR.

The project team assesses the ability of the project and all contributors to the project, including contractors, industrial partners, and other partners to use the International System of Units[60] (the Système Internationale (SI), commonly known as the metric system of measurement). This assessment determines an approach that maximizes the use of SI while minimizing short- and long-term risk to the extent practical and economically feasible or to the extent that the supply chain can support utilization without loss of markets to U.S. firms. Use of the SI or metric system of measurement is especially encouraged in cooperative efforts with international partners. This assessment documents an integration strategy if both SI and U.S. customary units are used in a project. The assessment is completed and documented in the preliminary **Project Plan** no later than the SDR/MDR. To the degree possible, projects need to use consistent measurement units throughout all documentation to minimize the risk of errors. Where full implementation of the metric system of measurement is not practical, hybrid configurations (i.e., a controlled mix of metric and nonmetric system elements) may be used to support maximum practical use of metric units for design, development, and operations. Where hybrid configurations are used, the project describes the specific requirements established to control interfaces between elements using different measurement systems.

[60] National Institute of Standards and Technology (NIST) Special Publication 330, The International System of Units (SI) at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.330-2019.pdf.

Following the SRR, the project updates the **Concept Documentation**, architectures, and requirements based on the results of the SRR and continues to perform analyses and trades in support of concept or design refinement.

Projects that plan to develop technologies initiate the development of technologies as agreed to in the **Formulation Agreement**. As the technologies develop, the project monitors, assesses, and reports the status of technology readiness advancement. Projects update their Technology Development Plan at SRR, including assessment points to terminate development of technologies that are not maturing adequately, with corresponding alternate approaches.

Projects implement engineering development plans, heritage hardware and software assessments (using *NASA/SP-2016-6015, Systems Engineering Handbook,* Appendix G, Technology Assessment/Insertion), and risk mitigation plans identified in the project **Formulation Agreement** for Phase A. As these risk reduction plans are executed, the project monitors, assesses, updates, and reports the status of **engineering development results and heritage assessments**. Projects update their plans when needed.

In accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects*, the project updates the preliminary **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status**; the preliminary **Criticality Identification Method for Hardware**; and the preliminary Hardware Quality Data Management Analytics at SRR and SDR/MDR. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project typically begins to refine the list of descope options that may be needed if development begins to exceed the resources allocated. Documentation of the project's descope plans typically includes a detailed description of the potential descope, the effect of the descope on the project's success criteria, the cost and schedule savings resulting from the descope, and key decision dates by when the descope needs to be exercised to realize these savings.

The **Project Plan** contains a number of required control plans, many of which are technical. NPR 7120.5F, Appendix I, Table I-5, and Table 4-7 at the end of this chapter show the control plans that are required during Phase A and when they need to be developed. Each of the technical control plans is described in this handbook section.

The project team baselines the **Systems Engineering Management Plan** (SEMP) at SRR and updates it at SDR/MDR.

If applicable, in accordance with NPR 7120.5 and NPR 7123.1, the project baselines the **Human Systems Integration (HSI) Plan** at SRR. The HSI Plan is updated at SDR/MDR.

In accordance with *NPR 8705.2, Human-Rating Requirements for Space Systems* for crewed missions and *NPR 8705.4, Risk Classification for NASA Payloads* for uncrewed missions and payloads, the project develops and baselines the **Safety and Mission Assurance (SMA) Plan** by SRR and updates the plan at SDR/MDR. The SMA Plan reflects a project life-cycle SMA process perspective, addressing areas including SMA domain management and SMA domain integration (e.g., for safety, reliability, maintainability, quality, planetary protection, etc.) with other engineering and management functions (e.g., concept and design trade-studies, risk analysis and risk assessments, risk-informed decision making, fault tolerance and contingency planning, knowledge capture, hardware and software design assurance, supply chain risk management and procurement, hardware and software design verification and test, manufacturing process design and control, manufacturing and product quality assurance, system verification and test, preflight verification and test, operations, maintenance, logistics planning, maintainability and sustainability, operational reliability and availability, decommissioning, and disposal). In addition, the SMA Plan describes:

- How the project will develop and manage a closed-loop problem reporting and resolution system and how it develops, tracks, and resolves problems. The data-collection process needs to be well-defined and include a data-collection system for hardware and software problem and anomaly reports, problem analysis, and corrective action.
- How the project will approach the flow-down requirements as appropriate to external developers and suppliers in acquisitions (e.g., contracts and purchase orders).
- How the project will develop, evaluate, and report indications of SMA program maturity and effectiveness at LCRs or other executive reviews including through the use of metrics and indicators that are not otherwise included in formal LCR deliverables or are not elements of the Certification of Flight Readiness (COFR) process (e.g., satisfactory progress towards human rating).

At SDR/MDR, the project updates the Technology Development Plan, baselined at MCR. This plan may be part of the **Formulation Agreement** rather than a separate plan. (The Technology Development Plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project develops the preliminary **System Security Plan** by SRR in accordance with *NPR 2810.1, Security of Information and Information Systems*. This plan identifies and prepares a System Security Plan for each information system. The System Security Plan provides an overview of the security requirements for an information system and describes the security controls in place or planned for meeting those requirements. System Security Plans are generated and stored within the NASA Risk Information and Security Compliance System (RISCS) at https://riscs-info.nasa.gov/. Multiple systems may be covered under a single System Security Plan. Controls selected within the System Security Plan are included as system requirements for the system or systems covered by the plan. This plan also describes the project's approach to implementing cybersecurity requirements in accordance with NPR 2810.1 if there are requirements outside the scope of the System Security Plan(s).

The project develops one or more preliminary **Software Management Plan**(s) by SRR and baselines them by SDR/MDR. The plan summarizes how the project will develop and/or manage the acquisition of software required to achieve project and mission objectives. It includes the content required by *NPR 7150.2, NASA Software Engineering Requirements* and *NASA-STD-8739.8, Software Assurance and Software Safety Standard*[61], unless approved otherwise. The plan needs to be aligned with the **Systems Engineering Management Plan** (SEMP).

The project develops a preliminary **Verification and Validation (V&V) Plan** by SDR/MDR and baselines it at PDR. The plan summarizes how the project will perform V&V of the project products. It indicates the methodology to be used in the V&V (test, analysis, inspection, or demonstration) as defined in NPR 7123.1. At this point in time, the level of detail is consistent with the level of detail of the concept or design.

The project updates the preliminary **Review Plan** presented at MCR, baselines the plan at SRR, and updates it at SDR/MDR. The plan summarizes how the project will conduct a series of reviews, including internal reviews and project LCRs in accordance with Center best practices, program review requirements, and the requirements in NPR 7123.1 and NPR 7120.5. The **Review Plan** identifies the LCRs the project plans to conduct and the purpose, content, and timing of those LCRs. It documents any planned deviations or waivers granted from the requirements in NPR 7123.1 and NPR 7120.5F, including tailoring to accommodate aspects of innovative acquisition approaches. It also provides the technical, scientific, schedule, cost, and other criteria that will be used in the consideration of a Termination Review. Projects that plan continuing production and operations, including integration of capability upgrades, with an unspecified Phase E end point, define the initial capability in the Review Plan for KDP B if the initial capability is not the first operational mission flight.

For projects that are part of tightly coupled programs, project Life-Cycle Reviews (LCRs) and Key Decision Points (KDPs) are planned in accordance with the project life cycle and KDP sequencing guidelines in the Program Plan. The Review Plan documents the sequencing of each project LCR and KDP with respect to the associated program LCR and KDP. In addition, the Review Plan documents which project KDPs are conducted simultaneously with other projects' KDPs and which project KDPs are conducted simultaneously with the associated program KDPs. The sequencing of project LCRs and KDPs with respect to program LCRs and KDPs is especially important for project Preliminary Design Review (PDR) LCRs that precede KDP Cs. Since changes to one project can easily impact other projects' technical, cost, and schedule baselines, and potentially impact other projects' risk assessments and mitigation plans, projects and their program generally need to proceed to KDP C/KDP I together.

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61 https://s3vi.ndc.nasa.gov/ssri-kb/static/resources/nasa-std-8739.8a.pdf

The project develops and baselines the **NEPA Compliance Documentation** by SDR/MDR. The documentation describes the level of NEPA analysis planned to comply with *NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114*. The NEPA Compliance Documentation is prepared based on consultation with the appropriate NEPA manager (Center NEPA Manager or Mission Directorate NEPA Liaison) and describes the project's NEPA strategy at all affected Centers, including decisions regarding programmatic NEPA documents. Critical NEPA milestones are inserted into the project schedule if preparation of an Environmental Assessment or Environmental Impact Statement is planned.

The project develops a preliminary **Integrated Logistics Support (ILS) Plan** by SRR and updates it at SDR/MDR (the plan is baselined at PDR). This plan describes how the project will implement *NPD 7500.1, Program and Project Life-Cycle Logistics Support Policy*, including a maintenance and support concept; participation in the design process to enhance supportability; supply support; maintenance and maintenance planning; packaging, handling, and transportation; technical data and documentation; support and test equipment; training; manpower and personnel for ILS functions; facilities required for ILS functions; and logistics information systems for the life of the project.

The project develops a preliminary **Integration Plan** by SDR/MDR. This plan defines the integration and verification strategies for a project interface with the system design and decomposition into the lower-level elements. The Integration Plan is structured to show how elements come together to assemble each subsystem and how the subsystems are assembled into the system/product. The primary purposes of the Integration Plan are to: (1) describe this coordinated integration effort that supports the implementation strategy, (2) describe for the participants what needs to be done in each integration step, and (3) identify the required resources and when and where they will be needed.

The project baselines the **Configuration Management Plan** by SRR and updates it at SDR/MDR. Configuration management addresses hardware, software, and firmware. This plan describes the configuration management approach that the project team will implement, consistent with NPR 7123.1 and *SAE/EIA 649, Configuration Management Standard*. It describes:

- How the project will plan and manage the configuration management function including the configuration management organization and tools to be used.
- What methods and procedures the project will use for configuration identification, configuration control, interface management, configuration change management, configuration verification and audit, and configuration status accounting and communications.
- How the project will audit configuration management.
- How the project will integrate contractor configuration management processes with the project.

The project develops a preliminary **Security Plan** by SDR/MDR. The plan describes the project's plans for ensuring security, including security requirements and emergency response requirements. It describes how the project will plan and implement the requirements for physical, personnel, and industrial security, and for security awareness and education requirements in accordance with *NPR 1600.1, NASA Security Program Procedural Requirements.* The plan also describes the project's emergency response plan to meet the emergency response requirements in *NPR 1040.1, NASA Continuity of Operations (COOP) Planning Procedural Requirements* and defines the range and scope of potential crises and specific response actions, the timing of notifications and actions, and the responsibilities of key individuals.

The project manager ensures development of a preliminary **Project Protection Plan** by SDR/MDR. The Project Protection Plan addresses *NASA-STD-1006, Space System Protection Standard* in accordance with *NPR 1058.1, NASA Enterprise Protection Program* and is approved by the Mission Directorate's designated approval authority and the implementing Center's Engineering Technical Authority (ETA). The plan assesses applicable adversarial threats to the project or system (including support systems, development environments, and external resources); identifies system susceptibilities, potential vulnerabilities, countermeasures, resilience strategies, and risk mitigations; and includes inputs from threat intelligence, candidate protection strategies provided by OCE, and other applicable standards. The results inform the project or system design and concept of operations in context with the project or system requirements. The project team assesses adversarial threats with support from the Office of Protective Services' Intelligence Division and OCE and requires access to Classified National Security Information. Since protection measures can be implemented either by designing the project or system architecture to be more resilient or by enhancing the capabilities provided by institutional security providers, it is important that the document identify to institutional security providers (both internal and external to NASA) the critical nodes and single points of failure in the project or system. The project **System Security Plan** and **Security Plan** should address how institutional security measures are implemented on each project to protect its critical nodes. Risk scenarios emerging from the **Project Protection Plan** analysis are tracked in accordance with the project's **Risk Management Plan**. The Project Protection Plan also provides technical information on NASA space systems to specific commands and agencies in the Department of Defense and Intelligence Community to assist those organizations in providing timely support to NASA in the event of an incident involving a NASA mission.

The project develops a preliminary **Technology Transfer Control Plan** by SDR/MDR. It describes how the project will implement the export control requirements specified in *NPR 2190.1, NASA Export Control Program*. The project supports the appropriate NASA export control officials in identifying and assessing export-controlled technical data that potentially will be provided to international partners and the approval requirements for release of that data as a part of developing the preliminary Technology Transfer Control Plan.

The project develops a preliminary Knowledge Management Plan by SDR/MDR. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.) The plan describes the project's approach to creating the knowledge management strategy and processes, including practices for identifying, capturing, and transferring knowledge and practices for capturing, documenting, and using lessons learned throughout the project life cycle in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy* and as described in *NPD 7120.6, Knowledge Policy for Programs and Projects* and other appropriate requirements and standards documentation.

The **Human-Rating Certification Package** (HRCP) is required for human space flight missions. If the program has developed an HRCP, the project may refer to the program HRCP. The initial HRCP is developed by SRR and updated at SDR/MDR. (The HRCP is updated at PDR, CDR, and ORR and certified at MRR/FRR.) The HRCP is developed in accordance with *NPR 8705.2, Human-Rating Requirements for Space Systems*. Human-rating certification focuses on integrating the human into the system, preventing catastrophic events during the mission, and protecting the health and safety of humans involved in or exposed to space activities, specifically the public, crew, passengers, and ground personnel.

The project establishes its Planetary Protection Categorization, if applicable, at SDR/MDR. The **Planetary Protection Plan**, which is baselined by PDR, specifies management aspects of the planetary protection activities of the project. Planetary protection encompasses: (1) the control of terrestrial microbial contamination associated with space vehicles intended to land, orbit, flyby, or otherwise encounter extraterrestrial solar system bodies and (2) the control of contamination of the Earth by extraterrestrial material collected and returned by missions. The scope of the plan contents and level of detail will vary with each project based upon the requirements in NASA policies *NPR 8715.24, Planetary Protection Provisions for Robotic Extraterrestrial Missions* and *NPD 8020.7, Biological Contamination Control for Outbound and Inbound Planetary Spacecraft*. The project also obtains a **planetary protection certification** for the mission, if required, in accordance with these two policy documents.

The project develops a preliminary **Quality Assurance Surveillance Plan** by SRR and baselines the plan by SDR/MDR. This plan is developed in accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects* and NASA FAR Supplement part 1837.604, Quality assurance surveillance plans. The plan provides a consolidated set of detailed instructions for the performance of Government contract quality assurance review and evaluation for the project and might include contractor documents, data, and records; products and product attributes; processes; quality system elements and/or attributes; and requirements related to quality data analysis, nonconformance reporting and corrective action tracking and resolution, and final product acceptance.

The project baselines a **Nuclear Launch Authorization Plan** for any U.S. space mission involving the use of radioactive materials. Planning begins in Formulation, and the Plan is baselined at SDR/MDR. This plan documents the project's approach for meeting the nuclear safety requirements in *NPR 8715.26, Nuclear Flight Safety*, which specifies the safety guidelines for the launch of spacecraft containing space nuclear systems. Procedures and levels of review and analysis required for nuclear launch authorization vary with the quantity of radioactive material planned for use and the potential risk to the general public and the environment.

NPR 8715.26 specifies the internal NASA procedural requirements for characterizing and reporting potential risks associated with a planned launch of radioactive materials into space, on launch vehicles and spacecraft, and during normal or abnormal flight conditions. NPR 8715.26 realigns NASA's requirements and practices with those specified in the National Security Presidential Memorandum (NSPM-20), "Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems," which was issued in August 2019. (See also NPR 8715.26, Appendix C, Additional Information Regarding NSPM-20 and Nuclear Flight Safety.)

The launch of any radioactive material requires some level of analysis, review, reporting, notification, and approval. These requirements for missions involving radioactive material are dependent on the A2 mission multiple, which is an International Atomic Energy Agency (IAEA) measure of radioactive material. (Specific details for calculating the A2 mission multiple are provided in NPR 8715.26, Appendix D, Calculation of the A2 Mission Multiple.) NSPM-20 establishes three tiers with associated criteria based on the A2 mission multiple.

The NASA Nuclear Flight Safety Assurance Manager (NFSAM) is the person appointed by the Chief, Safety and Mission Assurance to help projects meet the required nuclear launch safety requirements. The project works with and through the MDAA program executive to coordinate with the NFSAM to obtain nuclear launch safety approval or launch concurrence.

In coordination with the program executive, projects involving the launch of radioactive materials also need to:

- Comply with the provisions of the National Environmental Policy Act of 1969, in accordance with the policy and procedures contained in 14 CFR Part 1216, Subpart 1216.3, Procedures for Implementing the National Environmental Policy Act (NEPA), *NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114*.
- Develop radiological contingency plans in accordance with *NPD 8710.1, Emergency Management Program*, and *NPR 8715.2, NASA Emergency Management Program Procedural Requirements*.

4.3.5 Completing Concept and Technology Development (Phase A) and Preparing for Preliminary Design and Technology Completion (Phase B)

4.3.5.1 Establishing the Project's Preliminary Baseline

As the project approaches SDR/MDR and KDP B, the project team finalizes the project's preliminary baselines: technical (including requirements), resource (including funding, NOA, infrastructure and staffing), and cost and schedule. (Preliminary baselines are described in detail in Section 4.3.4.2.2.) The project baselines the **driving ground rules and assumptions** and constraints affecting the resource baseline at SDR/MDR. During Phase B, the **Performance Measurement Baseline** (PMB) is established and preliminary technical, resource, and cost and schedule baselines continue to be updated in preparation for project approval at KDP C.

4.3.5.2 Finalizing Plans for Phase B

The project develops its plans for work to be performed during the subsequent life-cycle phases, including generation of LCR plans and the project IMS, details on technical work to be accomplished, key acquisition activities planned, and plans for monitoring performance against plan. As the project approaches the SDR/MDR review and KDP B, the project updates its **Formulation Agreement** to finalize the plans for Phase B.

The project prepares and finalizes work agreements for Phase B. These work agreements can be between Centers or between organizations within a Center. They are usually used by the project to gain commitments from the performing organizations for the scope of work, the cost to perform that work, and the schedule for delivering the products for the next phase.

The project documents the results of Phase A activities and generates the appropriate documentation per NPR 7123.1 and NPR 7120.5F Tables I-4 and I-5 and Tables 4-6 and 4-7 at the end of this chapter. Documentation requirements may be satisfied by including in the **Formulation Agreement** the basis of cost and schedule estimates, draft and preliminary versions of project documents and plans, and/or the SDR/MDR briefing package.

4.3.5.3 Project Phase A Reporting Activities and Preparing for Major Milestones

4.3.5.3.1 Project Reporting

The project manager reports to the Center Director or designee and supports the program executive in reporting the status of project Formulation at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly Baseline Performance Review (BPR). (Section 5.12 provides further information regarding potential project reporting.)

4.3.5.3.2 Project Internal Reviews

Prior to LCRs, projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. (These internal reviews are described in Section 4.3.2.2.2.)

4.3.5.3.3 Preparing for Major Milestone Reviews

Projects support the SRR and SDR/MDR LCRs in accordance with NPR 7123.1, Center practices, and NPR 7120.5, ensuring that the LCR objectives and expected maturity states defined in NPR 7120.5 have been satisfactorily met. (LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP information in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate the project has met its expected maturity state. *NASA/SP-2016-3706, NASA Standing Review Board Handbook* also provides additional detail on this process for those reviews requiring an independent SRB.)

Projects plan, prepare for, and support the governing PMC review prior to KDP B and provide or obtain the KDP readiness products listed in Section 4.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the project updates its documents and plans, as required, to reflect the decisions made and actions assigned at the KDP.

For tightly coupled programs, project(s) transition to KDP B in accordance with the **Review Plan** documented in the Program or Project Plan(s)**.**

4.3.6 Project Phase B, Preliminary Design and Technology Completion Activities

4.3.6.1 Project Phase B Life-Cycle Activities

Project Formulation completes with the second of two sequential phases, Phase B (Preliminary Design and Technology Completion). The purpose of Phase B is for the project team to complete their technology development, engineering prototyping, heritage hardware and software assessments using *NASA/SP-2016-6105, Systems Engineering Handbook,* Appendix G, Technology Assessment/Insertion, other risk-mitigation activities identified in the project **Formulation Agreement,** and the preliminary design. The project demonstrates that its planning, technical, and cost and schedule baselines developed during Formulation are complete and consistent; the preliminary design complies with its requirements; the project is sufficiently mature to begin Phase C; and the cost and schedule are adequate to enable mission success with acceptable risk. It is at the conclusion of this phase that the project and the Agency commit to accomplishing the project's objectives for a given cost and schedule. For projects with an LCC or initial capability cost greater than $250 million, this commitment is made with the Congress and the U.S. Office of Management and Budget (OMB). This external commitment is the ABC.

Phase B Formulation continues to be an iterative set of activities rather than discrete linear steps. These activities are focused toward baselining the **Project Plan**, completing the preliminary design, and assuring that the systems engineering activities are complete to ensure the design is feasible for proceeding into Implementation. Phase B completes when the Decision Authority approves transition from Phase B to Phase C at KDP C. The major project LCR leading to approval at KDP C is the Preliminary Design Review (PDR).

The **objectives** of the PDR are to evaluate the completeness and consistency of the planning, technical, and cost and schedule baselines developed during Formulation; to assess compliance of the preliminary design with applicable requirements; and to determine if the project is sufficiently mature to begin Phase C.

At KDP C, the project is expected to demonstrate that the objectives of the PDR have been met and the approved cost and schedule are adequate to enable mission success with acceptable risk.

The general flow of activities for a project in Phase B is shown in Figure 4-11.

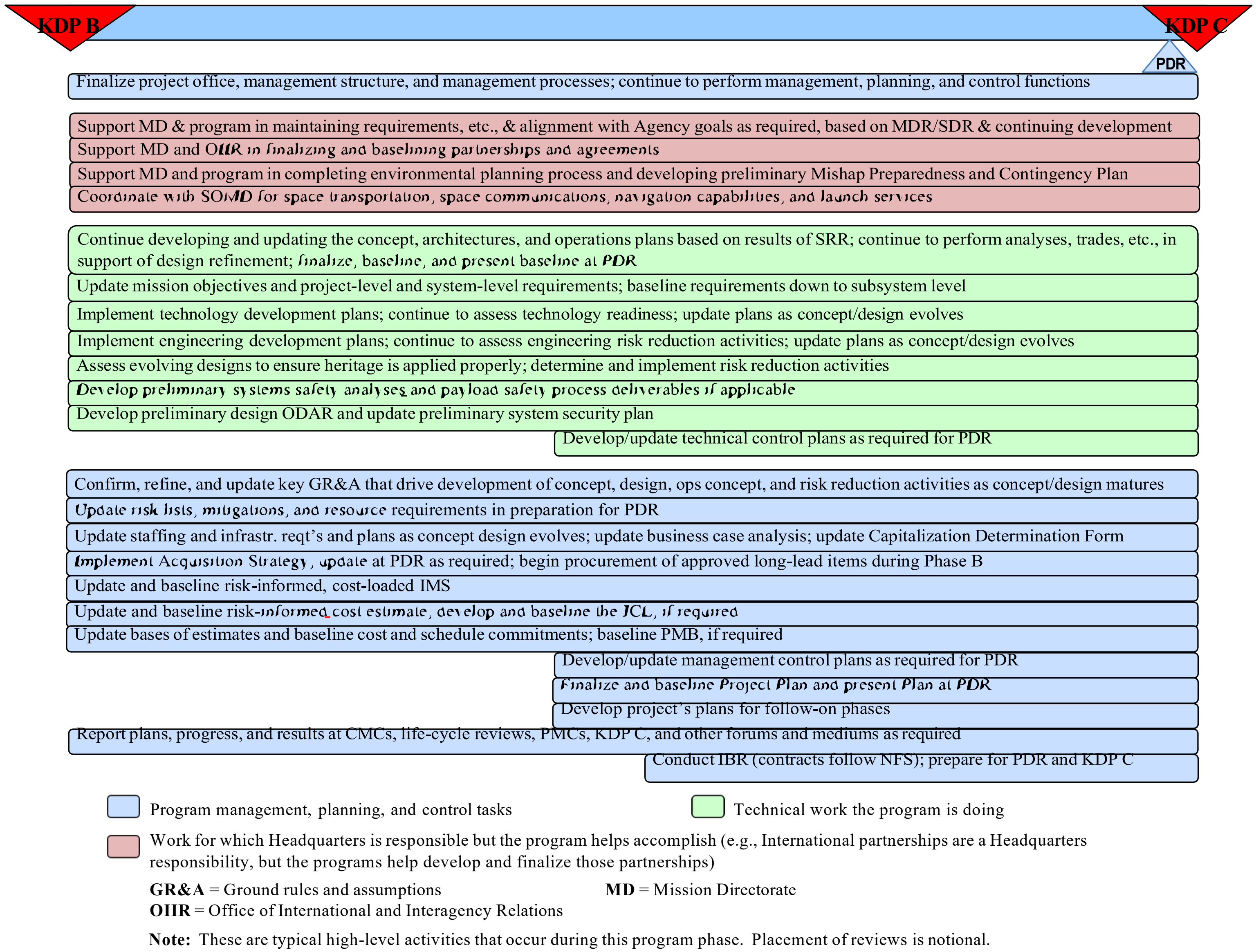

Figure 4-11 Project Phase B Flow of Activities

4.3.6.2 Project Phase B Management, Planning, and Control Activities

4.3.6.2.1 Supporting Headquarters Planning

During Phase B, the project manager and project team support the program manager and the MDAA in maintaining the baseline program requirements and constraints on the project, including mission objectives and goals; mission success criteria; and **driving mission, technical, and programmatic ground rules and assumptions**. The project obtains an update to these, if needed, and updates the project's documentation and plans accordingly.[62] The updated documentation supports the program manager and the MDAA in ensuring the continuing alignment of the project requirements, design approaches, and conceptual design with applicable Agency strategic goals.

The project works with the program, Mission Directorate, and other NASA organizations to obtain approval of any necessary modifications to prescribed requirements that are updated and reflected in modifications to the Formulation Agreement.

- Variances with NPR 7120.5 product maturities as documented in Appendix I of NPR 7120.5 are identified with supporting rationale in the **Formulation Agreement**. The approved Formulation Agreement serves as authorization for these variances.
- Tailoring of prescribed requirements (waivers and deviations) that apply to project activities during Implementation are documented in the Compliance Matrix that is attached to the Formulation Agreement (and Project Plan).
- The approval signatures of the MDAA, the Center Director, and the program manager certify that the Formulation Agreement implements all the Agency's applicable institutional requirements or that the owner of those requirements (e.g., OSMA) has agreed to the tailoring of those requirements contained in the Formulation Agreement and the attached Compliance Matrix.

In coordination with the program manager, the MDAA, and the NASA Headquarters Office of International and Interagency Relations (OIIR), the project manager supports the finalization and baselining of external agreements, such as **interagency and international agreements** (including the planning and negotiation of agreements and recommendations on joint participation in reviews, integration and test, and risk management), if applicable. International agreements are baselined at the Preliminary Design Review (PDR).

The project works with the program and the Mission Directorate to complete the environmental planning process as explained in *NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114* and planned in the project's **NEPA Compliance Documentation**. This includes preparing the final NEPA documentation.

The project works with the program and the Mission Directorate to develop a preliminary **Mishap Preparedness and Contingency Plan** in accordance with *NPR 8621.1, NASA*

[62] Program requirements on the project are contained in the Program Plan.

Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping.

The project coordinates with the Space Operations Mission Directorate (SOMD) to schedule space transportation services, space communication and navigation capabilities, or launch services, if applicable, in compliance with *NPD 8610.7, Launch Services Risk Mitigation Policy for NASA-Owned and/or NASA-Sponsored Payloads/Missions* and *NPD 8610.12, Orbital Space Transportation Services*.

4.3.6.2.2 Management Control Processes and Products

The project team continues planning that enables formulation and implementation of the mission concept(s), architectures, scenarios or DRMs, and requirements and implements the **Formulation Agreement** as updated at KDP B. The project team continues to work with the Center to obtain support for the project.

The project updates the **Technical, Schedule, and Cost Control Plan** as necessary to reflect adjustments to the project management approach. It continues to monitor and control the project requirements, technical design, schedule, and cost of the project to ensure that the high-level requirements levied on the project are met.

The project further confirms, refines, and updates the project's **key ground rules and assumptions** that drive implementation of the mission design and the funding profiles and schedules necessary for Phases C through F. The project continues to track them through Formulation to determine if they are being realized (i.e., remain valid) or if they need to be modified.

As the design matures, the project team updates their assessment of potential infrastructure and workforce needs versus current plans as well as any further opportunities to use infrastructure and workforce in other Government agencies, industry, academia, and international organizations. Based on this assessment, the project team updates the **requirements and plans for staffing and infrastructure** at the Preliminary Design Review (PDR). As part of this activity, the project updates the **business case analysis**[63] for infrastructure for each proposed real property infrastructure investment consistent with *NPR 8800.15, Real Estate Management Program* and the *NASA Business Case Guide for Real Property and Facilities Project Investments*.[64] This analysis needs to be completed in sufficient time to allow the analysis, documentation, review, approval, and funding of the infrastructure in time to support the mission requirements.

Also, in coordination with the OCFO and in accordance with *NPR 9250.1, Property, Plant, and Equipment and Operating Materials and Supplies*, projects update the **Capitalization**

[63] Business case analyses require the approval of the MDAA and the NASA Assistant Administrator for Strategic Infrastructure or designee.
[64] https://www.hq.nasa.gov/office/codej/codejx/Assets/Docs/NASA_Business_Case_Guide_11_29_10.pdf

Determination Form (CDF) (Form NF 1739),[65] to identify the acquisition components of the project and to determine the appropriate accounting treatment of the capital acquisitions within the project. Once completed, projects forward the questionnaire to the OCFO, Property Branch.

The project team implements its plans for acquisition in accordance with its approved **Acquisition Strategy**. The project finalizes its plans and executes long-lead procurements. (Long-lead procurements can be initiated in Phase B only when specifically approved by the Mission Directorate and/or program.) In accordance with the approved Acquisition Strategy, the project also updates, identifies, assesses, and mitigates (if feasible) supply chain risks, including critical or single-source suppliers needed to design, develop, produce, and support required capabilities at planned cost and schedule and report risks to the program. The Acquisition Strategy is updated at the Preliminary Design Review (PDR) to reflect any adjustments to procurement plans for the following phases.

The project updates the **Risk Management Plan**. As the concept and design evolve, the project continues to identify, assess, and update the technical, cost, schedule, and safety risks that threaten the system development, approved mission concept, operations concept, and technology development. Risks include but are not limited to technology development, engineering development, payload (robotic space flight), and procurement risks; risks associated with use of heritage hardware and software; and risks that are likely to drive the project's cost and schedule estimates at KDP C. The project identifies risk mitigation plans and associated resources for managing and mitigating risks in accordance with the Risk Management Plan.

The project team finalizes and baselines the Communications Plan, which was developed in preliminary form during Phase A. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project prepares the final **Project Plan** that follows the template in Appendix H of NPR 7120.5 and has the plan ready for baselining at PDR/KDP C. (See the product maturity Tables 4-6 and 4-7 at the end of this chapter or NPR 7120.5F Tables I-4 and I-5 for a list of required control plans and their required maturity by phase.)

The project continues to update its cost and schedule estimates as the design matures. As the project approaches PDR, the project finalizes its cost and schedule estimates in preparation for establishing the project's baseline at KDP C.

The results of this work include:

- Risk-informed and cost-loaded IMS.
- Risk-informed cost estimate.

[65] The questionnaire can be found in NASA's Electronics Forms Database website: https://nef.nasa.gov/

- JCL for projects with LCC or initial capability cost greater than $250 million, consistent with the confidence level approved by the Decision Authority. (See Section 5.7 for more information on the JCL.)
- UFE and schedule margins that have been determined by the confidence level provided by the joint cost and schedule calculations. (For projects that are not required to perform probabilistic analysis, the UFE is informed by the project's unique risk posture in accordance with Mission Directorate and Center guidance and requirements. The rationale for the UFE, if not determined using a probabilistic analysis, is appropriately documented and is traceable, repeatable, and defendable.)
- Proposed annual estimated costs by Government fiscal year and by the project's WBS.
- Assessment of the consistency of the time-phased Government Fiscal Year (GFY) LCCE with anticipated budget availability.
- Proposed external cost and schedule commitments, if applicable.
- Updated basis for cost and schedule estimates at the Preliminary Design Review (PDR).

The Basis of Estimate (BoE) documents the ground rules and assumptions and the drivers used in developing the cost and schedule estimates, including applicable model inputs, rationale or justification for analogies, and details supporting cost and schedule estimates. The BoE is contained in material available to the Standing Review Board (SRB) and management as part of the Life-Cycle Review (LCR) and Key Decision Point (KDP) process. Good BoEs are well documented, comprehensive, accurate, credible, traceable, and executable. Sufficient information on how the estimate was developed needs to be included to allow review team members, including independent cost analysts, to reproduce the estimate if required. Types of information can include estimating techniques (e.g., bottoms-up, vendor quotes, analogies, parametric cost models), data sources, inflation, labor rates, new facilities costs, operations costs, sunk costs, etc.

These products provide for adequate technical, schedule, and cost margins and incorporate the impacts of performance to UFE and schedule margin. Multiple cost estimates are reconciled by identifying the key differences in underlying assumptions used for the various estimate models, risks, and sensitivities to the project and briefing the results to the Convening Authorities to enable the Decision Authority to make an informed decision. The result of the reconciliation is a recommendation to the Decision Authority on what the LCC or initial capability cost estimate needs to be. For projects with an LCC or initial capability cost greater than $250 million, the goal is to provide sufficient understanding of the risks and associated impacts on cost and schedule to allow determination of a cost estimate and its associated confidence levels consistent with the estimate NASA commits to the external stakeholders. The estimates can be reconciled through the independent review process, the management review process (e.g., the DPMC), or at the KDP, which is the last point for reconciliation.

All space flight projects update a **Cost Analysis Data Requirement** (CADRe) parts A, B, and C consistent with the *NASA Cost Estimating Handbook*[66] 30 to 45 days after KDP C to reflect any changes from the KDP. This CADRe is based on the project baselines presented at the Preliminary Design Review (PDR).

4.3.6.3 Project Phase B Technical Activities and Products

The project team continues developing the concept and architecture of the project, its major components, and the way they will be integrated, including its operations concepts through the system engineering process described in NPR 7123.1. The project continues engineering development activities (e.g., engineering models, brass boards, bread boards, test beds, and full-up models) and incorporates the results into the preliminary design. As the project approaches the PDR, the project updates the concept, mission, and spacecraft architectures; launch service requirements (with LSP support as described in Section 4.3.4.3); and the ground and payload architectures and baselines the **Operations Concept Documentation**. The project updates the mission objectives and project-level and system-level requirements as needed and baselines the subsystem-level requirements. In support of the launch service procurement, if applicable, the project completes the spacecraft-to-launch vehicle Interface Requirements Document (IRD), which becomes an input to the Request for Launch Services Proposal that is developed by LSP. In addition, the project typically supports the evaluation of such proposals. (The project's level of involvement in evaluating such proposals is per mutual agreement between the project and LSP.) The project ensures that all requirements are traceable back to the program-level requirements on the project and develops an updated list of descope options in case some requirements cannot be met.

The Operations Concept Documentation is a description of how the flight system and the ground system are used together to ensure that the mission operations can be accomplished reasonably. This might include how mission data of interest, such as engineering or scientific data, are captured, returned to Earth, processed, made available to users, and archived for future reference. The Operations Concept Documentation typically describes how the flight system and ground system work together across mission phases for launch, cruise, critical activities, science observations, and the end of the mission to achieve the mission. The Operations Concept Documentation is baselined at PDR with the initial preliminary Operations Concept Documentation required at MCR.

The project completes its risk reduction and mitigation activities and updates its **technology, engineering, and heritage assessments**. The project completes mission-critical or enabling technology, as needed, to the level of a system or subsystem model or prototype demonstration in a relevant environment (ground or space) (i.e., TRL 6 by KDP C) unless otherwise documented in the Technology Development Plan. The project also finishes its engineering model and prototype developments.

[66] https://www.nasa.gov/content/cost-estimating-handbook

In accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects*, the project also baselines the **Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status**; the **Criticality Identification Method for Hardware**; and the Hardware Quality Data Management Analytics. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project develops preliminary **Systems Safety Analyses** as required by NPR 7120.5 and *NPR 8715.3, NASA General Safety Program Requirements*.

The project develops preliminary **Payload Safety Process Deliverables** by PDR in accordance with *NPR 8715.7, Payload Safety Program*. These deliverables apply to NASA projects involving design, fabrication, testing, integration, processing, launch, and recovery of payloads and the design of ground support equipment used to support payload-related operations during prelaunch operations and during recovery. The deliverables include items such as free-flying automated spacecraft, Space Launch System (SLS) payloads, International Space Station (ISS) payloads, Expendable Launch Vehicle (ELV) payloads, flight hardware and instruments designed to conduct experiments, and payload support equipment. *NASA-STD 8719.24, NASA Expendable Launch Vehicle Payload Safety*[67] provides more details on payload processing for launch.

The project develops the preliminary design **Orbital Debris Assessment Report** (ODAR) by PDR in accordance with *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* using the format and requirements contained in *NASA-STD-8719.14, Process for Limiting Orbital Debris*.

The project documents and uses lessons learned in accordance with the project's Knowledge Management Plan. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

Based on the evolving design, the project team updates the following control plans: **Safety and Mission Assurance (SMA) Plan**, Technology Development Plan, **Systems Engineering Management Plan** (SEMP), **System Security Plan**, **Software Management Plan**(s), **Review Plan**, **Configuration Management Plan**, and **Quality Assurance Surveillance Plan**. (The Technology Development Plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project team finalizes the **Verification and Validation (V&V) Plan** and baselines the plan by PDR. This plan summarizes the approach for performing V&V of the project products.

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67 https://standards.nasa.gov/standard/nasa/nasa-std-871924

The project finalizes the **Integrated Logistics Support (ILS) Plan** in accordance with *NPD 7500.1, Program and Project Life-Cycle Logistics Support Policy* and baselines the plan by PDR**.**

The project develops a preliminary Science Data Management Plan by PDR. (The plan is baselined at ORR.) (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.) This plan describes how the project will manage the scientific data generated and captured by the operational mission(s) and any samples collected and returned for analysis. It includes descriptions of how data will be generated, processed, distributed, analyzed, and archived, as well as how any samples will be collected, stored during the mission, and managed when returned to Earth. The plan typically includes the definition of data rights and services and access to samples, as appropriate, and identifies where the preliminary science data requirements will be documented. (These requirements should be documented by SRR.) The plan is developed in consultation with the Mission Directorate data leads and the Office of the Chief Information Officer (OCIO) early in the project life-cycle to ensure that metadata standards and data formats are appropriately considered and that infrastructure and security requirements are addressed. The plan explains how the project will accomplish the information management and disposition requirements in *NPD 2200.1, Management of NASA Scientific and Technical Information*; *NPR 2200.2, Requirements for Documentation, Approval and Dissemination of Scientific and Technical Information*; and *NPR 1441.1, NASA Records Management Program Requirements* as applicable to project science data. In addition, the plan explains how the project will implement NASA sample handling, curation, and planetary protection directives and rules, including *NPR 8715.24, Planetary Protection Provisions for Robotic Extraterrestrial Missions.*

The project finalizes the **Integration Plan** and baselines the plan by PDR. This plan defines the integration and verification strategies for a project interface with the system design and decomposition into the lower-level elements. The Integration Plan is structured to show how elements come together to assemble each subsystem and how the subsystems are assembled into the system/product.

The project finalizes the **Security Plan** and baselines the plan by PDR.

The project finalizes the **Project Protection Plan**, **Technology Transfer Control Plan**,[68] Knowledge Management Plan, and **Planetary Protection Plan**, if applicable, and baselines the plan(s) by PDR. (The Knowledge Management Plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

If required, the project updates the **Human-Rating Certification Package** by PDR as described in *NPR 8705.2, Human-Rating Requirements for Space Systems*. Per NPR 7120.5

[68] This plan describes how the project will implement the export control requirements specified in *NPR 2190.1, NASA Export Control Program*.

and NPR 7123.1, the project updates the Human System Integration Plan, if required, by PDR.

The project develops and finalizes the **Orbital Collision Avoidance Plan** (OCAP) per *NASA Interim Directive (NID) 7120.132, Collision Avoidance for Space Environment Protection* and baselines the plan by PDR. This plan describes how the project implements the design considerations and preparation for operations to avoid in-space collisions and provides a project overview, including a concept of operation, how orbit selection was performed, the spacecraft's ascent and descent plan, how the spacecraft's location tracking data will be generated, and whether there will be any autonomous flight control. The plan also discusses how the spacecraft's design will enable it to be acquired and tracked by the Space Surveillance Network and be cataloged by the U. S. Space Command. It also describes the process for routinely coordinating with other operator(s) for maneuvering. (See NID 7120.132 for more detail and plan template.)

The project develops preliminary **Range Safety Risk Management Process Documentation** in accordance with *NPR 8715.5, Range Flight Safety Program*. This documentation applies to launch and entry vehicle projects, scientific balloons, sounding rockets, drones, and Unmanned Aircraft Systems. The documentation does not apply to projects developing a payload that will that fly onboard a vehicle. The range flight safety concerns associated with a payload are addressed by the vehicle's range safety process. The focus is on the protection of the public, workforce, and property during range flight operations.

4.3.7 Completing Preliminary Design and Technology Completion (Phase B) and Preparing for Final Design and Fabrication (Phase C)

4.3.7.1 Establishing the Project's Baseline

The project team finalizes the project's baselines as the project approaches its approval milestone, KDP C. (This effort is described in more detail in Section 4.3.6.2.2.) All projects finalize their project baselines and the Management Agreement as part of the preparations for the PDR. This includes the project's technical baseline, risk posture, IMS, baseline LCC or initial capability cost estimate, and resource baseline, all consistent with the program requirements and constraints on the project, the key assumptions, workforce estimates, and **infrastructure requirements**. This typically includes an internal review of the entire scope of work with a series of in-depth assessments of selected critical work elements of the WBS prior to and following the project's PDR Life-Cycle Review (LCR) preceding KDP C. For projects with EVM requirements, the project works with the Mission Directorate or program to conduct a project-level IBR as part of the preparations for KDP C to ensure that the project's work is properly linked with its cost, schedule, and risk and that the systems are in place to conduct EVM. EVM reporting to the **Performance Measurement Baseline** (PMB) begins in Phase B. (Section 5.14 provides additional details on this review.)

Once approved at KDP C and documented in the Decision Memorandum, the project baselines are maintained under configuration control. (See Section 5.5 for maintaining baselines.)

4.3.7.1.1 Finalizing Plans for Phase C

The project develops and updates its plans for work to be performed during Phase C and the subsequent life-cycle phases, including updates, if needed, to LCR plans, the project IMS, details on technical work to be accomplished, key acquisition activities planned, and plans for monitoring performance against plan. The project incorporates the impact of performance against the plan established at KDP B.

The project prepares and finalizes work agreements for Phase C and D. The work scope and price for Phase C and D contracts may be negotiated but not executed prior to approval to proceed at KDP C unless otherwise approved. Once the project has been approved and funding is available, the negotiated contracts may be executed, assuming no material changes.

The project documents the results of Phase B activities and generates the appropriate documentation as described in NPR 7123.1, NPR 7120.5F Tables I-4 and I-5, and Tables 4-6 and 4-7 at the end of this chapter and captures it in retrievable project records.

4.3.7.2 Project Phase B Reporting Activities and Preparing for Implementation Approval Reviews

4.3.7.2.1 Project Reporting

The project manager reports to the Center Director or designee and supports the program executive in reporting the status of project Formulation at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly Baseline Performance Review (BPR). (Section 5.12 provides additional information regarding potential project reporting.)

4.3.7.2.2 Project Internal Reviews

Prior to the life-cycle reviews, projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. (These internal reviews are described in Section 4.3.2.2.2.)

4.3.7.2.3 Preparing for Project Implementation Approval

Projects support the PDR in accordance with NPR 7123.1, Center practices, and NPR 7120.5, including ensuring that the LCR objectives and expected maturity states defined in NPR 7120.5 have been satisfactorily met. LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP information in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate the project has met its expected maturity state. *NASA/SP-2016-3706, NASA Standing Review Board Handbook* provides additional detail on this process for those reviews requiring an independent SRB. Projects plan, prepare for, and support the governing PMC review prior to KDP C and provide or obtain the KDP readiness products listed in Section 4.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the project updates its documents and plans, as required, to reflect the decisions made and actions assigned at the KDP.

In tightly coupled programs, project(s) transition to KDP C in accordance with the **Review Plan** documented in the Program or Project Plan.

4.4 Project Implementation

4.4.1 Project Phase C, Final Design and Fabrication Activities

4.4.1.1 Project Phase C Life-Cycle Activities

Project Implementation begins with Phase C as the project team implements the project in accordance with the **Project Plan**. The purpose of Phase C is to:

- Complete and document the final design that meets the detailed requirements.
- Ensure that the systems engineering activities are performed to determine if the design is mature enough to proceed with full-scale implementation within the constraints of the Management Agreement and the ABC.
- Perform qualification testing.
- Develop product specifications and begin fabrication of test and flight architecture (e.g., flight article components, assemblies, subsystems, and associated software).
- Develop detailed integration plans and procedures.
- Ensure that all integration facilities and personnel are ready and available.

For projects that will develop or acquire multiple copies of systems, the project ensures that the system developers are ready to efficiently produce the required number of systems. The general flow of activities for a project in Phase C is shown in Figure 4-12.

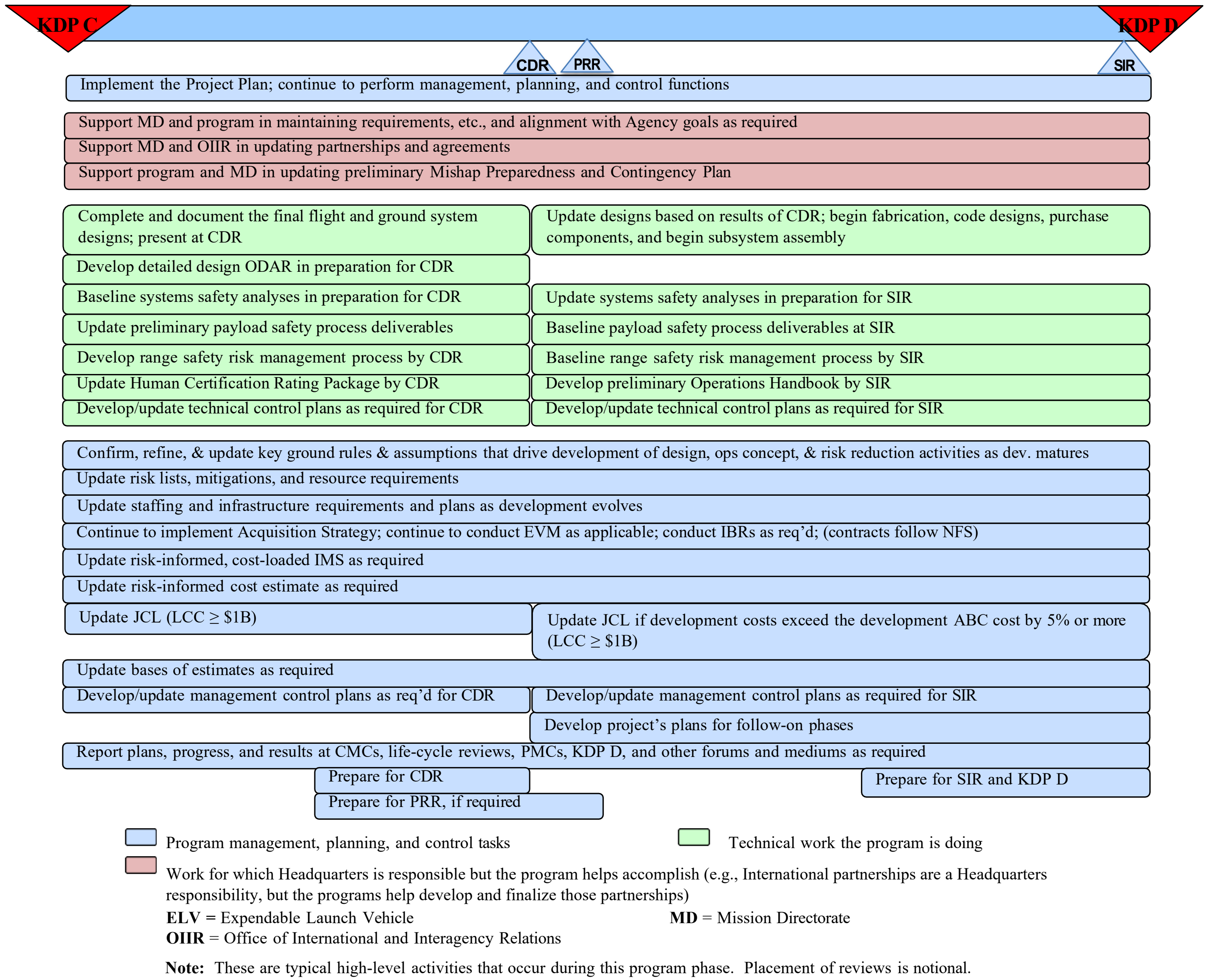

Figure 4-12 Project Phase C Flow of Activities

These activities are focused toward the Critical Design Review (CDR), the Production Readiness Review (PRR) (for projects developing or acquiring multiple[69] systems and/or units), and the System Integration Review (SIR). Phase C completes when the Decision Authority approves transition from Phase C to Phase D at KDP D:

- The **objectives** of the Critical Design Review (CDR) are to evaluate the integrity of the project design and its ability to meet mission requirements with appropriate margins and acceptable risk within defined project constraints, including available resources, and to determine if the design is appropriately mature to continue with the Final Design and Fabrication phase.
- The **objectives** of the Production Readiness Review (PRR) are to evaluate the readiness of system developer(s) to produce the required number of systems within defined project constraints for projects developing multiple similar flight or ground support systems and to evaluate the degree to which the production plans meet the system's operational support requirements. (See Table G-8 in Appendix G of NPR 7123.1 for entrance and success criteria of the PRR.)
- The **objectives** of the System Integration Review (SIR) are to evaluate the readiness of the project and associated supporting infrastructure to begin system AI&T, to evaluate whether the remaining project development can be completed within available resources, and to determine if the project is sufficiently mature to begin Phase D.

At KDP D, the project is expected to demonstrate that the project is still on plan, the risk is commensurate with the project's payload classification (or the Mission Directorate's risk definition if not a payload in accordance with *NPR 8705.4, Risk Classification for NASA Payloads*), and the project is ready for AI&T with acceptable risk within its ABC.

4.4.1.2 Project Phase C Management, Planning and Control Activities

4.4.1.2.1 Supporting Headquarters Planning

During Phase C, the project manager and project team continue to support the program manager and the MDAA in maintaining the baseline program requirements and constraints on the project, including mission objectives and goals; mission success criteria; and **driving mission, technical, and programmatic ground rules and assumptions**. The project obtains an update to the driving mission, technical, and programmatic ground rules and assumptions, if needed, and particularly if a descope is required, and updates the project's documentation and plans accordingly.[70] The updated documentation supports the program manager and the MDAA in ensuring the continuing alignment of the project requirements, design approaches, and the design with applicable Agency strategic goals. The project team updates, as needed, project external agreements, partnerships, and acquisition and other plans that are required for successful completion of this and remaining life-cycle phases.

[69] Typically more than three or as determined by the project.
[70] Program requirements on the project are contained in the Program Plan.

The project continues to coordinate with the Space Operations Mission Directorate (SOMD) to finalize the space transportation services, space communication and navigation capabilities, and launch services, as applicable.

The project updates the preliminary **Mishap Preparedness and Contingency Plan** at SIR. This plan is baselined at the Safety and Mission Success Review (SMSR).

4.4.1.2.2 Management Control Processes and Products

The project team implements the **Project Plan** approved at KDP C. This includes utilizing the **Technical, Schedule, and Cost Control Plan** and management tools to guide monitoring, managing, and controlling the project requirements and technical design, schedule, and cost of the project to ensure that the high-level requirements levied on the project are met. The project further confirms, refines, and updates the project's **key ground rules and assumptions** that will drive implementation of the design and the funding profiles and schedules necessary for Phases C through F. The project continues to track them through Implementation to determine if they are being realized (i.e., remain valid) or if they need to be modified. As the design matures and fabrication begins, the project team updates its assessment of potential infrastructure and workforce needs versus current plans. Based on this assessment, the project team updates the **requirements and plans for staffing and infrastructure** at CDR.

The project team implements its plans for acquisition in accordance with its approved **Acquisition Strategy**. The project also updates, identifies, assesses, and mitigates, if feasible, supply chain risks, including critical or single-source suppliers needed to design, develop, produce, and support required capabilities at planned cost and schedule. The project reports risks to the program. For contracts requiring EVM, the project conducts any required IBRs. (Refer to NFS Subpart 1834.2, Earned Value Management System.)

Projects using EVM update the PMB and conduct IBRs when there are major changes that significantly impact the cost and schedule baseline, including the PMB, and conduct any required IBRs for contracts requiring EVM. (Refer to NFS Subpart 1834.2, Earned Value Management System.) The project reports EVM metrics to the program and the Mission Directorate as defined in the **Project Plan**. (Section 5.14 provides additional details on the PMB and the IBR.)

As the design finalizes and fabrication begins, the project continues to identify, assess, and update the **technical, cost, schedule, and safety risks** that threaten the system development and risks that are likely to drive the project's cost and schedule estimates. The project maintains a record of accepted risks and the associated rationale for their acceptance, actively assesses open risks, and develops and implements mitigation plans. It updates resources being applied to manage and mitigate risks, including supply chain risks in accordance with the approved **Acquisition Strategy**.

Projects manage within the approved baselines identified in their Management Agreement. This includes the technical baseline, project's risk posture, IMS, and baseline LCC or initial capability cost estimate, all consistent with the program requirements and constraints on the project, the key assumptions, workforce estimates, and **infrastructure requirements**.

The project maintains and updates, if required, the project baselines and Management Agreement under configuration management with traceability to the ABC approved at KDP C. As a minimum, the project:

- Confirms key ground rules and assumptions that drive project requirements, designs, and the programmatic baseline. The project tracks the status of the realization of these, as appropriate, to determine if they are being realized (i.e., remain valid) or if they need to be modified.
- Manages technical and programmatic margins and resources to ensure successful completion of this and remaining life-cycle phases within budget, schedule, and risk constraints.
- Updates the risk-informed, cost-loaded IMS when changes warrant.
- Updates the risk-informed cost estimate when internal or external changes warrant.
- Updates and documents the basis for cost and schedule estimates for any tasks or system components added since KDP C.
- Assesses the adequacy of anticipated budget availability against phased LCC requirements and commitments, incorporating the impact of performance to date.
- Updates the JCL at CDR if the project LCC or initial capability cost is greater than or equal to $1 billion. (The updated JCL values for the ABC and Management Agreement are communicated to the APMC for informational purposes.)
- Updates the JCL at KDP D if the project LCC or initial capability cost is greater than or equal to $1 billion and current reported development costs exceed the development ABC cost by 5 percent or more. (The updated JCL values for the ABC and Management Agreement are documented in the KDP D Decision Memorandum.)
- Provides the program manager and the MDAA with immediate written notice if the latest estimate for the development cost (Phase C through D) exceeds the ABC cost for Phase C through D by 15 percent or more. Development cost growth of 15 percent or more for projects with LCC or initial capability cost over $250 million is reported to Congress.
- Provides a written report to the program manager and MDAA explaining the reasons for the change in the cost and a recovery plan within 15 days of the above notification.
- Provides the program manager and the MDAA with immediate notification of a breach[71] if the projected cost estimate for development cost exceeds the ABC cost for Phase C

[71] See Section 5.5 for additional information on a breach.

through D by 30 percent or more. Projects with a LCC or initial capability cost greater than $250 million prepare to respond to Agency direction and a potential requirement for reauthorization by Congress.

- Provides the program manager and the MDAA with immediate written notice and a recovery plan if a milestone listed for Phase C and D on the project life-cycle chart (Figures 2-4 and 4-1) is estimated to be delayed in excess of six months from the date scheduled in the ABC.
- If in breach, updates the **Project Plan** in accordance with direction and written notice.

(See Section 5.5 for more information on maintaining and updating project baselines, and Section 5.12 for more information on external reporting requirements associated with development cost growth of 15 percent or more, development schedule slip of six months or more, and breach due to development cost growth of 30 percent or more.)

Projects update the **Cost Analysis Data Requirement** (CADRe) parts A, B, and C consistent with the *NASA Cost Estimating Handbook*[72] 60 days after CDR to reflect the project's baseline presented at the Critical Design Review (CDR).

4.4.1.3 Project Phase C Technical Activities and Products

The project continues to perform the technical activities required in NPR 7123.1 for this phase. It completes the engineering design and development activities (e.g., qualification and life tests) and incorporates the results into the final design. It completes and baselines **flight and ground design documentation** by CDR and updates them, as necessary, at SIR, performing the systems engineering activities to determine if the design is mature enough to proceed with full-scale implementation. It develops product specifications and fabricates, purchases, and/or codes designs after the appropriate CDR(s) (e.g., flight article components, assemblies, and subsystems) and begins to implement the defined V&V program on flight and/or ground products. It updates the **Technology Readiness Assessment Documentation** by CDR, if required, and develops integration plans and procedures.

The project continues to work with the LSP to refine plans for integrating and testing the spacecraft at the launch site, preparing for launch, launch, and post-launch support.

The project develops the detailed design **Orbital Debris Assessment Report** (ODAR) by CDR in accordance with *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* using the format and requirements contained in *NASA-STD-8719.14, Process for Limiting Orbital Debris*.

In accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects*, the project updates the **Industrial Base and Supply Chain Risk**

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[72] https://www.nasa.gov/content/cost-estimating-handbook

Management (SCRM) Strategy and Status; the **Criticality Identification Method for Hardware**; and the Hardware Quality Data Management Analytics by CDR. The Hardware Quality Data Management Analytics is also updated in preparation for SIR. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project updates, documents, and baselines **Systems Safety Analyses** by the CDR in accordance with *NPR 8715.3, NASA General Safety Program Requirements*. These Systems Safety Analyses are updated at SIR. In addition, the project updates the preliminary **Payload Safety Process Deliverables** at CDR and baselines them at SIR. For launch vehicles, if applicable, the project updates the preliminary **Range Safety Risk Management Process Documentation** in accordance with *NPR 8715.5, Range Flight Safety Program* at CDR and baselines it by SIR.

The project develops the preliminary **Mission Operations Plan** and the **Operations Handbook** by SIR. (See "Operations Handbook" for more information.) The Mission Operations Plan describes the activities required to perform the mission and describes how the project will implement the associated facilities, hardware, software, and procedures required to complete the mission. It describes mission operations plans, rules, and constraints and describes the Mission Operations System (MOS) and Ground Data System (GDS) in the following terms:

- MOS and GDS human resources and training requirements.
- Procedures to ensure that operations are conducted in a reliable, consistent, and controlled manner using lessons learned during the project and from previous programs and projects.
- Facilities requirements (offices, conference rooms, operations areas, simulators, and test beds).
- Hardware (ground-based communications and computing hardware and associated documentation).
- Software (ground-based software and associated documentation).

Operations Handbook

The Operations Handbook provides information essential to the operation of the spacecraft. It generally includes the following:

1. A description of the spacecraft and the operational support infrastructure;
2. Operational procedures, including step-by-step operational procedures for activation and deactivation;
3. Malfunction detection procedures; and
4. Emergency procedures.

The handbook identifies the commands for the spacecraft, defines the functions of these commands, and provides supplemental reference material for use by the operations personnel. The main emphasis is placed on command types, command definitions, command sequences, and operational constraints. Additional document sections may describe uploadable operating parameters, the telemetry stream data contents (for both the science and the engineering data), the Mission Operations System displays, and the spacecraft health monitors.

For HSF missions, the project updates the **Human-Rating Certification Package** as described in *NPR 8705.2, Human-Rating Requirements for Space Systems* prior to CDR. In accordance with NPR 7120.5 and NPR 7123.1, the project updates the **Human Systems Integration Plan**, if required, prior to CDR.

The project documents and uses lessons learned in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy* and *NPD 7120.6, Knowledge Policy for Programs and Projects* and the project's Knowledge Management Plan. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project updates and baselines the **System Security Plan** by CDR and updates the plan by SIR in accordance with *NPR 2810.1, Security of Information and Information Systems*.

The project updates the following control plans by CDR: **Safety and Mission Assurance (SMA) Plan**, **V&V Plan**, **ILS Plan**, **Integration Plan**, **Project Protection Plan**, **Technology Transfer Control Plan**, Knowledge Management Plan, Communications Plan, **Quality Assurance Surveillance Plan**, and **Orbital Collision Avoidance Plan** (OCAP). (The Knowledge Management Plan and Communications Plan are best practices as opposed to requirements. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project updates the following control plans by SIR: **V&V Plan**, **Project Protection Plan**, and **Quality Assurance Surveillance Plan**.

4.4.2 Completing Final Design and Fabrication (Phase C) and Preparing for System Assembly, Integration and Test, Launch and Checkout (Phase D)

4.4.2.1 Finalize Plans for Phase D

The project develops and updates its plans for work to be performed during Phase D and the subsequent life-cycle phases, including updates, if needed, to LCR plans and the project IMS; details on technical work to be accomplished; key acquisition activities planned; and plans for monitoring performance against plan. The project incorporates the impact of performance against the plan established at KDP C.

The project prepares and finalizes Phase D work agreements.

The project documents the results of Phase C activities and generates the appropriate documentation as described in NPR 7123.1, NPR 7120.5F Tables I-4 and I-5, and Tables 4-6 and 4-7 at the end of this chapter.

4.4.2.2 Project Phase C Reporting Activities and Preparing for Major Milestones

4.4.2.2.1 Project Reporting

The project manager reports to the Center Director or designee and supports the program executive in reporting the status of project Implementation at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly Baseline Performance Review (BPR). (Section 5.12 provides further information regarding potential project reporting.)

4.4.2.2.2 Project Internal Reviews

Prior to LCRs, projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. (These internal reviews are described in Section 4.3.2.2.2.)

4.4.2.2.3 Preparing for Major Milestones

Projects plan, prepare for, and support the CDR, PRR (if required), and SIR (LCRs) in accordance with NPR 7123.1, Center practices, and NPR 7120.5, including ensuring that the LCR objectives and expected maturity states defined in NPR 7120.5 have been satisfactorily met. LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP information in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate the project has met the expected maturity state. (*NASA/SP-2016-3706, NASA Standing Review Board Handbook* and Section 5.10 of this handbook provide additional detail on this process for those reviews requiring an independent SRB.)

Projects plan, prepare for, and support the governing PMC review prior to KDP D and provide or obtain the KDP readiness products listed in Section 4.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the project updates its documents and plans as required to reflect the decisions made and actions assigned at the KDP.

In tightly coupled programs, project(s) transition to KDP D in accordance with the plan for reviews documented in the **Program or Project Plan**.

4.4.3 Project Phase D, System Assembly, Integration and Test, Launch and Checkout

4.4.3.1 Project Phase D Life-Cycle Activities

Project Implementation continues with Phase D as the project team implements the project in accordance with the **Project Plan**. The purpose of Phase D is to perform system AI&T; complete validation testing; finalize operations preparations; complete operational training; resolve failures, anomalies, and issues; certify the system for launch; launch the system; and complete on-orbit system checkout (robotic space flight projects) or initial operations (human space flight projects).

The transition from Phase D to Phase E is different from other phase transitions in the life cycle. KDP E marks the decision to conduct launch and early operations. However, the transition from Phase D to Phase E occurs after on-orbit checkout (robotic space flight projects) or initial operations (human space flight projects) at the conclusion of the Post-Launch Assessment Review (PLAR). The flow of activities in preparation for launch is very formal and involves important reviews. (Section 4.4.4 provides a detailed description of the flow of the review and approval process in preparation for launch for human and robotic space flight programs and projects. This process is the same for projects and programs.)

The phase activities focus on preparing for the ORR, SMSR, FRR, and LRR for HSF projects; or the ORR, LVRR, MRR, SMSR, FRR and LRR for robotic space flight projects; KDP E; launch; PLAR, and for certain HSF projects, PFAR. (The objectives of these reviews are described in detail in Section 4.4.4.) At KDP E, the project is expected to demonstrate that the project and all supporting systems are ready for safe, successful launch and early operations with acceptable risk within its ABC.

The general flow of activities for a project in Phase D is shown in Figure 4-13.

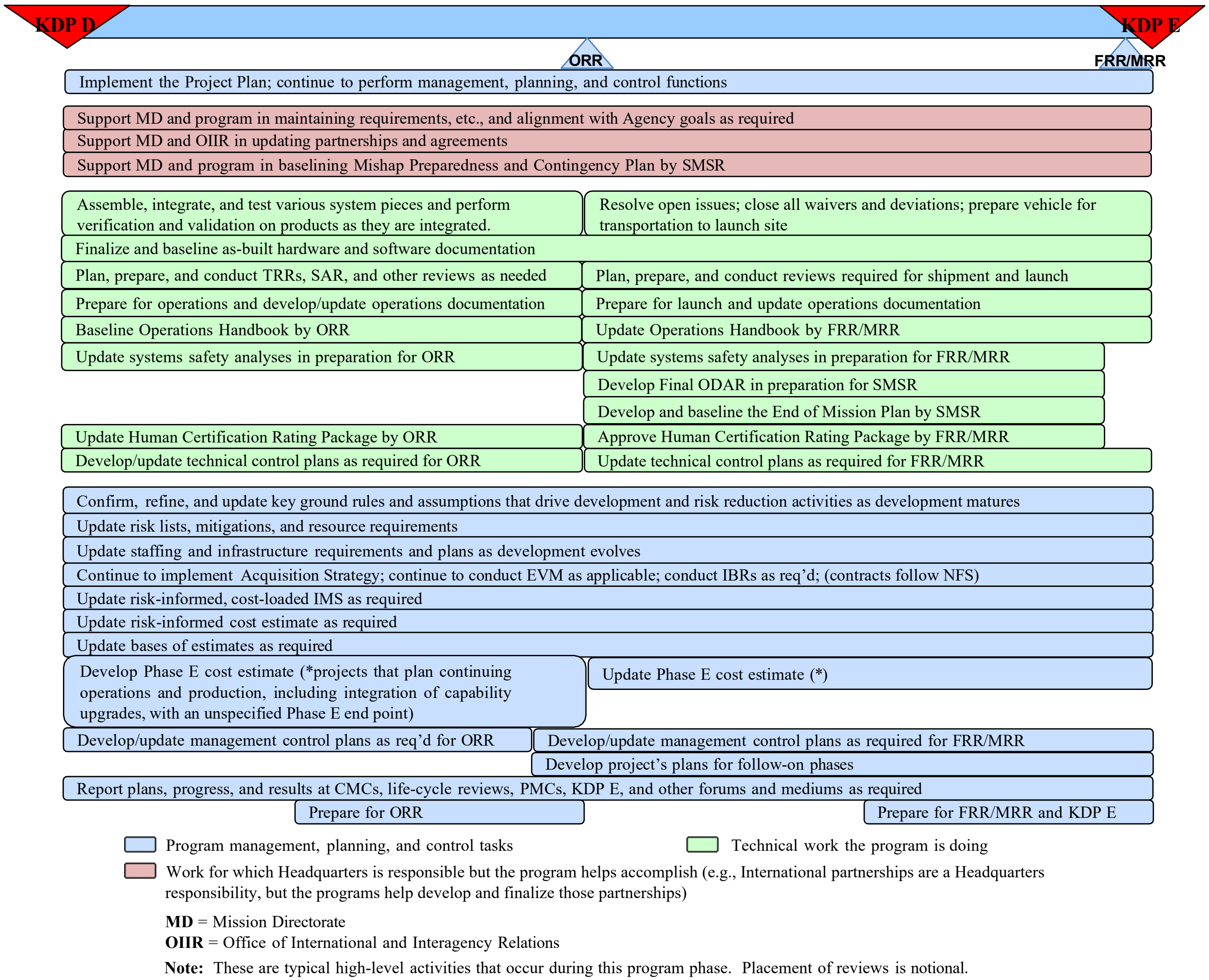

Figure 4-13 Project Phase D Flow of Activities

4.4.3.2 Project Phase D Management, Planning, and Control Activities

4.4.3.2.1 Supporting Headquarters Planning

During Phase D, the project manager and the project team continue to implement the baseline **Project Plan**. The project manager and project team continue to support the program manager and the MDAA in maintaining the baseline program requirements and constraints on the project, including mission objectives and goals; mission success criteria; and **driving mission, technical, and programmatic ground rules and assumptions**. The project obtains an update to these, if needed, and particularly if a descope is required, and updates the project's documentation and plans accordingly.[73] The updated documentation supports the program manager and the MDAA in ensuring the continuing alignment of the project requirements with applicable Agency strategic goals. The project updates, as needed, project external agreements, partnerships, and acquisition and other plans that are required for successful completion of this and remaining life-cycle phases.

The project supports the Mission Directorate in baselining the **Mishap Preparedness and Contingency Plan** and delivering the document to OSMA 30 days prior to the Safety and Mission Success Review (SMSR) per *NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping*.

4.4.3.2.2 Management Control Processes and Products

The project team implements the **Project Plan** as approved at KDP D. This includes utilizing the **Technical, Schedule, and Cost Control Plan** and management tools to guide monitoring, managing, and controlling the project requirements, and technical design, schedule, and cost of the project to ensure that the high-level requirements levied on the project are met. The project team ensures that appropriate infrastructure and, in coordination with the Centers engaged in the project, trained and certified staff are available and ready when needed to support the activities of this phase. It updates, as needed, project external agreements, partnerships, and acquisition and other plans that are required for successful completion of this and remaining life-cycle phases.

The project team implements its plans for acquisition in accordance with the approved **Acquisition Strategy**. The project also updates, identifies, assesses, and mitigates, if feasible, supply chain risks, including critical or single-source suppliers needed to design, develop, produce, and support required capabilities at planned cost and schedule. The project reports risks to the program.

Projects using EVM update the PMB and conduct IBRs when there are major changes that significantly impact the cost and schedule baseline, including the PMB, and conduct any required IBRs for contracts requiring EVM. (Refer to NFS Subpart 1834.2, Earned Value Management System.) Projects using EVM report EVM metrics to the program and the

[73] Program requirements on the project are contained in the Program Plan.

Mission Directorate as defined in the **Project Plan**. (Section 5.14 provides additional details on the PMB and the IBR.)

As system integration begins, the project continues to identify, assess, and update the **technical, cost, schedule, and safety risks** that threaten the system development and risks that are likely to drive the project's cost and schedule estimates. The project maintains a record of accepted risks and the associated rationale for their acceptance, actively assesses open risks, and develops and implements mitigation plans. It updates resources being applied to manage and mitigate risks.

Project managers manage the project within the approved baselines identified in their Management Agreement. This includes the technical baseline, project's risk posture, Integrated Master Schedule (IMS), and baseline Life-Cycle Cost Estimate (LCCE) or initial capability cost estimate, all consistent with the program requirements and constraints on the project, the key assumptions, workforce estimates, and **infrastructure requirements**.

The project maintains and updates, if required, the project baselines, including the IMS and LCCE or initial capability cost estimate, and Management Agreement under configuration management with traceability to the ABC approved at KDP C. Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, establish the Phase E cost estimate for the continuing operations and production phase as part of the ORR and KDP E for the five years after initial capability. The Phase E cost estimate is subsequently updated and documented annually for the next 5-year period.

The project updates the **Cost Analysis Data Requirement** (CADRe) parts A, B, and C consistent with the *NASA Cost Estimating Handbook*[74] with a final version 30 to 45 days after KDP D to reflect any changes from the KDP. This CADRe is based on the project baseline presented at SIR.

4.4.3.3 Project Phase D Technical Activities and Products

The project continues to perform the technical activities required in NPR 7123.1 for this phase. It plans, prepares for, and performs other reviews, as necessary and applicable. Examples of other reviews include Test Readiness Reviews (TRR) and System Acceptance Reviews (SAR). The project team conducts TRRs to ensure that the test articles (hardware and/or software), test facility, support personnel, and test procedures are ready for testing and data acquisition, reduction, and control. (See Table G-10 in Appendix G of NPR 7123.1 for entrance and success criteria of the TRR.) The SAR is conducted to evaluate whether a specific end item is sufficiently mature to be shipped from the supplier to its designated operational facility or launch site. (See Table G-11 in Appendix G of NPR 7123.1 for entrance and success criteria of the SAR.) The project and the LSP finalize plans for the integration and test of the spacecraft at the launch site, preparations for launch including

[74] https://www.nasa.gov/content/cost-estimating-handbook

readiness reviews, and launch and post-launch support. (See Section 4.3.1.4 for information about readiness reviews.)

As the various components and subassemblies arrive at the integration facility, the project:

- Begins to assemble, integrate, and test the various system pieces and complete V&V on the products as they are integrated.
- Prepares the preliminary V&V Report before ORR and then baselines the report by FRR/MRR.
- Transitions or delivers the final products and baselines the as-built hardware and software documentation.
- Prepares for operations, updates the Operations Concept, if needed, and baselines the **Mission Operations Plan** and the **Operations Handbook** at ORR. The Mission Operations Plan is also updated at FRR/MRR.

The project updates the **Design Documentation** by FRR/MRR. The project updates **Systems Safety Analyses** in accordance with *NPR 8715.3, NASA General Safety Program Requirements* at ORR and FRR/MRR. If required, the project updates the **Human-Rating Certification Package** prior to ORR and submits the package for certification prior to the SMSR. The project also updates the **Safety and Mission Assurance (SMA) Plan** prior to the SMSR.

The project baselines the Science Data Management Plan that was initially developed during Phase B at ORR and updates the plan at FRR/MRR, if required. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project updates the **Project Protection Plan** and Communications Plan by ORR. The project also updates the Project Protection Plan by MRR/FRR. (The Communications Plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The project updates the **System Security Plan** by ORR in accordance with *NPR 2810.1, Security of Information and Information Systems*.

The project develops the final **Orbital Debris Assessment Report** (ODAR) in accordance with *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* using the format and requirements contained in *NASA-STD-8719.14, Process for Limiting Orbital Debris* prior to the SMSR. The project baselines the **End of Mission Plan** (EOMP) in accordance with NPR 8715.6 and NASA-STD-8719.14, Appendix B, End of Mission Plans prior to the SMSR. The EOMP is a living document that grows with the project as it operates up to its inclusion in the **Decommissioning/Disposal Plan** at KDP F. The format for an EOMP is provided in Appendix B of NASA-STD-8719.14. The EOMP includes the project management approach and the mission overview; spacecraft description; assessment of spacecraft debris released during and after passivation; assessment of spacecraft potential for on-orbit collisions; assessment of spacecraft post-mission disposal plans and procedures; assessment of spacecraft reentry hazards (all data added during flight); and assessment of hazardous materials contained on the spacecraft.

In accordance with *NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects*, the project updates the Hardware Quality Data Management Analytics in preparation for ORR and for MRR/FRR. (The Hardware Quality Data Management Analytics is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

Once the hardware is shipped to the launch site, the project, with launch site support, begins the process of receiving and inspecting the hardware, reassembling the spacecraft as required, completing final spacecraft testing, and resolving any open issues that remain. The project supports launch rehearsals, participates in press conferences, and supports the launch approval process described below.

When the project is ready for launch, the project team obtains the approved documents required for launch. If applicable, the project manager ensures that the nuclear launch authorization process has been properly completed and provides the OSMA Nuclear Flight Safety Assurance Manager with required documentation in accordance with *NPR 8715.26, Nuclear Flight Safety*.

Finally, the project documents lessons learned in accordance with *NPD 7120.6, Knowledge Policy for Programs and Projects* and the project's Knowledge Management Plan. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

4.4.4 Launch Approval Process and Transition to Operations

This section applies to tightly coupled programs, single-project programs, and projects.

The process for completing KDP III (tightly coupled programs)/KDP E (projects and single-project programs) and obtaining approval for launch and early operations is complex and unique. The KDP III/KDP E decision to launch and conduct early operations includes approval for the transition to the operations phase of the life cycle; however, unlike other life-cycle phase transitions, the transition to operations does not occur immediately after the KDP III/KDP E. For robotic space flight programs and projects, this transition to operations occurs following a successful launch and on-orbit checkout. For human space flight programs and projects, this transition to operations occurs after initial operations[75]

[75] Human space flight programs and projects develop flight systems that return to Earth or develop flight systems that remain in orbit. Initial operations for the former programs and projects may require one or more launch, flight, landing, and recovery operations sequences to meet all flight test objectives. Initial operations for the latter programs and projects may include one or more launch and flight operations

have been successfully completed and all flight test objectives (including human rating) have been met. For the program or project to gain approval to launch and conduct early operations, the governing PMC meets to conduct a review of readiness for flight, at which the program or project is expected to demonstrate that it is ready for a safe, successful launch and early operations with acceptable risk within Agency commitments. For human space flight programs and projects, this review is the Agency Flight Readiness Review (FRR).[76] For robotic space flight programs and projects, this review is the Mission Readiness Briefing (MRB). The KDP III/KDP E decision is made at the end of the Agency FRR for human space flight programs and projects, and at the end of the MRB for robotic space flight programs and projects. The details of the process for human and robotic space flight programs and projects to gain approval to launch and conduct early operations are described below.

The decision to launch and conduct early operations is a critical decision for the Agency. The KDP III (KDP E for projects and single-project programs) decision occurs before launch to provide Decision Authority approval for this decision. The KDP III/KDP E decision includes approval for the transition to the operations phase of the life cycle; however, unlike other life-cycle phase transitions, the transition to operations does not occur immediately after the KDP III/KDP E. This transition occurs after launch and checkout. The timing for this transition stems from the historical practice of funding missions through on-orbit checkout, transitioning from the development team to the operations team following on-orbit checkout, and funding mission operations separately.

4.4.4.1 Human Space Flight Programs and Projects

For human space flight programs and projects, preparation for KDP III (tightly coupled programs)/KDP E (projects and single-project programs) and approval for launch and early operations includes a series of reviews to establish and assess the program or project's readiness. These reviews include the Operations Readiness Review (ORR); programmatic pre-FRR(s), which may be conducted by the project, program, and Mission Directorate (MD); the Center pre-FRR;[77] the Safety and Mission Success Review (SMSR); and finally, the Agency FRR. The KDP III/KDP E decision is made at the end of the Agency FRR. In the short timeframe between the Agency FRR and launch, the Launch Readiness Review (LRR) (also known as the L-1 day Mission Management Team (MMT) Review) is conducted for final review before launch.

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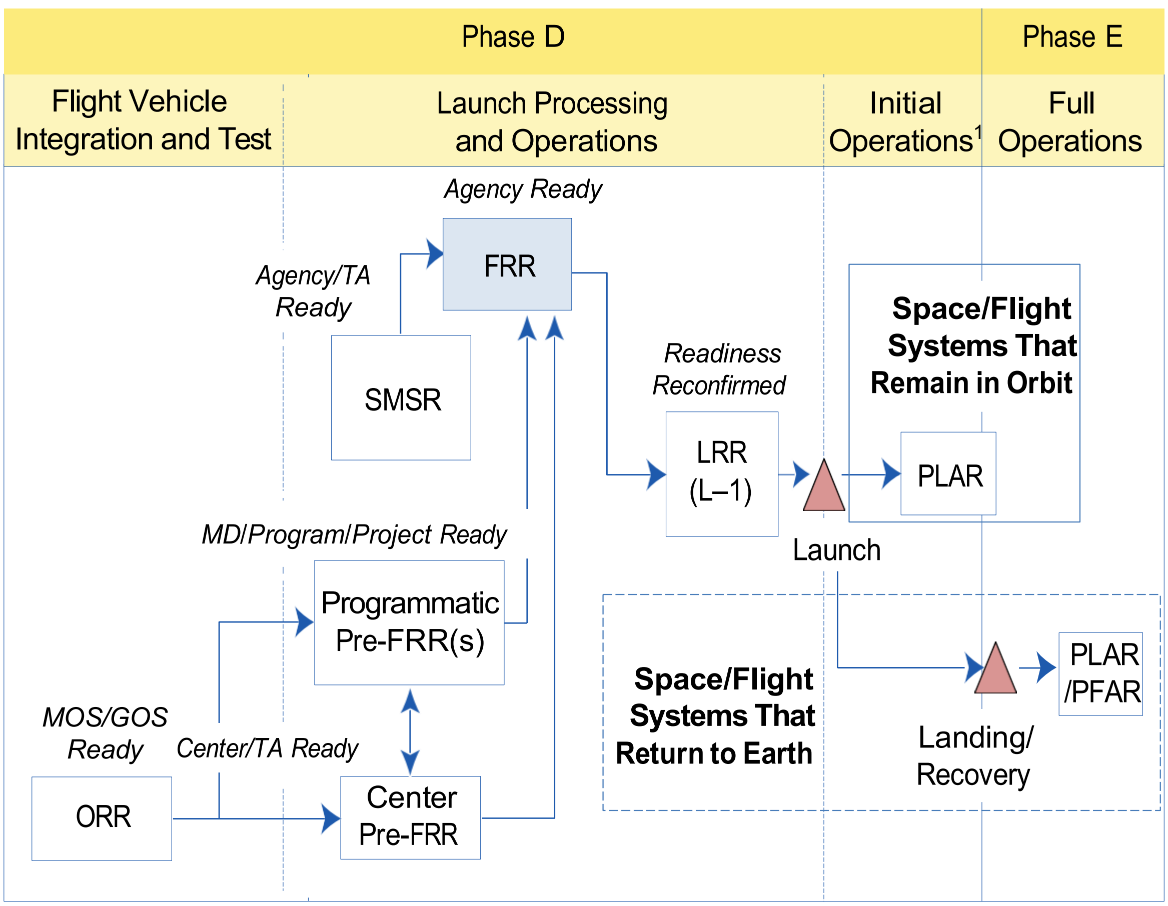
sequences, such as launch and assembly flights for the ISS Program. The initial operations timeline for both types of human space flight programs and projects may span multiple years.

[76] The human space flight Agency FRR is chaired by the MDAA and attended by the Decision Authority.

[77] The Center pre-FRR may be conducted in conjunction with the program or project pre-FRR.

When more than one launch and flight operations sequence or more than one launch, flight and landing/recovery operations sequence is needed to successfully complete initial operations, this series of reviews or a subset of the series is repeated for each sequence. The Agency FRR is conducted for each sequence. However, the KDP III/KDP E decision is made only once, at the initial Agency FRR.

A Post-Launch Assessment Review (PLAR) is conducted after launch to determine the program or project's readiness to begin the operations phase of the life cycle. For human space flight programs and projects that develop flight systems that return to Earth, the PLAR may be combined with the Post-Flight Assessment Review (PFAR), which is conducted after landing and recovery. Figure 4-14 depicts the series of reviews leading to KDP III/KDP E and launch for human space flight programs and projects, and the PLAR and PFAR reviews.



Review
KDP III/KDP E

[1] Initial operations may include multiple launch, flight, and landing/recovery operations sequences.

Figure 4-14 KDP III/KDP E Flow Chart for Human Space Flight Programs and Projects

The **objectives** of the Operations Readiness Review (ORR) are to evaluate the readiness of the program, project, ground systems, personnel, procedures, and user documentation to assemble, integrate, and test flight systems (using associated ground systems) during the development phase as well as to operate the flight system and associated ground systems in compliance with defined program or project requirements and constraints during the operations phase.

Programmatic pre-FRRs may be conducted by the project, program, and Mission Directorate in accordance agreements established by the Mission Directorate with the program and project. The **objectives** of these pre-Flight Readiness Reviews (pre-FRRs) are to determine the program or project's readiness for vehicle rollout to the launch pad, launch, and flight. The **objectives** of the Mission Directorate's pre-FRR, if conducted, may also include determining the readiness of external supporting entities (e.g., NASA Space Communications and Navigation (SCaN), Eastern and Western Range). The program or project certifies the completion of all tasks and identifies any planned work required to prepare the flight and ground hardware and software, support facilities, and operations personnel to safely support launch and flight. This includes review of necessary data to ensure satisfactory closeout of all Mission Directorate flight readiness certification requirements, exceptions, and launch constraints in sufficient detail to enable determination of flight readiness.

The **objectives** of the Center pre-FRR are for Center management and Technical Authorities to determine the readiness of the program or project and the Center institutional resources that support the program or project for vehicle rollout to the launch pad, launch, and flight.

The **objective** of the Safety and Mission Success Review (SMSR) is to prepare Agency safety and engineering management to participate in program final readiness reviews preceding flights or launches, including experimental and/or test launch vehicles or other reviews as determined by the Chief, Safety and Mission Assurance (SMA). The SMSR provides the knowledge, visibility, and understanding necessary for senior safety and engineering management to either concur or nonconcur in program decisions to proceed with a launch or significant flight activity.

The results of the programmatic pre-FRRs, Center pre-FRR, the SMSR, and the readiness of external supporting entities are presented to the Agency FRR. The **objective** of the Agency Flight Readiness Review (FRR) is to evaluate the program or project and all supporting systems, including ground, hardware, and software systems, personnel, and procedures, for readiness for a safe and successful launch and flight. The KDP III/KDP E decision is made at the end of the initial Agency FRR. At KDP III/KDP E, the program or project is expected to demonstrate that it is ready for a safe, successful launch and early operations with acceptable risk within Agency commitments. The Certification of Flight Readiness (COFR) is signed at the conclusion of the Agency FRR.

The Launch Readiness Review (LRR)/L-1 Review is held no later than 1 day before launch. The **objectives** of the LRR/L-1 Review are to update the vehicle, payload processing, and mission status; close out actions from preceding reviews, including the Agency FRR, programmatic pre-FRRs, and Center pre-FRR; resolve any remaining issues; address any issues associated with weather; and authorize approval to proceed into launch countdown.

The Post-Launch Assessment Review (PLAR) is a non-KDP-affiliated review that is conducted after launch. The **objective** of the PLAR, accomplished through the MMT meetings, is to evaluate the in-flight performance of the flight systems. More than one test flight (i.e., launch and flight operations sequence) may be required to successfully accomplish all flight test objectives, satisfy human-rating requirements, and complete initial operations, and multiple PLARs may be conducted throughout the initial operations period, as determined by the MMT. A PLAR is conducted by the Mission Directorate following completion of initial operations to determine the program or project's readiness to begin the operations phase of the life cycle and to transfer responsibility to the operations organization. At this PLAR, the program or project is expected to demonstrate that it is ready to conduct mission operations with acceptable risk within Agency commitments. For human space flight programs and projects that develop flight systems that return to Earth, this PLAR may be combined and conducted in conjunction with the PFAR.

The Post-Flight Assessment Review (PFAR) is a non-KDP-affiliated review associated with human space flight programs and projects that develop flight systems that return to Earth. It is conducted after a launch, flight, and landing and recovery operations sequence is completed. The **objective** of the PFAR is to evaluate accomplishment of flight test objectives, including satisfaction of human-rating requirements. Accomplishments and any vehicle and mission support facility performance issues and anomalies are documented, and lessons learned are captured and used. More than one test flight (i.e., launch, flight, and landing and recovery operations sequence) may be required to successfully accomplish all flight test objectives, satisfy human-rating requirements, and complete initial operations, and multiple PFARs may be conducted throughout the initial operations period.

4.4.4.2 Robotic Space Flight Programs and Projects

For robotic space flight programs and projects, preparation for KDP III (tightly coupled programs)/KDP E (projects and single-project programs) and approval for launch and early operations includes a series of reviews to establish and assess the readiness of the program or project's spacecraft and the launch vehicle. These reviews include the Operations Readiness Review (ORR), Mission Readiness Review (MRR), Launch Vehicle Readiness Review (LVRR), and Safety and Mission Success Review (SMSR). The KDP III/KDP E decision on mission readiness is made at the Mission Directorate Program Management Council (DPMC). The DPMC constitutes the governing PMC for Category 2 and 3 projects and Category 1 projects delegated by the NASA AA to the MDAA. The final launch decision is made at the Launch Readiness Review (LRR) where all involved parties provide their final readiness to launch. Figure 4-15 depicts the series of reviews leading to KDP III/KDP E and launch for robotic space flight programs and projects, and the Post-Launch Assessment Review (PLAR), at which the program or project's readiness to begin the operations phase of the life cycle is determined.

The MDAA for robotic programs (typically the AA of the Science Mission Directorate (SMD)) is presented with the results of the project's Operational Readiness Review (ORR), Mission Readiness Review (MRR), and Safety and Mission Success Review (SMSR) and, based on acceptable results, approves the project to proceed through the launch event into mission operations at the KDP III/KDP E DPMC. The DPMC constitutes the governing PMC for Category 2 and 3 projects and Category 1 projects (when delegated by the NASA AA to the MDAA). Category 1 projects not delegated to the MDAA have a subsequent Agency Program Management Council (APMC), where the KDP III/KDP E mission readiness decision is made.

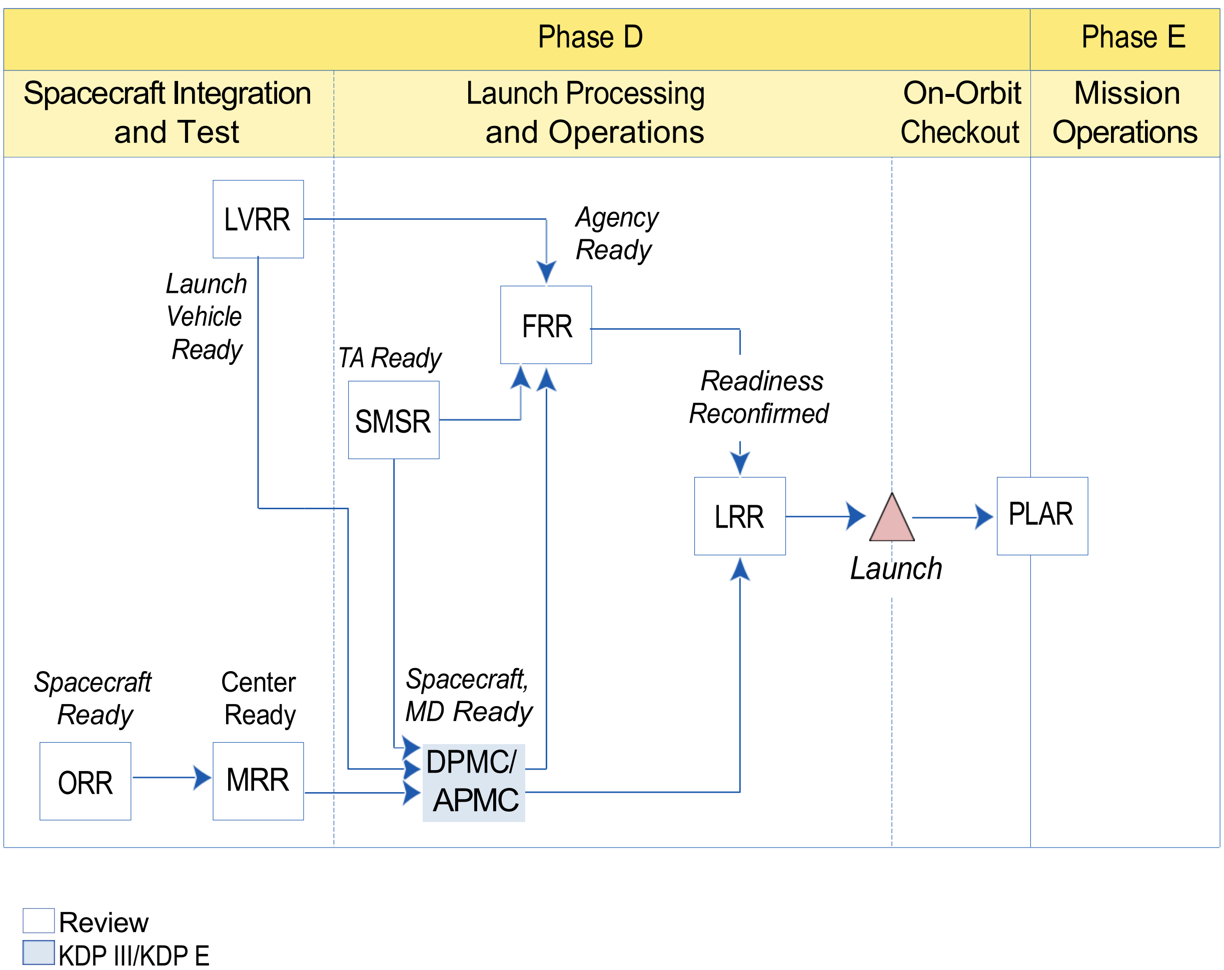


Figure 4-15 KDP III/KDP E Flow Chart for Robotic Space Flight Programs and Projects

The **objectives** of the Operations Readiness Review (ORR) are to evaluate the readiness of the spacecraft program, project, ground systems, personnel, procedures, and user documentation to operate the flight systems and associated ground systems in compliance with defined program or project requirements and constraints during the operations and sustainment phase.

The **objective** of the Launch Vehicle Readiness Review (LVRR) is to certify the readiness of the launch vehicle to proceed with spacecraft and launch vehicle integration activities.[78] Any launch vehicle anomalies and/or issues associated with the mission are reviewed. The LVRR is typically held prior to the MRR.

The **objective** of the Mission Readiness Review (MRR) is to evaluate the readiness of the program or project's spacecraft, ground systems, personnel, and procedures for a safe and successful launch and flight/mission.

The **objective** of the Safety and Mission Success Review (SMSR) is to prepare Agency safety and engineering management to participate in program or project final readiness reviews preceding flights or launches, including experimental and/or test launch vehicles or other reviews as determined by the Chief, Safety and Mission Assurance (SMA). The SMSR provides the knowledge, visibility, and understanding necessary for senior safety and engineering management to either concur or nonconcur in program or project decisions to proceed with a launch or significant flight activity.

At the DPMC meeting (and APMC, if applicable), the results of the ORR, MRR, and SMSR are presented. The **objective** of the KDP III/KDP E DPMC (or APMC) is to evaluate the program or project and all supporting systems, including ground, hardware, and software systems, personnel, and procedures, for readiness for a safe and successful launch and flight/mission. At KDP III/KDP E, the program or project is expected to demonstrate readiness for launch and early operations with acceptable risk within Agency commitments. Based on acceptable results, the MDAA (or NASA AA) approves the program or project to proceed to launch.

The **objective** of the Flight Readiness Review (FRR) is to determine the readiness of the launch vehicle and spacecraft to enter final launch preparation.[79] The FRR is held about 5 days before launch to review the mission status and close out any actions from the LVRR, MRR, SMSR, and MRB that constrain launch.

The **objectives** of the Launch Readiness Review (LRR) are to provide final launch readiness status from all the mission elements, close out any actions from the FRR that constrain launch, authorize approval to initiate the launch countdown, and sign the Certification of Flight Readiness (CoFR). The LRR is held at the launch site no later than 1 day before launch.

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[78] The LVRR is chaired by the Launch Services Program Manager.
[79] The FRR is chaired by the NASA Launch Manager.

The Post-Launch Assessment Review (PLAR) is a non-KDP-affiliated review that is conducted after the mission has launched and on-orbit checkout has been completed. The **objectives** of the PLAR are to evaluate the in-flight performance of the program or project flight systems early in the mission and to determine the program or project's readiness to begin the operations phase of the life cycle and transfer responsibility to the operations organization. At the PLAR, the program or project is expected to demonstrate that it is ready to conduct mission operations with acceptable risk within Agency commitments.

4.4.5 Completing System Assembly, Integration and Test, Launch and Checkout (Phase D) and Preparing for Operations and Sustainment (Phase E)

4.4.5.1 Finalizing Plans for Phase E

The project develops and updates its plans for work to be performed during Phase E and F, including updates, if needed and particularly if a descope is required, to Life-Cycle Review (LCR) plans, the project IMS, details on technical work to be accomplished, key acquisition activities planned, and plans for monitoring performance against plan. The project incorporates the impact of performance against the plan established at KDP D.

The project prepares and finalizes Phase E work agreements. The work scope and price for Phase E contracts may be negotiated prior to approval to proceed into operations but not executed. (Once the project has been approved to proceed at KDP E and funding is available, the negotiated contracts may be executed, assuming no material changes.)

The project documents the results of Phase D activities and generates the appropriate documentation as described in NPR 7123.1, NPR 7120.5F Tables I-4 and I-5, and Tables 4-6 and 4-7 at the end of this chapter.

4.4.5.2 Project Phase D Reporting Activities and Preparing for Major Milestones

4.4.5.2.1 Project Reporting

The project manager reports to the Center Director or designee and supports the program executive in reporting the status of project Implementation at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly Baseline Performance Review (BPR). (Section 5.12 provides further information regarding potential project reporting.)

4.4.5.2.2 Project Internal Reviews

Prior to LCRs, projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. (These internal reviews are described in Section 4.3.2.2.2.)

4.4.5.2.3 Preparing for Major Milestone Reviews

Projects support the LCRs described in Section 4.4.4 in accordance with NPR 7123.1, Center practices, and NPR 7120.5, ensuring that the LCR objectives and expected maturity states defined in NPR 7120.5 have been satisfactorily met. LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP information in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate the project has met the expected maturity state. *NASA/SP-2016-3706, NASA Standing Review Board Handbook* provides additional detail on this process for the Operations Readiness Review (ORR), which requires an independent SRB.

Projects plan, prepare for, and support the governing PMC review prior to KDP E and provide or obtain the KDP readiness products listed in Section 4.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the project updates its documents and plans as required to reflect the decisions made and actions assigned at the KDP.

In tightly coupled programs, project(s) transition to KDP E in accordance with the plan for reviews documented in the Program or Project Plan.

4.4.6 Project Phase E, Operations and Sustainment Activities

4.4.6.1 Project Phase E Life-Cycle Activities

During Phase E, the project implements the **Project Plan/Mission Operations Plan** developed in previous phases. Mission operations may be periodically punctuated with Critical Event Readiness Reviews (CERR), e.g., a trajectory correction maneuver or orbit insertion maneuver. Human space flight missions may conduct PFARs specific to the project needs. (See Sustainment and Sustaining Engineering box for an explanation of sustainment activities.)

Sustainment and Sustaining Engineering

Sustainment generally refers to supply, maintenance, transportation, sustaining engineering, data management, configuration management, manpower, personnel, training, habitability, survivability, environment, safety, supportability, and interoperability functions.

The term "sustaining engineering" refers to technical activities that can include, for example, updating designs (e.g., geometric configuration), introducing new materials, and revising product, process, and test specifications. These activities typically involve first reengineering items to solve known problems and then qualifying the items and sources of supply. The problems that most often require sustaining engineering are lack of a source (e.g., vendor going out of business), component that keeps failing at a high rate, and long production lead time for replacing items.

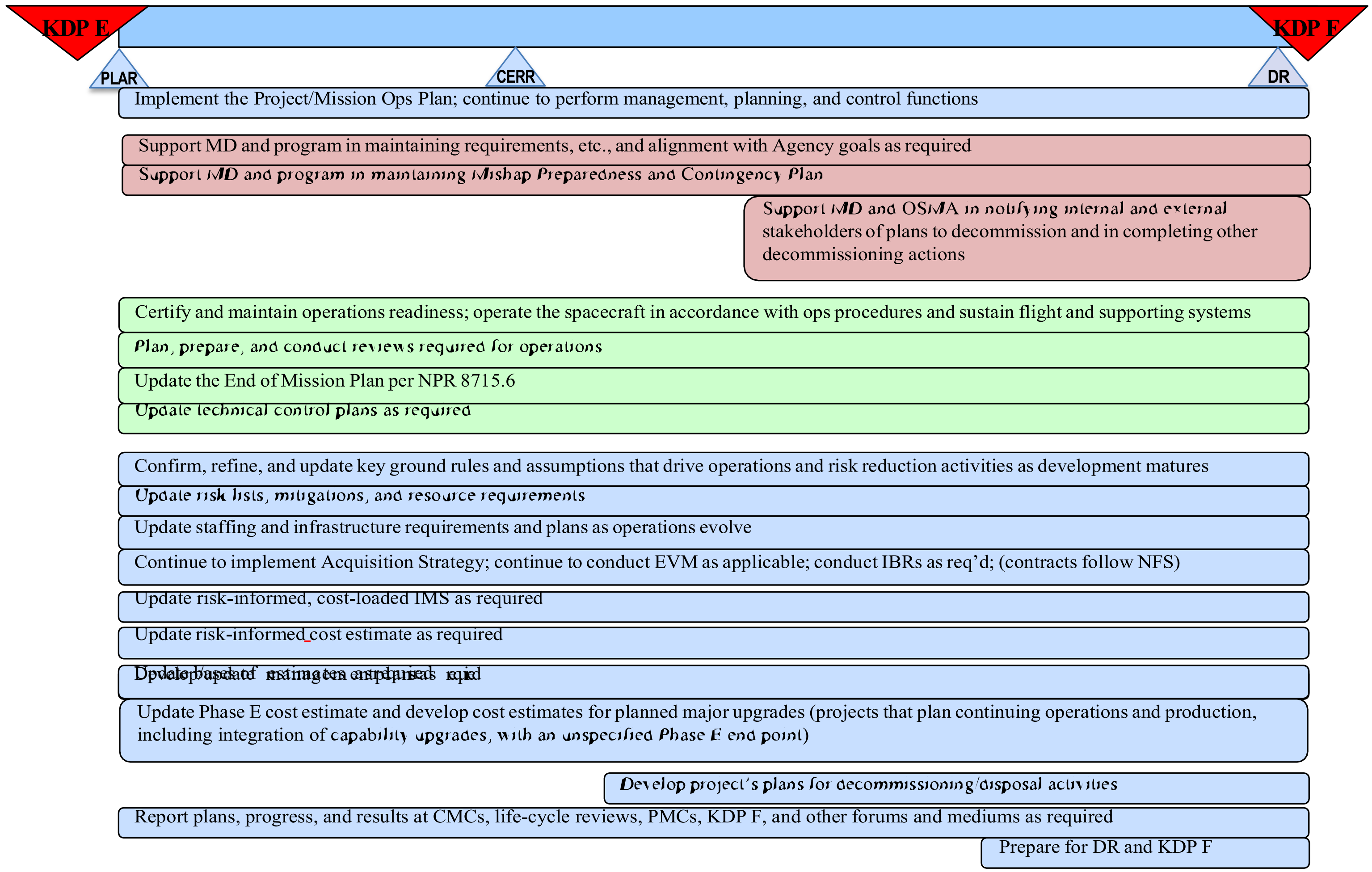
As parts age, the need and opportunity for sustaining engineering increase. The practice of sustaining engineering includes not only the technical activity of updating designs but also the business judgment of determining how often and on what basis the designs need to be reviewed.

The mission operation phase ends with the Decommissioning Review (DR) and KDP F, at which time mission termination is approved. The DR may be combined with the Disposal Readiness Review (DRR) if the spacecraft will be disposed of immediately after the DR:

- The **objectives** of the Critical Event Readiness Reviews (CERR) are to evaluate the readiness of the project and the flight system for execution of a critical event during the flight operations phase of the life cycle.
- The **objectives** of the Post-Flight Assessment Review (PFAR) when conducted during this phase are to evaluate how well mission objectives were met during a space flight mission and to evaluate the status of the returned vehicle.
- The **objectives** of the Decommissioning Review (DR) are to evaluate the readiness of the project to conduct closeout activities, including final delivery of all remaining project deliverables and safe decommissioning of space flight systems and other project assets, and to determine if the project is appropriately prepared to begin Phase F.
- The **objective** of the Disposal Readiness Review (DRR) is to evaluate the readiness of the project and the flight system for execution of the spacecraft disposal event.

At KDP F, the project team is expected to demonstrate that the project decommissioning is consistent with program objectives and the project is ready for safe decommissioning of its assets and closeout of activities, including final delivery of all remaining project deliverables and disposal of its assets.

A general flow of Phase E activities is shown in Figure 4-16.



Program management, planning, and control tasks

Technical work the program is doing

Work for which Headquarters is responsible but the program helps accomplish (e.g., International partnerships are a Headquarters responsibility, but the programs help develop and finalize those partnerships)

MD = Mission Directorate

Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 4-16 Project Phase E Flow of Activities

4.4.6.2 Project Phase E Management, Planning and Control Activities

4.4.6.2.1 Supporting Headquarters Planning

During Phase E, the project manager and the project team implement the **Project Plan/Mission Operations Plan**. In some cases, the project team that developed the mission is disbanded and Phase E is managed by a project team that specializes in mission operations. The project manager and project team continue to support the program manager and the MDAA in maintaining the baseline program requirements and constraints on the project, including mission objectives and goals and mission success criteria. The project obtains an update to these and updates the project's documentation and plans if operations performance shortfalls or new mission requirements are identified.[80] The updated documentation supports the program manager and the MDAA in ensuring the continuing alignment of the project requirements with applicable Agency strategic goals. The project supports the program manager and the MDAA in developing options to resolve operations deficiencies or to enhance mission operations performance.

Prior to the Decommissioning Review (DR), the project works with the Mission Directorate to update the **Mishap Preparedness and Contingency Plan** if necessary.

4.4.6.2.2 Management Control Processes and Products

The project team implements the **Project Plan/Mission Operations Plan** as approved at KDP E. The project team ensures that appropriate infrastructure and trained and certified staff are available and ready when needed to support the activities of this phase. The project team updates, as needed, project external agreements, partnerships, and acquisition and other plans that are required for successful completion of this and remaining life-cycle phases. As directed by the program manager, the project supports the development of Project Plan revisions to continue the mission into extended operations beyond the primary mission phase or beyond any extension previously included in the plan.

The project team implements acquisition activities in accordance with the approved **Acquisition Strategy**. The project updates, identifies, assesses, and mitigates (if feasible) supply chain risks, including critical or single-source suppliers needed to design, develop, produce, and support required capabilities at planned cost and schedule. The project reports risks to the program. The project implements contract closeouts, as appropriate.

As mission operations begin, the project continues to identify, assess, and update the **technical, cost, schedule, and safety risks** that threaten the system operations and drive cost and schedule estimates. The project maintains a record of accepted risks and the associated rationale for their acceptance, actively assesses open risks, and develops and

[80] Program requirements on the project are contained in the Program Plan.

implements mitigation plans. It updates resources being applied to manage and mitigate risks.

Project managers manage the project within the approved baselines identified in the Management Agreement. The project maintains and updates, if required, the project baselines and Management Agreement under configuration management. As a minimum, the project does the following:

- Manages programmatic margins and resources to ensure successful completion of this and remaining life-cycle phases within budget, schedule, and risk constraints.
- Updates the IMS when changes warrant.
- Updates cost estimates and their basis when changes warrant.
- Assesses the adequacy of anticipated budget availability against phased LLC requirements and commitments, incorporating the impact of performance to date.

Projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, update and document the Phase E cost estimate annually for the next 5-year period. Upgrades during Phase E that meet the Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purposes of establishing their own development ABC outside the Phase E cost estimate. The project Phase E cost estimate is updated to include the production and operations costs associated with these upgrades. Development, production, and operations costs of other (i.e., non-major) upgrades are included in the project Phase E cost estimate. (See Section 5.5.4 for information on the Phase E cost estimate.)

Projects provide an **updated Cost Analysis Data Requirement (**CADRe) parts A, B, and C consistent with the *NASA Cost Estimating Handbook*[81] within 90 days after the completion of spacecraft post-launch checkout. This CADRe is based on the "as built" launched baseline.

4.4.6.3 Project Phase E Technical Activities and Products

The project performs its operations technical activities as required in NPR 7123.1 for this phase. It certifies and maintains mission operations readiness, as required; operates the spacecraft in accordance with the operations procedures; sustains the spacecraft and supporting systems as the need arises; captures and archives mission technical results; and evaluates when it is ready for end of mission. It updates the **End of Mission Plan** (EOMP) as described in *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments* and *NASA-STD-8719.14, Process for Limiting Orbital Debris, Appendix B, End of Mission Plans* as well as updating the

[81] https://www.nasa.gov/content/cost-estimating-handbook

Security and **Project Protection Plans** annually. The project also updates the **Safety and Mission Assurance (SMA) Plan**.

Finally, the project team documents lessons learned in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy, NPD 7120.6, Knowledge Policy for Programs and Projects,* and the project's Knowledge Management Plan. (This plan is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

4.4.7 Project Decommissioning and Disposal

All projects will eventually cease as a natural evolution of completing their mission objectives. When this occurs, the Mission Directorate, program, and project need to be sure that all the products produced by the project (e.g., spacecraft, ground systems, test beds, spares, science data, operational data, returned samples) are properly dispositioned and that all project activities (e.g., contracts, financial obligations) are properly closed out. The project develops a **Decommissioning/Disposal Plan** to cover all activities necessary to close the project out and conducts a DR in preparation for final approval to decommission by the Decision Authority (or designee) at KDP F.

The decommissioning of a project with operating spacecraft requires that the project team ensure the safe and adequate disposal of the spacecraft. Figure 4-17 provides an overview of the disposal of a spacecraft, the various documents that are produced as part of this, and the order and timing of major activities and document deliveries.

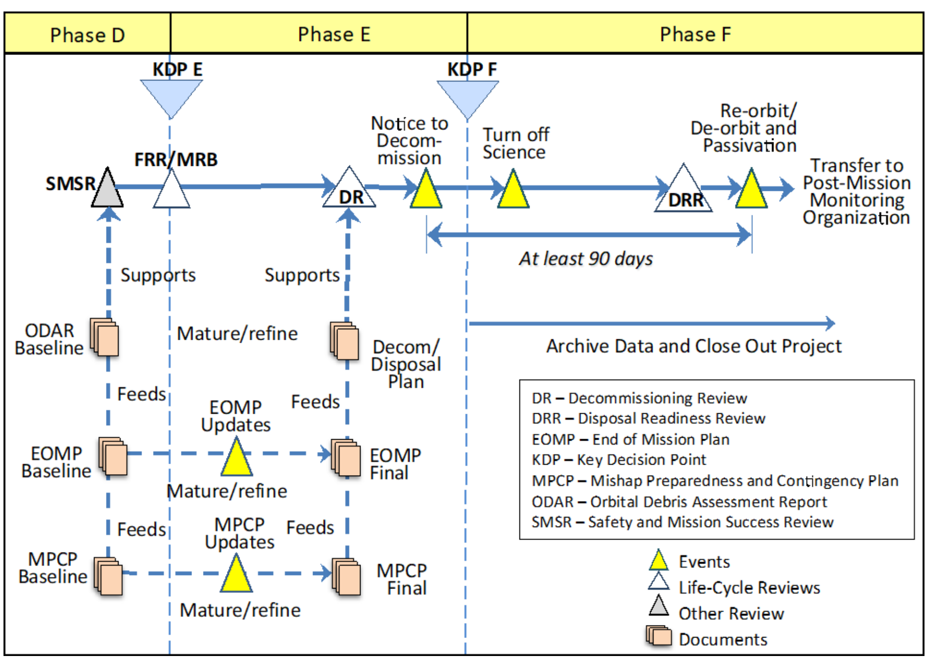


Figure 4-17 Spacecraft Disposal Process Flow

The actual disposal of the spacecraft (reorbit, deorbit, and passivation) needs to meet Agency orbital debris requirements and is a critical event. As a result, this event requires a DRR to evaluate the readiness of the project and the flight system for execution of the spacecraft disposal event. (See NPR 7120.5F and Table E-3 in this handbook.) In many cases, such as small spacecraft, the decommissioning and disposal occur relatively close together. In these instances, the DR and DRR may be conducted together.

Decommissioning/disposal and Phase F end when the project funding is finally terminated.[82]

The **Decommissioning/Disposal Plan** is prepared by the project manager and approved by the program manager; Center Director; Chief, SMA (through the Orbital Debris Program Manager); the MDAA; and the Decision Authority if not the MDAA. This plan is approved and baselined at KDP F.

The **Decommissioning/Disposal Plan** contains the following:

- Updated EOMP, including the method and location of disposal; the planned status of spacecraft after disposal; and schedule, safety, and environmental considerations.
- Updated **Mishap Preparedness and Contingency Plan** and predefined contingency and mishap scenarios.
- Approach and plans for notifying stakeholders and customers of the intent to decommission the project and spacecraft as described in *NPD 8010.3, Notification of Intent to Decommission or Terminate Operating Space Systems and Terminate Missions*.
- Approach and plans for:
  - Archiving science, operations, and engineering data (e.g., methods, media, locations).
  - Maintaining communications security.
  - Dispositioning all hardware, software, and facilities remaining on the ground.
  - Closing out contracts, financial obligations, and project infrastructure and transferring project personnel.
  - Long-term monitoring of spacecraft remaining on orbit.

4.4.7.1 Completing Operations and Sustainment (Phase E) and Preparing for Decommissioning and Closeout (Phase F)

The project develops and updates its plans for work to be performed during Phase F, including updates, if needed, to LCR plans, project IMS, details on technical work to be

[82] Funding for SMD projects covers the archival of the science data produced by the spacecraft (and the ancillary data for its interpretation) prior to project termination. This ensures that the science community will have access to this data for follow-on science research and data analysis.

accomplished, key acquisition activities planned, and plans for monitoring performance against plan. The project incorporates the impact of performance against the plan established at KDP E.

The project prepares and finalizes Phase F work agreements.

The project documents the results of Phase E activities and generates the appropriate documentation as described in NPR 7123.1, NPR 7120.5F Tables I-4 and I-5, and Tables 4-6 and 4-7 at the end of this chapter.

4.4.7.2 Project Phase E Reporting Activities and Preparing for Major Milestones

4.4.7.2.1 Project Reporting

The project manager reports to the Center Director or designee and supports the program executive in reporting the status of project Implementation at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly Baseline Performance Review (BPR). (Section 5.12 provides further information regarding potential project reporting.)

4.4.7.2.2 Project Internal Reviews

Prior to the LCRs, projects conduct internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5. (These internal reviews are described in Section 4.3.2.2.2.)

4.4.7.2.3 Preparing for Major Milestone Reviews

Projects plan, prepare for, and support the CERR, PFAR, and DR (and DRR if combined with the DR) life-cycle reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5, ensuring that the life-cycle review objectives and expected maturity states defined in NPR 7120.5 have been satisfactorily met. Life-cycle review entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP information in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate that the project has met the expected maturity state.

Projects plan, prepare for, and support the governing PMC review prior to KDP F and provide or obtain the KDP readiness products listed in Section 4.2.3.

Once the KDP has been completed and the Decision Memorandum signed, the project updates its documents and plans as required to reflect the decisions made and actions assigned at the KDP.

In tightly coupled programs, project(s) transition to KDP F in accordance with the plan for reviews documented in the Program or Project Plan.

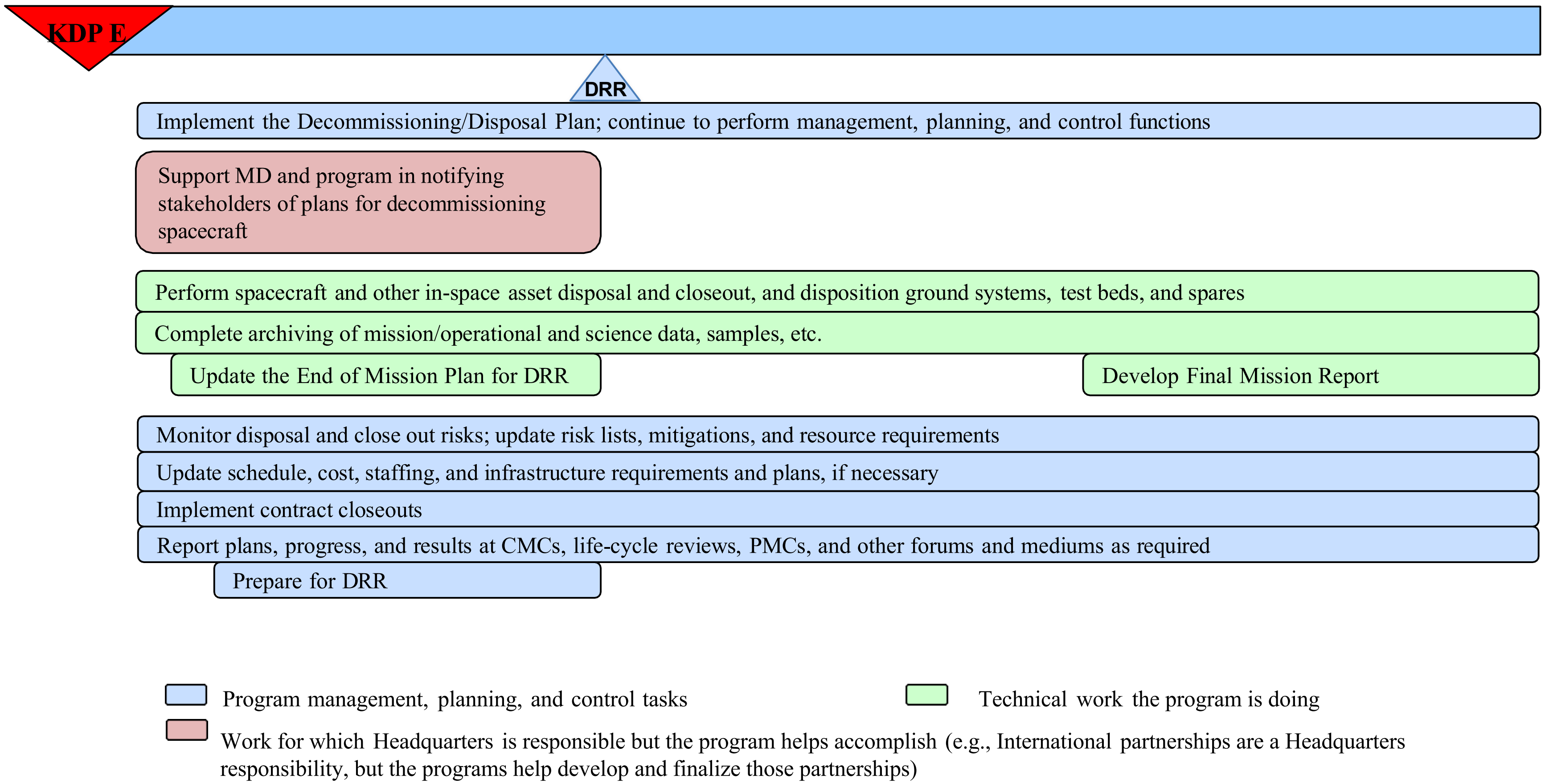
4.4.8 Project Phase F, Decommissioning/Disposal and Closeout Activities

4.4.8.1 Project Phase F Life-Cycle Activities

During Phase F, the project implements the **Decommissioning/Disposal Plan** developed and approved in Phase E. The project dispositions all spacecraft ground systems, data, and returned samples, including safe and adequate disposal of the spacecraft. The project dispositions other in-space assets and closes out all project activities in accordance with the Decommissioning/Disposal Plan. The project performs a Disposal Readiness Review (DRR) if it was not performed as part of the Decommissioning Review (DR).

The **objective** of the DRR is to evaluate the readiness of the project and the flight system for execution of the spacecraft disposal event.

A general flow of Phase F activities is shown in Figure 4-18.



Note: These are typical high-level activities that occur during this program phase. Placement of reviews is notional.

Figure 4-18 Project Phase F Flow of Activities

4.4.8.2 Project Phase F Planning, Control, and Technical Activities and Products

During Phase F, the project manager and the project team perform the technical activities required in NPR 7123.1 for this phase. They perform spacecraft and other in-space asset disposal and closeout and disposition ground systems, test beds, and spares. They monitor decommissioning and disposal risks, actively assess open risks, and develop and implement mitigation plans.

If the project's DRR was not performed as part of the DR, the project updates its **Mishap Preparedness and Contingency Plan, End of Mission Plan** (EOMP), disposal portions of the **Decommissioning/Disposal Plan**, and **Safety and Mission Assurance (SMA) Plan** prior to the DRR. The project also updates its **technical, cost, schedule, and safety risks, cost estimates,** and **BoE** prior to the DRR. In addition, the project continues updating the **Security and Project Protection Plans** annually.

The project team completes archiving mission/operational and science data and documents the results of Phase F activities. It completes storage and cataloging of returned samples and archives project engineering and technical management data. It implements contract closeouts, as appropriate. It develops the Final Mission Report and documents lessons learned in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy, NPD 7120.6 Knowledge Policy for Programs and Projects,* and the project's Knowledge Management Plan. (The Final Mission Report is a best practice as opposed to a requirement. See Section 4.5.1 for additional information on expectations associated with best practices.)

The Final Mission Report is a summary of what the mission accomplished and is prepared at the end of a mission. It has also been called an End of Mission report, but this is not to be confused with the End of Mission Plan (EOMP) required by NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments. (See Section 4.4.3.3.) The Final Mission Report generally includes a summary of the mission accomplishments, science data and/or samples collected, and a summary of the results achieved. This report is prepared in conjunction with documenting the mission's lessons learned in accordance with NPD 7120.6, Knowledge Policy for Programs and Projects and the project's Knowledge Management Plan. Projects need to ensure that resources are allocated to develop the Final Mission Report and lessons learned. These provide a valuable historical record of NASA's accomplishments and the issues that were encountered and overcome as part of the mission.

The project team provides the final update to the **Cost Analysis Data Requirement** (CADRe) Part C consistent with the *NASA Cost Estimating Handbook*[83] within 60 days after the end of decommissioning and disposal. The purpose is to capture the content and the

[83] https://www.nasa.gov/content/cost-estimating-handbook

actual cost of Phase E MOS/GDS along with any costs associated with the decommissioning and disposal.

Decommissioning and disposal and Phase F end when project money is finally terminated.[84]

4.4.8.3 Project Phase F Reporting Activities and Preparing for Closeout

The project continues to report to the Center Director or designee and the Mission Directorate as required to report the status of decommissioning and disposal. The project manager will probably be required to report the status at many other forums, including Mission Directorate monthly status meetings and the Agency's monthly BPR.

The project plans, prepares for, and supports the project DRR life-cycle review, if needed, in accordance with NPR 7123.1, Center practices, and the guidance in this handbook, including the DRR objectives and expected maturity state defined in NPR 7120.5F and Table D-3 in this handbook. Life-cycle review entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP information in Appendix E of this handbook provide specifics for addressing the six assessment criteria required to demonstrate that the project has met the expected maturity state.

Prior to the DRR, the project conducts internal reviews in accordance with NPR 7123.1, Center practices, and NPR 7120.5 and performs an assessment of the project's readiness to proceed to the DRR.

4.5 Project Products by Phase

4.5.1 Product Owner and Requirement or Best Practice

- The product owner for each product is indicated in Tables 4-6 and 4-7 in the column titled "Product Owner/Requirement or Best Practice".
- Products listed in Tables 4-6 and 4-7 are either requirements or best practices.
- "R" in the Product Owner/Requirement or Best Practice column indicates that a product is a requirement. Products that are requirements are included in the Compliance Matrix in Appendix C of NPR 7120.5.
- "BP" in the Product Owner/Requirement or Best Practice column indicates that the product is considered a best practice. The expectation is that the product will be developed in accordance with the table as part of normal project management activities.

[84] Funding for SMD projects covers the archival of the science data produced by the spacecraft (and the ancillary data for its interpretation) prior to project termination. This ensures that the science community will have access to this data for follow-on science research and data analysis.

4.5.2 Non-Configuration-Controlled Documents

For non-configuration-controlled documents, the following terms and definitions are used in Tables 4-6 and 4-7:

- "Initial" is applied to products that are continuously developed and updated as the project matures.
- "Final" is applied to products that are expected to exist in this final form, e.g., minutes and final reports.
- "Summary" is applied to products that synthesize the results of work accomplished.
- "Plan" is applied to products that capture work to be performed in the following phases.
- "Update" is applied to products that are expected to evolve as the formulation and implementation processes evolve. Only expected updates are indicated. However, any document may be updated as needed.

4.5.3 Configuration-Controlled Documents

For configuration-controlled documents, the following terms and definitions are used in Tables 4-6 and 4-7:

- "Preliminary" characterizes a product as it stabilizes but before it is put under configuration control. It is the initial development leading to a baseline. Some products will remain in a preliminary state for multiple LCRs. The initial preliminary version is likely to be updated at subsequent LCRs but remains preliminary until baselined.
- "Baseline" indicates putting the product under configuration control so that changes can be tracked, approved, and communicated to the team and any relevant stakeholders. Products typically enter the designated LCR as at least final drafts and are baselined during the review. Baselining a product that will eventually become part of the Project Plan indicates that the product has the concurrence of stakeholders and is under configuration control. Updates to baselined documents require the same formal approval process as the original baseline.
- "Approve" is used for a product, such as Concept Documentation, that is not expected to be put under classic configuration control but still requires that changes from the "approved" version are documented at each subsequent "update."
- "Update" is applied to products that are expected to evolve as the formulation and implementation processes evolve. Only expected updates are indicated. However, any document may be updated as needed. Updates to baselined documents require the same formal approval process as the original baseline.

4.5.4 Control Plans

- Control plans in Table 4-7 can either be part of the Project Plan or separate stand-alone documents referenced in the appropriate part of the Project Plan.

- Considerations for determining if a control plan should be a stand-alone document include a requirement that the control plan be stand-alone in the NPR that requires the control plan; differences between when the control plan is baselined and when the Project Plan is baselined; how frequently the control plan will be updated since updates to the Project Plan require signatures; and how long the control plan is.
- When the control plan is a stand-alone document, the Project Plan contains a reference to the stand-alone document.

4.5.5 Formats for Non-Control Plan Products

- Unless a specific form, format, document, or document template is identified by the NPR that requires a production Table 4-6, the documentation format is flexible, e.g., LCR or KDP presentation charts or as part of a document such as the Project Plan.

Table 4-6 Project Milestone Products Maturity Matrix

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
Headquarters and Program Products[1]											
1. FAD [Required per NPR 7120.5]	OCE/R	Baseline									
2. Program Plan [Required per NPR 7120.5]	OCE/R	Baseline									
2.a. Applicable Agency strategic goals [Required per NPR 7123.1]	OCE/R	Baseline	Update	Update							
2.b. Documentation of program-level requirements and constraints on the project (from the Program Plan) and stakeholder expectations, including mission objectives/goals and mission success criteria [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	Update	Update						
2.c. Documentation of driving mission, technical, and programmatic ground rules and assumptions [Required per NPR 7120.5]	OCE/R	Preliminary	Preliminary	Baseline	Update	Update	Update				
3. Partnerships and interagency and international agreements	OCE/R	Preliminary	Update	Baseline U.S. partnerships and agreements	Baseline international agreements						
4. ASM Decision Memorandum or ASM meeting summary [additional information in NPD 1000.5]	OCE/R		Final								
5. Mishap Preparedness and Contingency Plan [Required per NPR 8621.1]	OSMA/R				Preliminary		Update		Baseline (SMSR)	Update	Update
Project Technical Products[2]											
1. Concept Documentation [Required per NPR 7123.1]	OCE/R	Approve	Update	Update	Update						

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
2. Mission, Spacecraft, Ground, and Payload Architectures [Required per NPR 7123.1]	OCE/R	Preliminary mission and spacecraft architecture(s) with key drivers	Baseline mission and spacecraft architecture, preliminary ground and payload architectures. Classify payload(s) by risk per NPR 8705.4.	Update mission and spacecraft architecture, baseline ground and payload architectures	Update mission, spacecraft, ground and payload architectures						
3. Project-Level, System, and Subsystem Requirements [Required per NPR 7123.1]	OCE/R	Preliminary project-level requirements	Baseline project-level and system-level requirements	Update Project-level and system-level requirements, Preliminary subsystem requirements	Update project-level and system-level requirements. Baseline subsystem requirements						
4. Design Documentation [Required per NPR 7123.1]	OCE/R				Preliminary	Baseline	Update		Update		
5. Operations Concept Documentation [Required per NPR 7120.5]	OCE/R	Preliminary	Preliminary	Preliminary	Baseline						
6. Technology Readiness Assessment Documentation [Required per NPR 7120.5 Appendix F FA Template]	OCE/R	Initial	Update	Update	Update	Update					
7. Engineering Development Assessment Documentation [Required per NPR 7120.5 Appendix F FA Template]	OCE/R	Initial	Update	Update	Update						
8. Heritage Assessment Documentation [Required per NPR 7120.5 Appendix F FA Template]	OCE/R	Initial	Update	Update	Update						
9. Systems Safety Analyses (e.g.,	OSMA/R				Preliminary	Baseline	Update	Up-	Update		

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
safety data packages) [Baseline at CDR] [Required per NPR 8715.3]								date			
10. Payload Safety Process Deliverables [Required per NPR 8715.7]	OSMA/R				Preliminary	Prelim-inary	Baseline				
11. Verification and Validation Report [Required per NPR 7123.1]	OCE/R							Prelim-inary	Baseline		
12. Operations Handbook [additional information in NPR 7120.5 Appendix A]	OCE/R						Prelim-inary	Baseline	Update	Update	
13. Orbital Debris Assessment [Required per NPR 8715.6]	OSMA/R	Preliminary Assessment			Preliminary design ODAR	Detailed design ODAR			Final ODAR (SMSR)		
14. End of Mission Plans [Required per NPR 8715.6; additional information in NASA-STD-8719.14, App B]	OSMA/R								Baseline (SMSR)	Update per 8715.6	Update
15. Final Mission Report [additional information in NPR 7120.5 Appendix A]	OCE/BP										Final
16. Decommissioning/Disposal Plan [Required per NPR 7123.1]	OCE/R									Baseline	Update Dispos-al portions
17. Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status [Required per NPR 8735.2]	OSMA/R	Preliminary	Update	Update	Baseline	Update					
18. Criticality Identification Method for Hardware [Required per NPR 8735.2]	OSMA/R	Preliminary	Update	Update	Baseline	Update					
19. Hardware Quality Data Management Analytics [additional information in NPR 8735.2]	OSMA/BP	Preliminary	Update	Update	Baseline	Update	Update	Update	Update		
Project Management, Planning, and Control Products											

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	**SRR**	**SDR/MDR**	**PDR**	**CDR**	**SIR**	**ORR**	**MRR/FRR**	**DR**	**DRR**
1. Formulation Agreement [Required per NPR 7120.5]	OCE/R	Baseline for Phase A; Preliminary for Phase B		Baseline for Phase B							
2. Project Plan [Required per NPR 7120.5]	OCE/R			Preliminary	Baseline						
3. Documentation of performance against Formulation Agreement (see #1 above) or against plans for work to be accomplished during Implementation life-cycle phase, including performance against baselines and status/closure of formal actions from previous KDP [Required by NPR 7120.5]	OCE/R		Summary	Summary	Summary	Summary	Summary	Sum-mary	Summary	Sum-mary	
4.Project Baselines											
4.a. Top technical, cost, schedule and safety risks, risk mitigation plans, and associated resources [Required by NPR 7120.5]	OCE/R	Initial	Update	Update	Update	Update	Update	Update	Update	Update	Update
4.b. Staffing requirements and plans [Required by NPR 7120.5]	OCE/R	Initial	Update	Update	Update	Update		Update			
4.c.i Infrastructure requirements and plans [Required per NPR 9250.1, NPD 8800.14 and NPR 8820.2] Business case analysis for infrastructure [Required per NPR 8800.15.]	OSI-FRED/R	Initial	Update	Update	Update	Update					
4.c.ii Capitalization Determination Form (CDF) (NASA Form 1739) [Required per NPR 9250.1]	OCFO/R	Initial	Update	Update	Update	Update					
4.d. Schedule [Required per NPR 7120.5]	OCFO-SID/R	Risk informed at project level with preliminary Phase D completion ranges	Risk informed at system level with preliminary Phase D completion	Risk informed at subsystem level with preliminary Phase D completion ranges or	Risk informed and cost-loaded. Baseline Integrated Master Schedule	Update IMS	Update IMS	Update IMS	Update IMS	Update IMS	Update IMS

Products	Product Owner/ Requirement or Best Practice	Pre-Phase A KDP A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F	Phase F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/FRR	DR	DRR
			ranges	high and low schedule values with JCL[3]. Preliminary Integrated Master Schedule							
4.e. Cost Estimate [Required per NPR 7120.5]	OCFO-SID/R	Preliminary Range estimate	Update	Risk-informed range estimate or high and low-cost values with JCL[3]	Risk-informed Baseline	Update	Update	Update	Update	Update	Update
4.f. Basis of Estimate (cost and schedule) [Required per NPR 7120.5]	OCFO-SID/R	Initial (for range)	Update (for range)	Update (for range or high and low values with JCL[3])	Update for cost and schedule estimate	Update	Update	Update	Update	Update	Update
4.g. Confidence Level(s) and supporting documentation [Required per NPR 7120.5]	OCFO-SID/R			Preliminary cost confidence level and preliminary schedule confidence level or JCL[3]	Baseline Joint Cost and Schedule Confidence Level	Update[4]	Update[5]				
4.h. External Cost and Schedule Commitments [Required per NPR 7120.5]	OCFO-SID/R			Preliminary for ranges or high and low values with JCL[3]	Baseline						
4.i. CADRe [Required per NPR 7120.5]	OCFO-SID/R		Baseline	Update	Update	Update	Update		Update[6]	Update	
4.j PMB [Required per NPR 7120.5]	OCFO-SID/R				Baseline	Update	Update	Update	Update		

[1] These products are developed by the Mission Directorate.

[2] These products document the work of the key technical activities performed in the associated phases.

[3] Projects with LCC or initial capability cost of $1B or over develop high and low values for cost and schedule with the corresponding JCL values at KDP B per Section 2.4.3.1.a.
[4] Projects with LCC or initial capability cost of $1B or over update the JCL at CDR per Section 2.4.3.3.
[5] Projects with LCC or initial capability cost of $1B or over update the JCL at KDP D per Section 2.4.3.4 if current development costs exceed development ABC cost by 5 percent or more.
[6] The CADRe for MRR/FRR is considered the "Launch CADRe" to be completed after the launch.

Table 4-7 Project Plan Control Plans Maturity Matrix

(See NPR 7120.5F Appendix H Template for Control Plan Details.)	Product Owner/ Requirement or Best Practice	Pre-Phase A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/ FRR	DR
1. Technical, Schedule, and Cost Control Plan [Required per NPR 7120.5]	OCE/R	Approach for managing schedule and cost during Phase A[1]	Preliminary	Baseline	Update					
2. Safety and Mission Assurance Plan [Required per NPRs 8705.2 and 8705.4]	OSMA/R		Baseline	Update	Update	Update			Update (SMSR)	Update
3. Risk Management Plan [Required per NPR 8000.4]	OSMA/R	Approach for managing risks during Phase A[1]	Baseline	Update	Update					
4. Acquisition Strategy [Required per NPD 1000.5]	OCE/R	Preliminary Strategy	Baseline	Update	Update					
5. Technology Development Plan (may be part of Formulation Agreement) [additional information in NPR 7500.2, NPR 7123.1, and NPR 7120.5]	OCE/BP	Baseline	Update	Update	Update					
6. Systems Engineering Management Plan [Required per NPR 7123.1]	OCE/R	Preliminary	Baseline	Update	Update					
7. System Security Plan [Required per NPR 2810.1]	OCIO/R		Preliminary		Update	Baseline	Update	Update		
8. Software Management Plan(s) [Required per NPR 7150.2; additional information in NASA-STD-8739.8]	OCE/R		Preliminary	Baseline	Update					
9. Verification and Validation Plan [Required per NPR 7120.5, additional information in NPR 7123.1]	OCE/R	Preliminary Approach[2]		Preliminary	Baseline	Update	Update			
10. Review Plan [Required per NPR 7120.5][3]	OCE/R	Preliminary	Baseline	Update	Update					
11. Mission Operations Plan [Required per NPR 7120.5]	OCE/R						Preliminary	Baseline	Update	
12. NEPA Compliance Documentation [Required per NPR 8580.1]	OSI-EMD/ R			Baseline						
13. Integrated Logistics Support Plan [Required per NPD 7500.1]	OSI-LMD/R	Approach for managing logistics[2]	Preliminary	Preliminary	Baseline	Update				

(See NPR 7120.5F Appendix H Template for Control Plan Details.)	Product Owner/ Requirement or Best Practice	Pre-Phase A	Phase A KDP B		Phase B KDP C	Phase C KDP D		Phase D KDP E		Phase E KDP F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/ FRR	DR
14. Science Data Management Plan [additional information in NPD 2200.1 and NPRs 2200.2, 1441.1, and 8715.24]	SMD/BP				Preliminary			Baseline	Update	
15. Integration Plan [Required per NPR 7120.5]	OCE/R	Preliminary approach[2]		Preliminary	Baseline	Update				
16. Configuration Management Plan [Required per NPR 7120.5; additional information in NPR 7123.1 and SAE/EIA 649]	OCE/R		Baseline	Update	Update					
17. Security Plan [Required per NPR 1040.1 and NPR 1600.1]	OPS/R			Preliminary	Baseline					Update annually
18. Project Protection Plan [Required per NPR 1058.1, additional information in NASA-STD-1006]	OCE/R			Preliminary	Baseline	Update	Update	Update	Update	Update annually
19. Technology Transfer (formerly Export) Control Plan [Required per NPR 2190.1]	OIIR/R			Preliminary	Baseline	Update				
20. Knowledge Management Plan [additional information in NPD 7120.4 and NPD 7120.6]	OCE/BP	Approach for managing during Phase A[1]		Preliminary	Baseline	Update				
21. Human-Rating Certification Package [Required per NPR 8705.2]	OSMA/R	Preliminary approach [2]	Initial	Update	Update	Update		Update	Approve Certifi-cation	
22. Planetary Protection Plan [Required per NPD 8020.7 and NPR 8715.24]	OSMA/R			Planetary Protection Categorization (if applicable)	Baseline					
23. Nuclear Launch Authorization Plan [additional information in NPR 8715.26]	OSMA/R			Baseline (mission has nuclear materials)						
24. Range Safety Risk Management Process Documentation [Required per NPR 8715.5]	OSMA/R				Preliminary	Preliminary	Baseline			
25. Communications Plan [additional information in NPR 7120.5]	OComm/BP		Preliminary		Baseline	Update		Update		
26. Quality Assurance Surveillance Plan [Required per NPR 8735.2 and NASA FAR Supplement Part 1837.604]	OSMA/R		Preliminary	Baseline	Update	Update	Update			

(See NPR 7120.5F Appendix H Template for Control Plan Details.)	Product Owner/ Requirement or Best Practice	Pre-Phase A	Phase A	KDP B	Phase B KDP C	Phase C	KDP D	Phase D	KDP E	Phase E KDP F
		MCR	SRR	SDR/MDR	PDR	CDR	SIR	ORR	MRR/ FRR	DR
27. Orbital Collision Avoidance Plan [Required per NID 7120.132]	OCE/R				Baseline	Update				
28. Human Systems Integration Plan [additional information in NASA/SP-20210010952 NASA HSI Handbook and NPR 7123.1]	OCE-OSMA-OCHMO/R	Preliminary	Baseline	Update	Update	Update				

[1] Not the Plan, but documentation of high-level process. May be documented in MCR briefing package.

[2] Not the Plan, but documentation of considerations that might impact the cost and schedule baselines. May be documented in MCR briefing package.

[3] Review Plan should be baselined before the first review.

5 Special Topics

This chapter explores particular policy topic areas in more detail. Additional information can be found in the documents listed in Appendix G and in the websites of various communities of practice.

5.1 NASA Governance

NASA's management structure focuses on safety and mission success across a challenging portfolio of high-risk, complex endeavors, many of which are executed over long periods of time. *NPD 1000.0, NASA Governance and Strategic Management Handbook* sets forth NASA's Governance framework, the principles and structures through which the Agency manages its missions and executes its responsibilities. All individuals with a significant role in NASA programs and projects or their support need an understanding of the fundamental principles of NASA Governance.

Certain aspects of NASA Governance are especially important to the management and execution of space flight programs and projects. Appendix D provides a summary of the roles and responsibilities for key program and project management officials.

A cornerstone of NASA's system of checks and balances that supports safety and mission success is the organizational separation of Programmatic and Institutional Authorities, which takes advantage of the different perspectives that different organizational elements bring to issues. (See Figure 2-3.)

- Programmatic Authority resides with the Mission Directorates and their respective programs and projects.
- Institutional Authority resides with all Headquarters and associated Center organizations and authorities not in Programmatic Authority. It includes the offices within the Mission Support Directorate and its associated organizations at the Centers, the Center Directors, and the Technical Authorities (TAs), who are individuals with specifically delegated authority in Engineering (ETA), Safety and Mission Assurance (SMA TA), and Health and Medical (HMTA).

NPR 7120.5 differentiates between "programmatic requirements" and "institutional requirements." Both categories of requirements need to be satisfied in program and project Formulation and Implementation.

Programmatic requirements focus on the products to be developed and delivered and specifically relate to the goals and objectives of a particular NASA program or project. These programmatic requirements flow down from the Agency's strategic planning process and are the responsibility of the Programmatic Authorities. Table 5-1 shows this flow down from Agency strategic planning through Agency, directorate, program, and project requirements levels to the systems that will be implemented to achieve the Agency goals.

Table 5-1 Programmatic Requirements Hierarchy

Requirements Level	Content	Governing Document	Approver	Originator
NASA Strategic Goals	Agency goals, objectives, and strategic direction	NPD 1001.0, NASA Strategic Plan; and Strategic Planning Guidance	NASA Administrator	OCFO
Mission Directorate Requirements	High-level requirements levied on a program to carry out strategic and architectural direction, including programmatic direction for initiating specific projects	Program Commitment Agreement (PCA)	NASA AA	MDAA
Program Requirements	Detailed requirements levied on a program to implement the PCA and high-level programmatic requirements allocated from the program to its projects	Program Plan	MDAA	Program Manager
Project Requirements	Detailed requirements levied on a project to implement the Program Plan and flow down programmatic requirements allocated from the program to the project	Project Plan	Program Manager	Project Manager
System Requirements	Detailed requirements allocated from the project to the next lower level of the project	System Requirements Documentation	Project Manager	Responsible System Lead

MDAA = Mission Directorate Associate Administrator; NASA AA = NASA Associate Administrator

Institutional requirements focus on how NASA does business and are independent of a program or project. These requirements are issued by NASA Headquarters (including the Office of the Administrator, Mission Support Directorate (MSD), and other mission support offices) and by Center organizations and are the responsibility of the Institutional Authorities. Institutional requirements may respond to Federal and State statute, regulation, treaty, or Executive Order. They are normally described in the document types listed below. (See *NPD 1400.1, Documentation and Promulgation of Internal NASA Requirements and Charters* and *NPR 1400.1, NASA Directives and Charters Procedural Requirements* for additional information.)

- **NASA Policy Directives (NPDs).** Agency policy documents that describe what is required by NASA management to achieve NASA's vision, mission, and external mandates and who is responsible for carrying out those requirements.
- **NASA Procedural Requirements (NPRs).** Documents that provide the Agency's mandatory requirements for implementing NASA policy as delineated in associated NPDs.

- **NASA Standards.** Formal documents that establish a norm, requirement, or basis for comparison, a reference point to measure or evaluate against. A technical standard, for example, establishes uniform engineering or technical criteria, methods, processes, and practices. NASA standards include Agency-level standards as well as Center-level standards.
- **Center Policy Directives (CPDs).** Center-specific policy documents that describe requirements and responsibilities that apply only to the issuing Center and operations performed by NASA personnel at that Center. CPDs extend requirements delineated in associated NPDs and NPRs.
- **Center Procedural Requirements (CPRs).** Center-specific procedural requirements and responsibilities for implementing the policies and procedural requirements defined in related NPDs, NPRs, or CPDs. CPRs apply only to the issuing Center and operations performed by NASA personnel at that Center.
- **Mission Directorate Requirements.** Requirements contained in Mission Directorate documentation that apply to activities, products, or services supporting program and project office needs, which could extend across multiple Centers.

Figure 5-1 shows the flow down from *NPD 1000.0, NASA Governance and Strategic Management Handbook* through Program and Project Plans. The figure identifies the five types of institutional requirements that flow down to these plans: engineering, program or project management, safety and mission assurance, health and medical, and mission support requirements. These terms are defined in Appendix A.

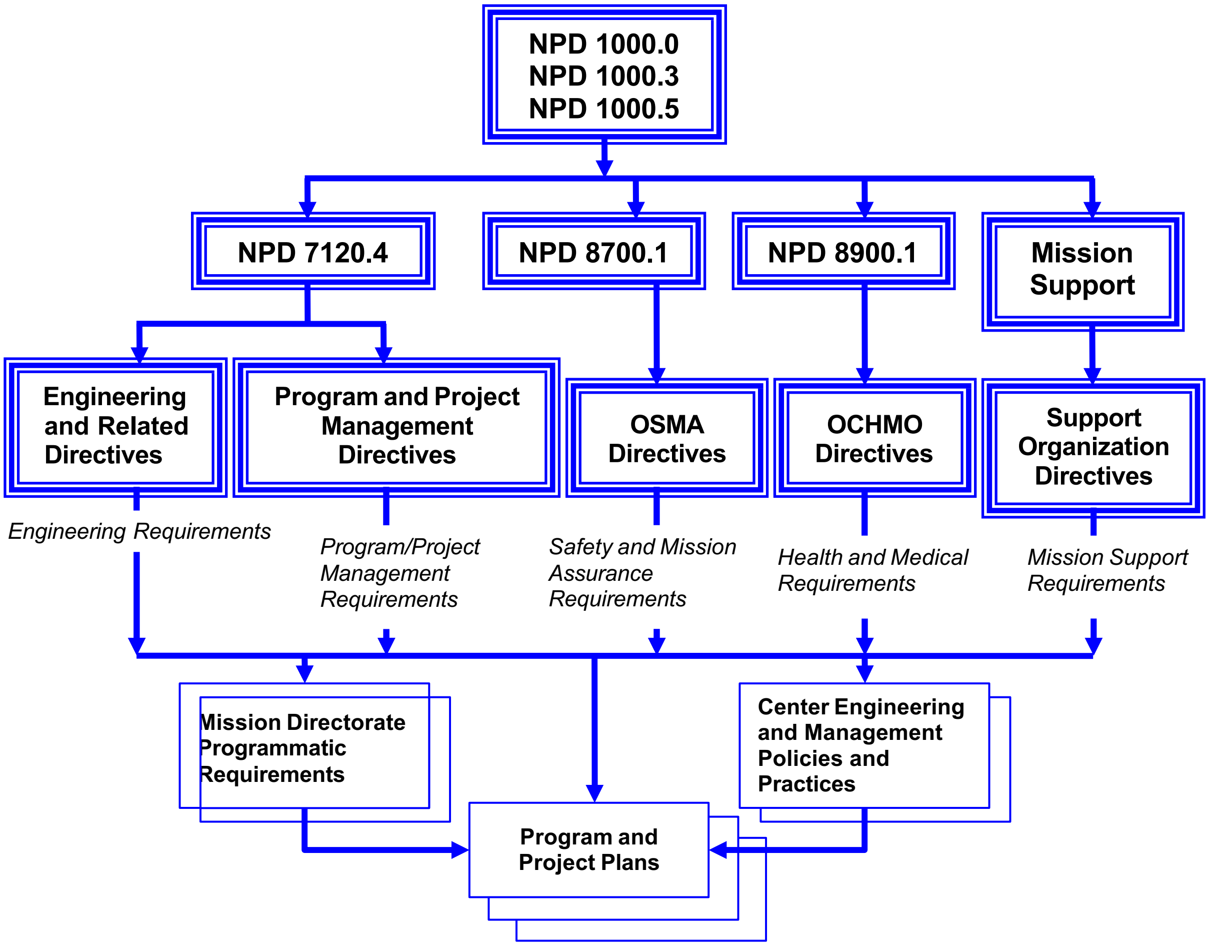


Figure 5-1 Institutional Requirements Flow Down

5.1.1 Programmatic Authority

Programmatic Authority flows from the Administrator through the Associate Administrator to the Mission Directorate Associate Administrator (MDAA), to the program manager, and finally to the project manager in accordance with *NPD 1000.0, NASA Governance and Strategic Management Handbook*. Because different types of programs and projects require different management approaches, the MDAA may delegate some Programmatic Authority to deputy associate administrators, division directors, or their equivalent such as program directors, depending on the Mission Directorate organizational structure, consistent with the following principles:

- As a rule, the MDAA delegates responsibility only within his or her immediate organization for strategic planning; policy formulation and approval; definition and approval of programs, projects, and missions; assignment of programs, projects, and selected managers; Mission Directorate budget development and allocation; and assessment and reporting of performance. Delegations are documented to ensure roles and responsibilities are understood and accountability is clear. Delegations of Decision

Authority are documented in the applicable authority documents (PCA, Formulation Agreement, Program Plan, Project Plan).

- The program manager is responsible for the formulation and implementation of the program as described in NPR 7120.5 and NPR 7123.1. This includes responsibility and accountability for ensuring program safety; technical integrity; technical, cost, and schedule performance and mission success; developing and presenting time-phased cost estimates, budget, and funding requirements; developing and implementing the Program Plan, including managing program resources; implementing a risk management process that incorporates Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM); overseeing project implementation, including resolution of project risks by such means as allocation of margins to mitigate risks; periodically reporting progress to the Mission Directorate; and supporting Mission Directorate activities.
- The project manager reports to the program manager, and both are supported by one or more NASA Centers with facilities and experts from line or functional organizations. The project manager, however, is responsible for the formulation and implementation of the project as described in NPR 7120.5 and NPR 7123.1. This includes responsibility and accountability for the project safety, technical integrity, and mission success of the project, while also meeting programmatic (technical, cost, and schedule performance) commitments. To accomplish this, the project manager needs, among other aspects of program and project management, knowledge about governing laws, acquisition regulations, policies affecting program and project safety. training of direct-report personnel, risk management, environmental management, resource management, program- and project-unique test facilities, the health of the industrial base and supply chain supporting the program and project including critical and single-source suppliers, software management, responding to external requests for audits (e.g., OMB), and protecting intellectual property and technology.
- The program and project manager coordinate early and often throughout the program or project life cycle with mission support organizations at NASA Headquarters through the sponsoring Mission Directorate and the implementing Centers. These mission support organizations include legal, procurement, security, finance, export control, human resources, public affairs, international affairs, property, facilities, environmental, aircraft operations, information technology, planetary protection, and others. They provide essential expertise and ensure compliance with relevant laws, treaties, Executive Orders, and regulations. It is important to ensure that organizations having a substantive interest in supporting activities such as facilities and logistics are integrated effectively into the program or project's activities as early as appropriate and throughout the duration of the organizations' interest to include their needs, benefit from their experience, and encourage communication.

5.1.2 Institutional Authority

The Institutional Authority comprises those organizations not in the Programmatic Authority, including engineering, safety and mission assurance, and health and medical organizations, Mission Support Organizations (MSOs), and Center Directors. (See Figure 2-3.)

The engineering, safety and mission assurance, and health and medical organizations support programs and projects in two ways:

1. They provide technical personnel and support and oversee the technical work of personnel who provide the technical expertise to accomplish the program or project mission.
2. They provide Technical Authorities (TAs), who independently oversee programs and projects. These individuals have formally delegated Technical Authority traceable to the Administrator and are funded independently of programs and projects. TAs are described in Section 5.2.

Key roles and responsibilities within the Institutional Authority reside with the Mission Support Directorate (MSD) and the Center Director.

The **MSD Associate Administrator** establishes directorate policies and procedures for institutional oversight for mission support functional areas, including human capital, strategic infrastructure, procurement, protective services, headquarters operations, and the NASA Shared Services Center. The human capital, strategic infrastructure, and procurement mission support functional areas follow an Enterprise operating model in which capabilities are managed horizontally across the Agency and shared across Centers. Rather than a Center-centric model, mission support functions follow a more interdependent model, requiring more standard systems, practices, and processes across NASA locations.

The responsibilities of the mission support functional areas vary. Common responsibilities of the mission support functional areas are to:

- Represent the institutional function and convey respective institutional requirements established by law, Agency policy, or other external or internal authority to program and project managers.
- Ensure statutory, regulatory, and fiduciary compliance.
- Ensure integration and alignment of mission support activities in support of Agency strategic needs and interfaces with the NASA Deputy Administrator, the NASA AA, the NASA Deputy AA, the Chief of Staff, Mission Directorates, and Centers to support integration and alignment of these activities.
- Ensure conformance with institutional requirements.

- Disposition all requests for modification of prescribed institutional requirements[85] in their respective areas of responsibility.

Because programs and projects are executed at NASA Centers, a Center has both execution and Institutional Authority responsibilities, and the **Center Director** needs to ensure that both functions operate within the Governance and management structure dictated by *NPD 1000.0, NASA Governance and Strategic Management Handbook*.

As part of the execution responsibility, the Center Director is responsible for ensuring that the Center is capable of accomplishing the programs, projects, and other activities assigned to it in accordance with Agency policy and the Center's best practices and institutional policies. In accomplishing this role, a Center Director:

- Establishes, develops, and maintains the institutional capabilities (processes and procedures, human capital including trained and certified program and project personnel, facilities, and infrastructure) required for the execution of programs and projects. This includes sound technical and management practices, internal controls, and an effective system of checks and balances to ensure the technical and programmatic integrity of program or project activities being executed at the Center.
- Works with the Mission Directorate and the program and project managers, once assigned, to assemble the program and project team(s) that will accomplish the program or project.
- Supports programs and projects by allocating needed Center resources to support program and project requirements and schedules, including project management, engineering, and safety and mission assurance; providing support and guidance to programs and projects in resolving technical and programmatic issues and risks; monitoring the technical and programmatic progress of programs and projects to help identify issues as they emerge; and proactively working with the Mission Directorates, programs, projects, and other Institutional Authorities to find constructive solutions to problems.
- Proactively works on cross-Center activities to benefit both the programs and projects and the overall long-term-health of the Agency.

[85] A prescribed requirement is one levied on a lower organizational level by a higher organizational level.

In accordance with NPR 7120.5: "Center Directors are responsible and accountable for all activities assigned to their Center. They are responsible for the institutional activities and for ensuring the proper planning for and successful execution of programs and projects assigned to the Center." This means that the Center Director is responsible for ensuring that programs and projects develop plans that are executable within the guidelines from the Mission Directorate and that these programs and projects are executed within the approved plans. In cases where the Center Director believes a program or project cannot be executed within approved guidelines and plans, the Center Director works with the project manager, program manager, and Mission Directorate to resolve the problem.

As part of the Institutional Authority responsibility, a Center Director assures that program and project teams at the Center accomplish their goals in accordance with the prescribed requirements and the Agency and Center procedures and processes. Institutional Authority responsibility also means that the Center Director has the responsibility to ensure that the programs and projects are accomplishing their work in accordance with the institutional (including technical) requirements. When the program or project violates institutional requirements, the Center can direct the program or project to correct the deficiency. As an example, if the program or project is not performing requirements flow down properly, the Center may direct the program or project to correct how requirements are established, documented, and traced. However, this authority does not mean that the Institutional Authority can direct a program or project to exceed the programmatic requirements and constraints when correcting deficiencies. When this situation occurs, the program or project, Center Director, and MDAA need to work together to resolve the issue(s). In accomplishing this, the Center Director:

- Is delegated Technical Authority in accordance with NPR 7120.5F Section 3.3, concurs with the Center's Technical Authority implementation plan, and ensures that delegated institutional and technical authority is properly executed by programs and projects at the Center.
- Ensures that programs and projects properly follow institutional and technical authority requirements.
- Establishes and maintains on-going processes and forums, including the Center Management Council (CMC), to monitor the status and progress of programs and projects at the Center.
- Periodically reviews programs and projects, including special reviews, to assess technical and programmatic progress to assure they are performing in accordance with Agency and Center requirements, procedures, and processes.
- Supports Mission Directorates in planning and managing independent reviews.
- Keeps the Decision Authority and appropriate forums, including Agency and Mission Directorate PMCs, advised of the executability of all aspects of the programs and projects (such as programmatic and technical) along with major risks, mitigation strategies, and significant concerns.

- Concurs in the adequacy of cost and schedule estimates and technology assessments and the consistency of these estimates with planned Agency requirements, workforce, and other resources stipulated in proposed Program and Project Plans.
- Certifies that programs and/or projects have been accomplished properly as part of the launch approval process.
- Ensures that Center training and certification programs for program and project managers are in place and ensures that program and project managers have met the initial requirements for OMB's Federal Acquisition Certification for Program and Project Managers (FAC-P/PM).

5.2 Technical Authority

This section discusses key aspects of NASA's policy for Technical Authority and provides additional information to clarify the policy. The section discusses:

- The origin of the Technical Authority process and the rationale behind it.
- Technical Authority and NASA Governance—how Technical Authority flows through the NASA organization as part of NASA's checks and balances.
- The roles that are common to all Technical Authorities.
- Engineering Technical Authority (ETA)—ETA delegations, various ETA roles from the NASA Chief Engineer down to the project, and examples of ETA implementation.
- The Safety and Mission Assurance Technical Authority (SMA TA) process and the SMA documents that govern it.
- The Health and Medical Technical Authority (HMTA) process and the HMTA documents that govern it.

5.2.1 Overview

As one of the important checks and balances built into NASA Governance, the Technical Authority process provides assistance and independent oversight of programs and projects in support of safety and mission success. In NPR 7120.5 and this document, the term "Technical Authority" refers both to elements of the TA process and to individuals with delegated levels of authority.

Technical Authorities (TAs), whose formally delegated responsibility is traceable to the Administrator, provide independent oversight of the technical activities of programs and projects. Technical Authorities are provided by the engineering, safety and mission assurance, and health and medical organizations.

TAs who further delegate their Technical Authority are not abdicating that authority; i.e., they retain the responsibility and authority with which they are entrusted. They remain accountable and participate in the TA chain of authority.

5.2.2 The Origin of the Technical Authority Process

After the loss of the space shuttle *Columbia*, NASA recognized that its system of checks and balances needed strengthening. The Columbia Accident Investigation Board (CAIB) recommended the "establishment of an independent Technical Engineering Authority that is responsible for technical requirements and all waivers to them and will build a disciplined, systematic approach to identifying, analyzing, and controlling hazards throughout the life cycle of the Shuttle System."[86] The CAIB report includes additional insights for anyone involved in space flight programs and projects.

NASA chose to take a comprehensive approach to strengthening its systems and processes supporting the safety and mission success of all programs and projects while also addressing the CAIB's shuttle system recommendations. The resulting changes included improvements in NASA Governance, a revised statement of Agency core values, formalization of improved principles and processes for providing relief from prescribed requirements (Tailoring Principles, Section 5.4), establishment of a formally recognized process for resolving serious dissent by any individual (Formal Dissent Process, Section 5.3), and establishment of the Technical Authority process to provide independent oversight of programs and projects in support of safety and mission success.

5.2.3 Technical Authority and NASA Governance

All NASA programs and projects are required to follow the Technical Authority process established in Section 3.3 of NPR 7120.5. The Program or Project Plan describes the program or project's implementation of Technical Authority, including engineering, safety and mission assurance, and health and medical. The Technical Authority policy stems from NASA's Governance policy, which is documented in *NPD 1000.0, NASA Governance and Strategic Management Handbook* and defines the structure by which the Office of the Administrator and senior staff provide leadership across the Agency and the core values and the principles by which NASA manages itself. Key principles in this framework include having clearly defined roles and responsibilities and having an effective system of checks and balances to provide a firm foundation for the balance of power between organizational elements.

The Technical Authority process is built on the organizational and financial separation of the Programmatic and Institutional Authorities.[87] (See Section 5.1.) The separation enables the roles of the Programmatic and Technical Authorities to be wired into the basic organizational structure in a way that emphasizes their shared goal of mission success while taking advantage of the different perspectives each brings to issues.

Technical Authority originates with the NASA Administrator and is then delegated to the NASA AA and then to the NASA Chief Engineer for Engineering Technical Authority (ETA); the Chief, Safety and Mission Assurance for SMA Technical Authority (SMA TA); and then to the Center Directors for ETA and SMA TA. The Center Director (or designee) is responsible for establishing and maintaining Center Technical Authority policies and practices consistent with Agency policies and standards. The Administrator delegates Health and Medical Technical Authority (HMTA) to the NASA Chief Health and Medical Officer (CHMO).

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[86] Refer to R7.5-1 of the CAIB report accessible at "CAIB Report Table of Contents (nasa.gov)."

[87] Programmatic Authority resides with the Mission Directorates and their respective programs and projects. The Institutional Authority includes the remaining Headquarters and Center organizations.

Subsequent delegations by the Center Director are made to selected individuals at specific organizational levels. Such delegations are formal and traceable to the Administrator and documented in the Center plan for Technical Authority implementation. The individuals with Technical Authority are funded independent of a program or project. Technical Authorities located at Centers remain part of their Center organization.

The process supports clearly defined Technical Authorities and ensures their independence.

The responsibilities of the program or project manager are not diminished by the implementation of Technical Authority. The program or project manager is still responsible for the success of the program or project.

Nothing in the Technical Authority process is intended or may be construed to abridge or diminish the SMA power to "suspend work" granted in NPD 1000.3, The NASA Organization. The Chief, Safety and Mission Assurance (SMA) is authorized to suspend any operation or project activity that presents an unacceptable risk to personnel, property, or mission success and provide corrective action.

5.2.4 Common Technical Authority Roles

5.2.4.1 General TA Roles for Program- and Project-Level TAs

Individuals with delegated Technical Authority at the program or project level have common responsibilities as delineated below. These responsibilities are formalized in policy so that the Technical Authority's day-to-day involvement in program or project activities ensures that significant views from the Technical Authorities are available to the program and project in a timely manner and are handled during the normal program and project processes. TAs are expected to keep their discipline chain of authority informed of issues as they arise, including direct communication between the Center's Engineering Director, SMA Director (or equivalent), and Chief Medical Officer with their counterparts at NASA Headquarters. Common responsibilities include:

- Serving as members of program or project control boards, change boards, and internal review boards.
- Working with the Center management and other Technical Authority personnel, as necessary, to ensure that the quality and integrity of program or project processes, products, and standards of performance related to engineering, SMA, and health and medical reflect the level of excellence expected by the Center or, where appropriate, by the NASA Technical Authority community.
- Ensuring that requests for waivers or deviations from Technical Authority requirements are submitted by the program or project to and acted on by the appropriate level of Technical Authority. (Refer to Section 5.4.)

- Assisting the program or project in making risk-informed decisions that properly balance technical merit, cost, schedule, and safety across the system.
- Providing the program or project with their view of matters based on their knowledge and experience, assisting the program or project in obtaining the Technical Authority community view of requirements or issues when needed, and raising a Formal Dissent (Section 5.3) on a decision or action when appropriate significant, substantive disagreement exists.
- Serving as an effective part of NASA's overall system of checks and balances.

5.2.5 Special Risk Acceptance Roles

In recognition of the importance of systems that are associated with human flight, the top-level documents developed by a program detailing Agency-level requirements for human-rated systems are signed by the Administrator or his or her formally delegated designee.

To ensure proper oversight, decisions related to technical and operational matters involving safety and mission success residual risk[88] require formal concurrence by the responsible Technical Authority(ies) (ETA, SMA TA, and/or HMTA). This concurrence is based on the technical (engineering and safety) merits of the case.

Residual risks to personnel or high-value hardware require not only TA concurrence, but also the concurrence of the cognizant safety organization.

For matters involving human safety risk (see *NPR 8000.4, Agency Risk Management Procedural Requirements*), the actual risk taker(s) (or official spokesperson(s) and their supervisory chain) must formally consent to taking the risk, and the responsible program, project, or operations manager must formally accept the risk. (For requirements in policy, see both *NPD 1000.0, NASA Governance and Strategic Management Handbook* and NPR 7120.5 as well as *NPR 8705.2, Human-Rating Requirements for Space Systems*.)

5.2.5.1 Derived Technical Authority Roles

The TAs have additional roles that are specified in NPR 7120.5 but are not specifically discussed in the Technical Authority Roles and Responsibilities of the NPR. These are:

- Dispositioning requests for a Non-Applicable designation for a prescribed requirement that a program or project has evaluated as being "not relevant" and/or "not capable of being applied" to the applicable program, project, system, or component when the requirement is specified for implementation at the level of the Technical Authority. (See Section 5.4.6 of this handbook.)

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[88] "Residual risk" is the risk that remains after all mitigation actions have been implemented or exhausted in accordance with the risk management process. (See *NPD 8700.1, NASA Policy for Safety and Mission Success*.)

- Assisting the program or project manager in determining when the program or project is ready for a life-cycle review as part of the readiness assessment. (See Section 5.10 of this handbook.)

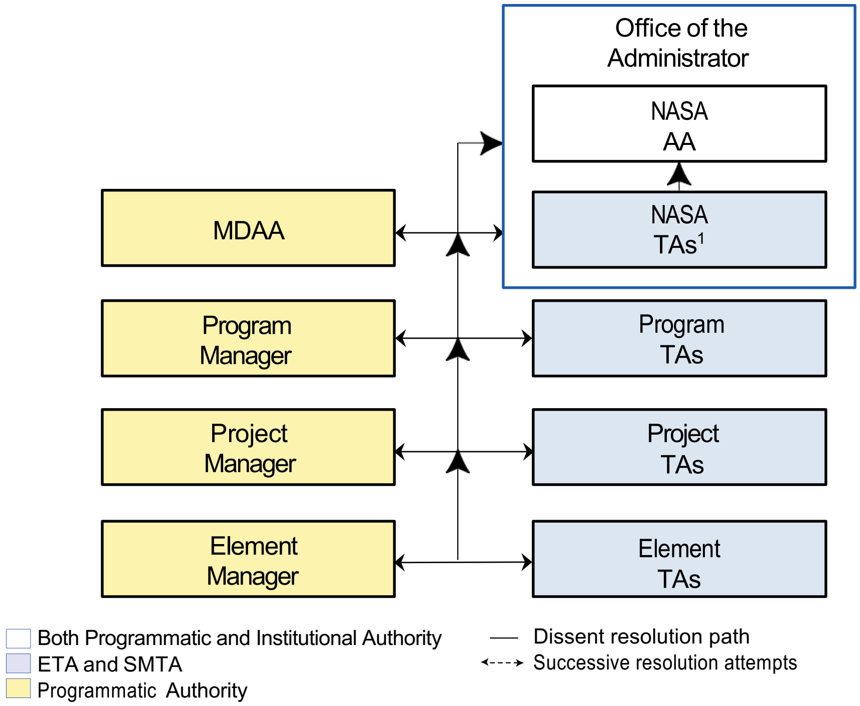
5.2.6 Technical Authority and Formal Dissent

Infrequent circumstances may arise when a Technical Authority disagrees with a proposed programmatic or technical action and judges that the issue rises to a level of significance that needs to be brought to the attention of the next higher level of management; i.e., a Formal Dissent exists. (See Section 5.3.) In such circumstances, resolution occurs prior to implementation of the action whenever possible. However, if the program or project manager considers it to be in the best interest of the program or project, he or she has the authority to proceed at risk in parallel with the pursuit of a resolution. The program or project manager informs the second-higher level of management of the decision to proceed at risk. Since in this case the disagreement is between the program or project manager and the TA, the notification would be to the second-higher level of both Programmatic and Technical Authority.

Notification of the second-higher level of management is provided because of the importance of a Formal Dissent and its resolution. This is particularly important in this instance because the Programmatic Authority has decided to proceed at risk in the presence of a Formal Dissent. The second-higher level of management is notified to provide personnel at that level with the option of becoming involved. This is not intended to skip a management level in the resolution process so much as to position the second-higher level to be knowledgeable of the issue and to support expeditious resolution at that level if it becomes necessary.

Resolution is jointly attempted at successively higher levels of both Programmatic and Technical Authority until the dissent is resolved.

Final appeals are made to the NASA Administrator. The adjudication path (Figure 5-2) for the resolution is essentially the opposite of the authority flow-down path from the Administrator. (See Section 5.3 for more details on the Formal Dissent process.)



[1]"NASA TAs" represents TAs above program level, including the NASA Chief Engineer and Center Directors, some of whom are at Headquarters.

Note: This figure is a simplified representation of levels of dissent and does not necessarily depict all involved parties. Resolution is attempted at each level. If not resolved, the issue rises to the next level. The formal dissent process can start at any level.

Figure 5-2 Formal Dissent Resolution for Issues Between Programmatic Authority and Technical Authority

5.2.7 Specific Roles of the Different Technical Authorities

All Technical Authorities are part of Institutional Authority and, as delineated in NPR 7120.5, provide technical oversight of and guidance to programs or projects.

5.2.7.1 Engineering Technical Authority

The Engineering Technical Authority (ETA) establishes and is responsible for the engineering design processes, specifications, rules, best practices, and other activities necessary to fulfill programmatic mission performance requirements.

Figure 5-3 provides a high-level illustration of the structure of ETA and its interface with Programmatic Authority. Note that a Center may have more than one engineering organization and ETA is delegated to different areas as needed.

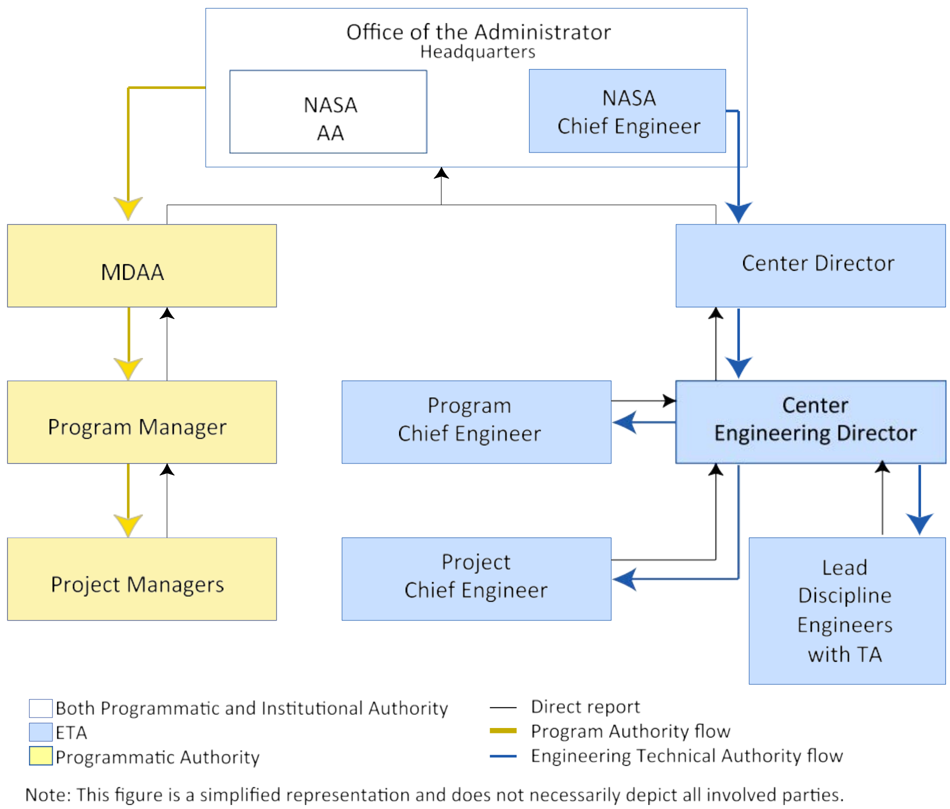


Figure 5-3 Simplified Illustration of a Representative Engineering Technical Authority Structure

5.2.7.1.1 Roles of High-Level Engineering Technical Authorities

NASA Chief Engineer. The NASA Chief Engineer approves the appointment of the Center engineering directors (or equivalent) and the appointment of ETAs on programs and Category 1 projects. The NASA Chief Engineer is notified of the appointment of other ETAs established by the Center Director.

Office of the Chief Engineer's (OCE's) Mission Directorate Chief Engineers. Mission Directorate chief engineers report to the NASA Chief Engineer and oversee the performance of all programs and projects in their assigned Mission Directorate. Although Mission Directorate chief engineers are not in the line of authority, they have an advisory responsibility to be aware, involved, and informed. They serve as advisors to the NASA Chief Engineer and the assigned Mission Directorate. This includes assisting in the resolution of Formal Dissents that are elevated to Headquarters.

Center Director. The Center Director or designee (1) develops the Center's ETA policies and practices, consistent with Agency policies and standards; (2) delegates Center ETA implementation responsibility to an individual in the Center's engineering leadership; (3) with the approval of the NASA Chief Engineer, appoints individuals for the position of Center Engineering Director (or equivalent) and for ETA positions down to and including program chief engineers and Category 1 project chief engineers or equivalent;[89] and (4) appoints Category 2 and 3 project chief engineers and lead discipline engineers.

Center Engineering Director (or Equivalent). The Center Engineering Director is responsible for supporting the Center Director in establishing, implementing, and managing ETA for the Center. In addition, the Center Engineering Director supports the program- and project-level Technical Authorities in processing changes to, waivers of, or deviations from requirements that are the responsibility of the ETA. These include all applicable Agency and Center engineering directives, procedural requirements, and standards.

Centers further delegate ETA depending on the Center's organizational structure and management approach.

5.2.7.1.2 Roles of Program- and Project-Level Engineering Technical Authorities

Program or Project Chief Engineer. The program- or project-level ETA is delegated to the position of Program or Project Chief Engineer (PCE), respectively**.** The ETA at the program and project level manages the engineering activities including systems engineering, design, development, sustaining engineering, and operations and remains part of Institutional Authority. The ETAs have access to the depth and breadth of expertise within a Center's engineering organization when needed.

Lead Discipline Engineer (LDE). The LDE is a senior technical engineer in a specific discipline at the Center. Different Centers use different titles for this position. The LDE assists the program or project through direct involvement with working-level engineers to identify engineering requirements and develop solutions that comply with the requirements. The LDE works through and with the project-level ETA to ensure the proper application and management of discipline-specific engineering requirements and Agency standards. LDEs who are ETAs have formally delegated Technical Authority traceable to the Administrator and are funded independent of programs and projects.

To support the program or project while maintaining ETA independence and providing an effective check and balance, the following provisions apply:

1. The program manager concurs in the appointment of the program-level ETA and the project manager concurs in the appointment of the project-level ETA.
2. An ETA cannot approve a request for relief from a nontechnical derived requirement established by a Programmatic Authority. However, ETAs are expected to provide their recommendation(s).

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[89] Centers may use an equivalent term for these positions, such as Program/Project Systems Engineer.

3. An ETA may approve a request for relief from a technical derived requirement[90] if the ETA ensures that the independent Institutional Authority Subject Matter Expert (SME) who is the steward for the involved technical requirement concurs in the decision to approve the requirement relief. (Any party with a dispute regarding authority for granting relief from a technical derived requirement may raise a Formal Dissent. See Section 5.3 for details on the Formal Dissent process.)

The rationale behind the second and third provisions for ETA is as follows:

- Without the second provision, the ETA (an Institutional Authority) could be put in the position of granting relief from a nontechnical requirement established by a Programmatic Authority. This would be noncompliant with NASA Governance.
- Further, if the program or project ETA is, or acts as, the Decision Authority on matters related to granting requirement relief to a derived technical requirement, the Technical Authority system of checks and balances would be compromised for requirements derived at the program or project level. This is because the board is empowered to grant relief from requirements that it has established. Therefore, the TA (in this case the board chair) could not provide the independent oversight that is fundamental to Technical Authority.
- In the case of granting relief from Technical Authority requirements, the third provision enables effective checks and balances to be maintained. This is accomplished by ensuring that a second ETA agrees with the action to accept the tailoring of a requirement that is the responsibility of the Technical Authority.

5.2.7.2 Safety and Mission Assurance Technical Authority

The Safety and Mission Assurance Technical Authority (SMA TA) establishes and oversees implementation of the SMA processes, specifications, rules, and best practices necessary to fulfill safety and programmatic mission performance requirements.

SMA TA originates with the NASA Administrator and is formally delegated to the NASA AA and then to the Chief, Safety and Mission Assurance (SMA). SMA TA then flows from the Chief, SMA through the Center Director to the Center SMA Director. (See blue lines in Figure 5-4.) The Center SMA Director is responsible for establishing and maintaining institutional SMA policies and practices, consistent with Agency policies and standards; assuring that programs and projects comply with the Center SMA and Agency SMA requirements and adhere to their SMA Plan. The program or project SMA Plan serves as an agreement between the program or project and SMA TA, describing how the SMA requirements will be implemented and providing the basis for evaluation of SMA performance. The Center SMA Director also monitors, collects, and assesses institutional, program, and project SMA performance results.

[90] "Technical derived requirements" in this paragraph are those owned by the Technical Authority (policies, requirements, procedures, practices, and technical standards of the Agency or Center).

SMA TA is assigned when new programs or projects are started. The Center SMA Director, in consultation with the NASA Chief, SMA, appoints program- and project-level Chief Safety and Mission Assurance Officers (CSOs) to exercise the TA role within programs and projects. The SMA TA provides input to program or project planning; oversees any proposed technical or process changes or decisions that might increase risk to safety, quality, or reliability; and guides and advises program, project, or Agency management on handling this risk. The SMA TA also reviews and authorizes the closure of safety issues prior to flight and operations and for decommissioning and disposal of spacecraft in whole or in part. Depending on the level of risk and entity at risk (e.g., public and high-value assets), the Chief, SMA is consulted or his or her concurrence is obtained on the acceptance of increased risks. For example, *NPR 8715.26, Nuclear Flight Safety* delineates principles for risk acceptance decisions concerning radioactive material that may require a decision by the Chief, SMA. The CSO also consults with the Chief, SMA when program risk decisions based on the program risk matrices are elevated to the NASA Administrator or AA. Center-specific and some program- and project-level SMA TA plans document the agreed upon responsibilities, reporting, processes, and deliverables of the Center SMA TAs to the Chief, SMA. The Center SMA directors obtain concurrence from the NASA Chief, SMA on these Center SMA TA plans.

NASA SMA TA includes safety (institutional and programmatic), reliability, maintainability, quality, and software assurance, as well as micro-meteoroid and orbital debris, launch and range safety, nuclear flight safety, nondestructive evaluation, workmanship, explosives, pressure vessels, metrology and calibration, and Electrical, Electronic, and Electromechanical (EEE) parts assurance.

SMA requirements are both NASA-specific and flowed down from a variety of sources, including Federal laws and regulations and Presidential Directives. To ensure that NASA's compliance with these requirements, program and project requirements that impact safety and mission success, and other external SMA requirements and direction, the Office of the Chief, SMA (OSMA) has defined the delegation of authority for granting relief from requirements for which OSMA is responsible. This delegation authority is defined in *NPR 8715.3, NASA General Safety Program Requirements*. The Chief, SMA hears appeals of SMA decisions when issues cannot be resolved below the Agency level.

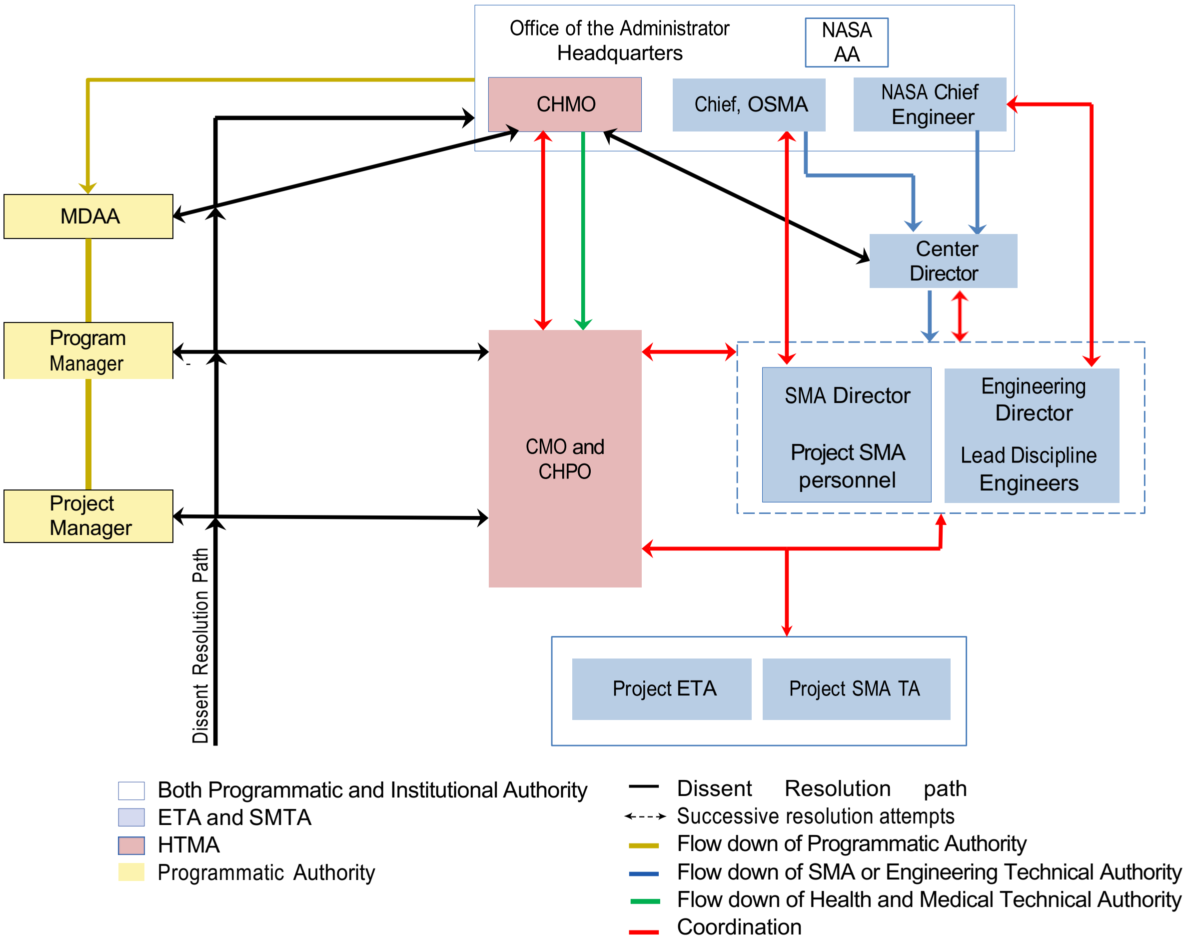
SMA TA closely collaborates with the Engineering Technical Authority (ETA) and with the Health and Medical Technical Authority (HMTA). An assessment of the safety risks that may result from engineering changes is the minimum interaction that needs to take place. Early involvement of the SMA TA in the program and project and various boards, beginning with program and project solicitations and planning, and in evaluating tailoring (waiver and deviation requests) helps ensure mission success without unnecessary risk to NASA systems, personnel, and the public.

5.2.7.3 Health and Medical Technical Authority

The Health and Medical Technical Authority (HMTA) originates with the Administrator and is formally delegated to the NASA AA and then to the Chief Health and Medical Officer (CHMO). HMTA provides prevention and mitigation of adverse health and medical events and provides support for the human performance required for successful mission execution. (Refer to *NPR 7120.11, NASA Health and Medical Technical Authority (HMTA) Implementation.*) HMTA closely collaborates with the Safety and Mission Assurance Technical Authority (SMA TA) and with the Engineer Technical Authority (ETA).

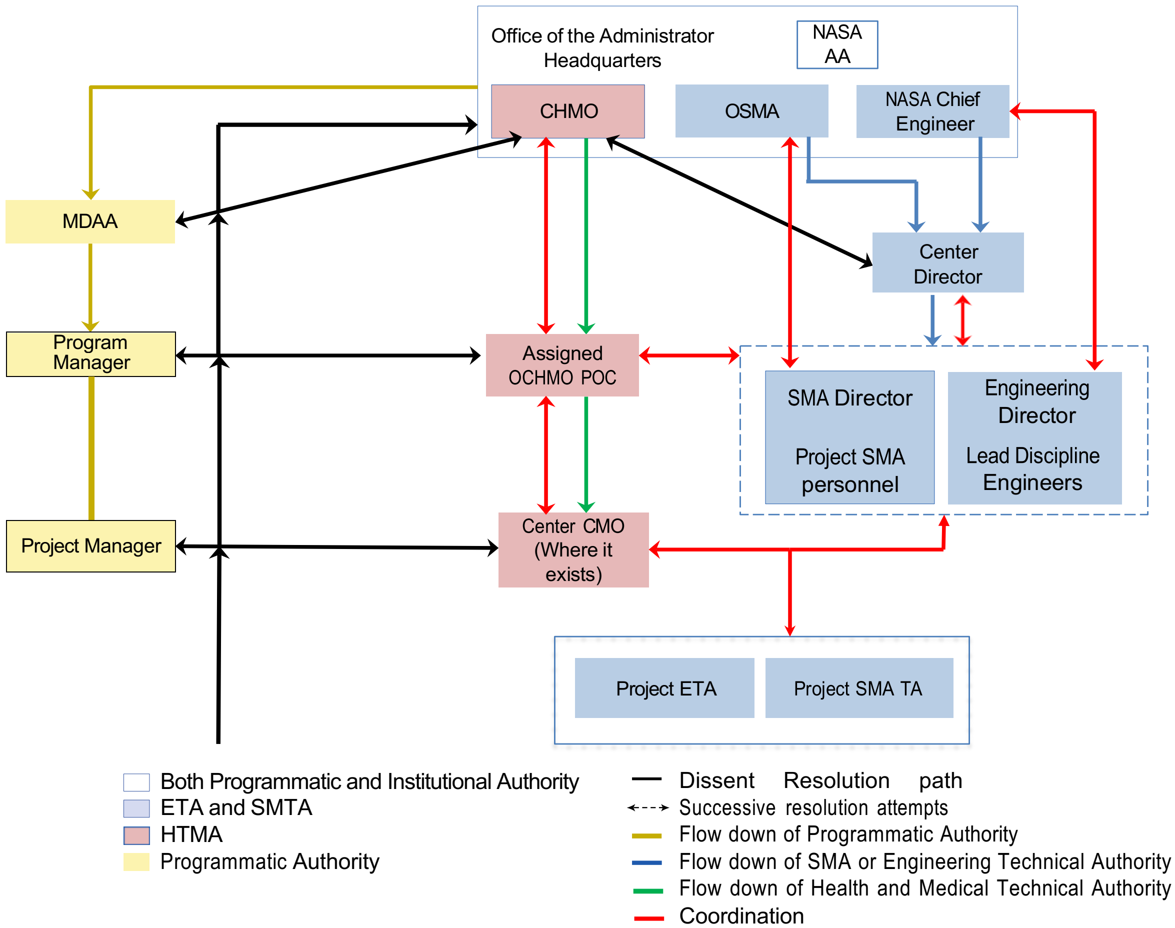
The HMTA develops and maintains NASA health, medical, and human performance policy and standards for NASA programs and projects. The HMTA provides oversight of programmatic and project requirements for compliance to HMTA policy and standards. The HMTA dispositions requests for relief from NASA health, medical, and human performance policy, standards, and requirements. Additional responsibilities of the HMTA include developing a disciplined systematic approach to identifying, analyzing, and controlling health, medical, and human performance risks that affect the humans involved in flight.

Figures 5-4 and 5-5 illustrate the HMTA flow paths for potential issues identified in programs and projects.



Note: This figure is a simplified representation of levels of dissent and does not necessarily depict all involved parties. Resolution is attempted at each level. If not resolved, the issue rises to the next level. The formal dissent process can start at any level.

Figure 5-4 Human Space Flight Health and Medical, Engineering, and SMA Flow of Technical Authority and Formal Dissent Resolution



Note: This figure is a simplified representation of levels of dissent and does not necessarily depict all involved parties. Resolution is attempted at each level. If not resolved, the issue rises to the next level. The formal dissent process can start at any level.

Figure 5-5 Robotic Health and Medical, Engineering, and SMA Flow of Technical Authority and Formal Dissent Resolution

The HMTA flowdown, delegation, and communications processes, including roles and responsibilities, are specified in *NPR 7120.11, NASA Health and Medical Technical Authority (HMTA) Implementation* and further described in Center HMTA Implementation Plans. The NPR recognizes that medical staff has a special obligation to protect the handling and dissemination of an individual's medical information. These legal and ethical restrictions are managed by the HMTA and must be complied with by all Agency personnel.

5.3 Formal Dissent Process

NASA has historically supported the full airing of issues, including alternative and divergent views. There are numerous examples where a Formal Dissent has led to changes that enhanced safety and mission success. However, NASA has also had some notable examples where dissenting views did not make their way to decision makers at the appropriate level in a timely manner. Two examples can be found in the Shuttle accidents. (See Challenger and Columbia Case Studies box.)

Challenger and Columbia Case Studies

Challenger (STS51-L). The night before the launch of the Challenger, there were discussions between NASA and its contractor for the Solid Rocket Motor (SRM) and within the contractor's organization about the effect of the temperature predicted for launch. The predicted temperatures were lower than any previous launch, and the concern was that it would adversely affect the performance of the O-rings designed to seal the joints between the SRM segments that prevented hot gas leakage in the vicinity of the external tank. The initial recommendation by Morton Thiokol was not to launch.

The report of the Presidential Commission on the Challenger Accident (Rogers report) concluded:[91]

"The decision to launch the Challenger was flawed. Those who made that decision were unaware of the recent history of problems concerning the O-rings and the joint and were unaware of the initial written recommendation of the contractor advising against the launch at temperatures below 53 degrees Fahrenheit and the continuing opposition of the engineers at Morton Thiokol after the management reversed its position. They did not have a clear understanding of Rockwell's concern that it was not safe to launch because of ice on the pad. If the decision makers had known all the facts, it is highly unlikely that they would have decided to launch 51-L on January 28, 1986." (Vol. 1 Chapter 5)

"The unrelenting pressure to meet the demands of an accelerating flight schedule might have been adequately handled by NASA if it had insisted upon the exactingly thorough procedures that were its hallmark during the Apollo program." (Vol. 1 Chapter 7)

The process of arriving at the launch decision illuminates how serious safety concerns can be overridden by concerns for schedule, particularly when there is no effective check and balance by an authority that can speak with an equal voice to the Programmatic Authority.

Columbia STS107. Post-launch photographic analysis of Columbia showed a large piece and two smaller pieces of foam struck Columbia's underside and left wing. Analysis the day after launch indicated the large piece of foam (20–27 inches long and 12–18 inches wide) impacted the shuttle at a relative speed of 416–573 mph. As a result, the photo analysis team requested high-resolution photos be obtained by the Department of Defense to assist in the assessment and subsequent analysis. This was the first of three distinct requests for on-orbit imagery. Schedule pressure contributed to management declining to pursue the requests for imagery. (See CAIB report Vol. 1 Section 6.2 for more background information.[92])

[91] Rogers Commission Report 1.doc (nasa.gov)
[92] https://www.nasa.gov/columbia/caib/html/start.html

STS-121 Return to Flight Launch Decision

In June 2006 with the FRR for the mission approaching, the top engineering and SMA authorities at NASA determined that the residual risk was "probable catastrophic" or unacceptable for mission execution. This was reported up through the SMA and engineering channels respectively. The Shuttle program manager reported this also to NASA Headquarters but disagreed with the hazard categorization. He asked that a higher authority address the matter at the FRR scheduled for June 17, 2006.

After discussing the issue with technical authorities and the other review board members, NASA Chief Engineer Chris Scolese and Chief SMA Officer Bryan O'Connor decided to "nonconcur" in proceeding to launch, recommending that the mission be delayed until the faulty design could be improved. First and foremost came flight safety, and Scolese and O'Connor were concerned that the as yet unresolved ice/frost-ramp problem could jeopardize the safe return of the orbiter and its crew.

In the FRR, Scolese and O'Connor were the last two to be polled. Everyone had been go for launch until Scolese said "no." "It wasn't easy being the only one to say no. I wasn't completely sure what Bryan would say after me. It wasn't fun, but I think it was the right thing to do, and it was the right way to do it."

The flight readiness endorsement document does not have an option for "nonconcurrence." On the forms, Scolese and O'Connor had to cross off "concurrence" and write in their own nonconcurrence and rationale.

Following two days of discussion, the FRR Chair and Associate Administrator for the Space Operations Mission Directorate, W.H. Gerstenmaier, believed that the risks were acceptable and decided to proceed with launch. Because of the Chief Engineer's and the SMA Chief's "nonconcurrence," the chair elevated the final decision to the Administrator, Michael Griffin. The following is Michael Griffin's assessment of the situation regarding the "dissent" or nonconcurrence:

Some of the senior NASA individuals responsible for particular technical areas, particular disciplines, expressed that they would rather stand down until we had fixed the ice/frost ramps with something better, whereas many others said, "No, we should go ahead."

So, we did not have unanimity. Therefore, a decision had to be made. Now, one possible way of making decisions is that unless everybody feels that we should go, then we will stand down. In which case, I don't think for Shuttle flights or any other flights, we don't need an Administrator. We don't actually make decisions. We just make sure that no one is unhappy. That's not the method that we're using.[93]

Having carefully considered both sides of the story, Griffin agreed with the FRR chair that the risk was acceptable. He made the decision to proceed with the flight.

In the end, neither Scolese nor O'Connor asked him to reconsider. They believed that the mandatory requirement for safe haven and a crew rescue launch-on-need capability adequately mitigated the flight-crew safety risk.

[T]he two Agency officials said the foam loss will not threaten the crew because NASA has a plan for the astronauts to move into the International Space Station if in-orbit inspections find serious damage to the spacecraft. The crew would await rescue 81 days later by a second space Shuttle.[94]

After the FRR meeting, Scolese and O'Connor issued a statement about their nonconcurrence in the decision process.

Crew safety is our first and most important concern. We believe that our crew can safely return from this Mission.

We both feel that there remain issues with the orbiter—there is the potential that foam may come off at the time of launch. That's why we feel we should redesign the ice/frost ramp before we fly this Mission. We do not feel, however, that these issues are a threat to the safe return of the crew. We have openly discussed our position in the Flight Readiness Review—open communication is how we work at NASA. The Flight Readiness Review Board and the Administrator have heard all the different engineering positions, including ours, and have made an informed decision and the Agency is accepting this risk with its eyes wide open.[95]

Reflections on the Launch Decision

The Shuttle *Discovery (STS-121)* launched on July 4, 2006, and successfully concluded 13 days in space. The crew had spent the mission transferring cargo to the International Space Station and performing a variety of other tasks, including testing crack-repair methods in the reinforced carbon–carbon panels on the leading edge of the orbiter's wing. In the aftermath of *Columbia* and prior to *STS-121*, it had been noted that in theory:

Astronauts will be able to repair cracks as small as a fraction of an inch or plug holes in the wings as big as 4 inches (10 centimeters). Anything bigger—the gash in Columbia's left wing was between 6 and 10 inches (10 to 25 centimeters)—and the Shuttle crew will have to move into the Station until [another Shuttle] can be launched to rescue them.[96]

After the fact, Scolese noted that he believed that the *STS-121* launch decision was an example that the review process works. He and O'Connor believed that in the process, Griffin had been made fully aware of the residual risks to both the orbiter and the flight crew, and that the decision process had been appropriately thorough, professional, and consistent with NASA's core values and Governance. He felt *STS-121* was a great success, showing that the NASA culture had changed in the wake of *Columbia*.

A year later, NASA Administrator, Michael Griffin, wrote the following in *ASK* magazine:

Generally speaking, decisions are the responsibility of line organizations, either programmatic or institutional. In some cases, where there is a substantial disagreement, decisions will be appealed by one side or the other. A good recent example is the launch decision for *STS-121*. In that case, programmatic authorities made the decision to launch, and institutional authorities appealed that decision in light of concerns about ice/frost ramp foam losses from the Shuttle's external tank. In that case, the appeal came to the level of the Administrator, because agreement could not be found at lower levels. And my belief is that decisions of that magnitude deserve the attention of NASA's top management, so our Governance process worked well in that case.[97]

To support mission success, NASA teams need to have full and open discussions with all facts made available to support understanding and objective assessment of issues to make the best possible decisions. Diverse views are to be fostered and respected in an

[93] John Kelly, "NASA Chief Michael Griffin's STS-121 Flight Rationale Explained." *Florida Today*, (June 21, 2006). Reproduced in Space.com. Available at http://www.space.com/2525-nasa-chief-michael-griffin-sts-121-flight-rationale-explained.html.
[94] Mike Schneider, "Shuttle Launch a Go Despite Damaged Foam." (July 4, 2006) *Washington Post*, Available at http://www.washingtonpost.com/wp-dyn/content/article/2006/07/03/AR2006070300996.html.
[95] NASA, NASA Statement on Decision to Launch Shuttle Discovery. (June 19, 2006) Available at http://www.nasa.gov/mission_pages/shuttle/news/121frr_oconnor_scolese.html. See Appendix 5 for a list of references.
[96] MSNBC, "NASA Says It's Fixed Shuttle Foam Problem." (August 31, 2004) Available at http://www.msnbc.msn.com/id/5831547/.
[97] Michael D. Griffin, "The Role of Governance." *ASK*, Issue 26 (Spring 2007).

environment of integrity and trust with no suppression or retribution. To support these goals, NASA has established a uniform, recognized, and accepted Formal Dissent process for resolving serious dissent and has formalized it in policy. The Formal Dissent process further empowers team members to provide their best input to decision makers on important issues and clearly defines the roles and responsibilities of both sides when there is a dissent. A Formal Dissent expresses a view that a decision or action, in the dissenter's judgment, needs to be changed for the good of NASA and requests a review by higher-level management. In this context, "for the good of NASA" is to be read broadly to cover NASA, mission success, safety, the project, and the program.

Formal Dissent Process and Safety and Mission Assurance (SMA) "Suspend Work":

- *NPD 1000.3, The NASA Organization states: "The Chief, Safety and Mission Assurance is authorized to suspend any operation or project activity that presents an unacceptable risk to the public, workforce, property, environment, or mission success and provide guidance for corrective action."*
- *Nothing in the Formal Dissent process is intended or may be construed to abridge or diminish this SMA responsibility.*

The Formal Dissent process is based on a belief that each team member brings unique experience and equally important expertise to every issue and that the recognition of and openness to that unique experience, expertise, and insight improves the probability of identifying and resolving challenges to safety and mission success. NASA's core value of teamwork captures this philosophy.

NASA's most powerful tool for achieving mission success is a multidisciplinary team of diverse competent people across all NASA Centers. NASA's approach to teamwork is based on a philosophy that each team member brings unique experience and important expertise to project issues. Recognition of and openness to that insight improves the likelihood of identifying and resolving challenges to safety and mission success. NASA is committed to creating an environment that fosters teamwork and processes that support equal opportunity, collaboration, continuous learning, and openness to innovation and new ideas.

In the team environment in which NASA operates, team members often have to determine where they stand on a decision. In assessing a decision or action, team members have three choices: agree, disagree but be willing to fully support the decision, or disagree and raise a Formal Dissent.

There are three parts to a Formal Dissent:

1. A disagreement by an individual with a decision or action that is based on a sound rationale (not on unyielding opposition),
2. An individual's judgment that the issue is of sufficient importance that it warrants a specific review and decision by higher level management, and

3. The individual specifically requests that the dissent be recorded and resolved by the Formal Dissent process.

The decision on whether the issue in question is of the significance that warrants the use of the Formal Dissent process is the responsibility and personal decision of the dissenting individual.

5.3.1 Responsibilities of the Individual Raising a Formal Dissent

Individuals who raise a Formal Dissent have the following responsibilities:

- Be knowledgeable of the Formal Dissent process.
- Be competent in the matter involved in the dispute.
- Raise the concern and the basis and rationale for the concern in a professional and timely manner. (This normally is done during the team deliberations leading up to a decision to ensure that the decision maker understands all views before making the decision.)
- Support the joint resolution process.

5.3.2 Responsibilities of a Decision Maker

A decision maker has a responsibility to fully support NASA's "teamwork" core value. This includes conducting discussions, meetings, and boards in a professional manner that:

- Promotes full and open discussion of issues with all their associated facts and considerations,
- Fosters and respects diverse views,
- Invites thoughtful presentations of alternative ideas and approaches, and
- Ensures the team understands the basis for the decisions made.

Such an approach helps ensure that the decision maker has the best possible basis for the decision. It also minimizes the need for Formal Dissents. Note that the decision maker's responsibilities start before the Formal Dissent exists. When a Formal Dissent is raised, the decision maker receiving a Formal Dissent has an obligation to work to support the resolution process and to maintain an environment of integrity and trust with no suppression or retribution.

Unresolved issues of any nature (e.g., programmatic, safety, engineering, health and medical, acquisition, accounting) within a team need to be quickly elevated to achieve resolution at the appropriate level. The decision on whether the issue in question is of significance to warrant the use of the Formal Dissent process is the responsibility and personal decision of the dissenting individual. Supporting the resolution of the dissent is the responsibility of both parties and is a joint process involving representatives on both sides of the issue.

The emphasis on the joint process involving both parties to a Formal Dissent at all phases of the resolution process is intended to ensure that the authorities involved in resolving the dissent fully understand the position of both parties.

When time permits, the disagreeing parties jointly document the issue. This involves clearly defining the issue, identifying the agreed-to facts, discussing the differing positions with rationale and impacts, and documenting each party's recommendations. The joint documentation is approved by the representative of each view, concurred with by affected parties, and communicated at a minimum of two levels of management above the original program or project decision. This may involve a single authority (e.g., the Programmatic Authority) or multiple authorities (e.g., Programmatic and Technical Authorities). In cases of urgency, the disagreeing parties may jointly present the information stated above orally with all affected organizations represented, advance notification to the second-higher level of management, and documentation follow up.

The preparation of a joint document is encouraged because of the clarifying effect that comes from writing things down. Experience has shown that the process of committing the issue to writing tends to depersonalize the issue and in many cases leads to a clearer understanding of the issue and the differing views. At times this has led to a resolution prior to elevating the issue up the management chain. Even if writing the document does not result in resolution, there is a secondary benefit; specifically, the document leads to an efficient presentation and decision process.

Management's decision on the memorandum (or oral presentation) is documented and provided to the dissenter and to the notified managers and becomes part of the program or project's retrievable records. If the dissenter is not satisfied with the process or outcome, the dissenter may appeal to the next higher level of management. The dissenter has the right to take the issue upward in the organization, even to the NASA Administrator if necessary.

5.3.3 Appeal Path for Formal Dissents

Figure 5-6 illustrates potential appeal paths for Formal Dissents among various authorities in a single-Center environment. The three parts of the figure show different ways a Formal Dissent may be generated. The path on the left shows a Formal Dissent flow where the dissent is strictly within the programmatic path. As the figure shows, the dissent flows up the programmatic chain until resolution is achieved. A simple example may be a project manager requiring an element manager to have a Preliminary Design Review (PDR) by a specific date, which the element manager determines is unreasonable due to a nontechnical issue. They would try to work this schedule conflict among themselves, but if they cannot resolve it, then it rises to the program manager. If the program manager cannot resolve the issue, then it rises to the MDAA and next to the NASA Associate Administrator (AA). Since the requirement owner is the OCE, the NASA Chief Engineer would be consulted along with the NASA AA.

In Figure 5-6, the figure on the right is similar to the one on the left except that the Formal Dissent is now strictly within the TA and engineering chain of command. For example, if the project chief engineer and the LDE disagree on a waiver to a TA requirement and they cannot resolve it among themselves, then the dissent rises to the next higher level of management, in this case the program chief engineer and the Center engineering director. If they cannot resolve it, then it goes to the Center Director and the NASA Chief Engineer.

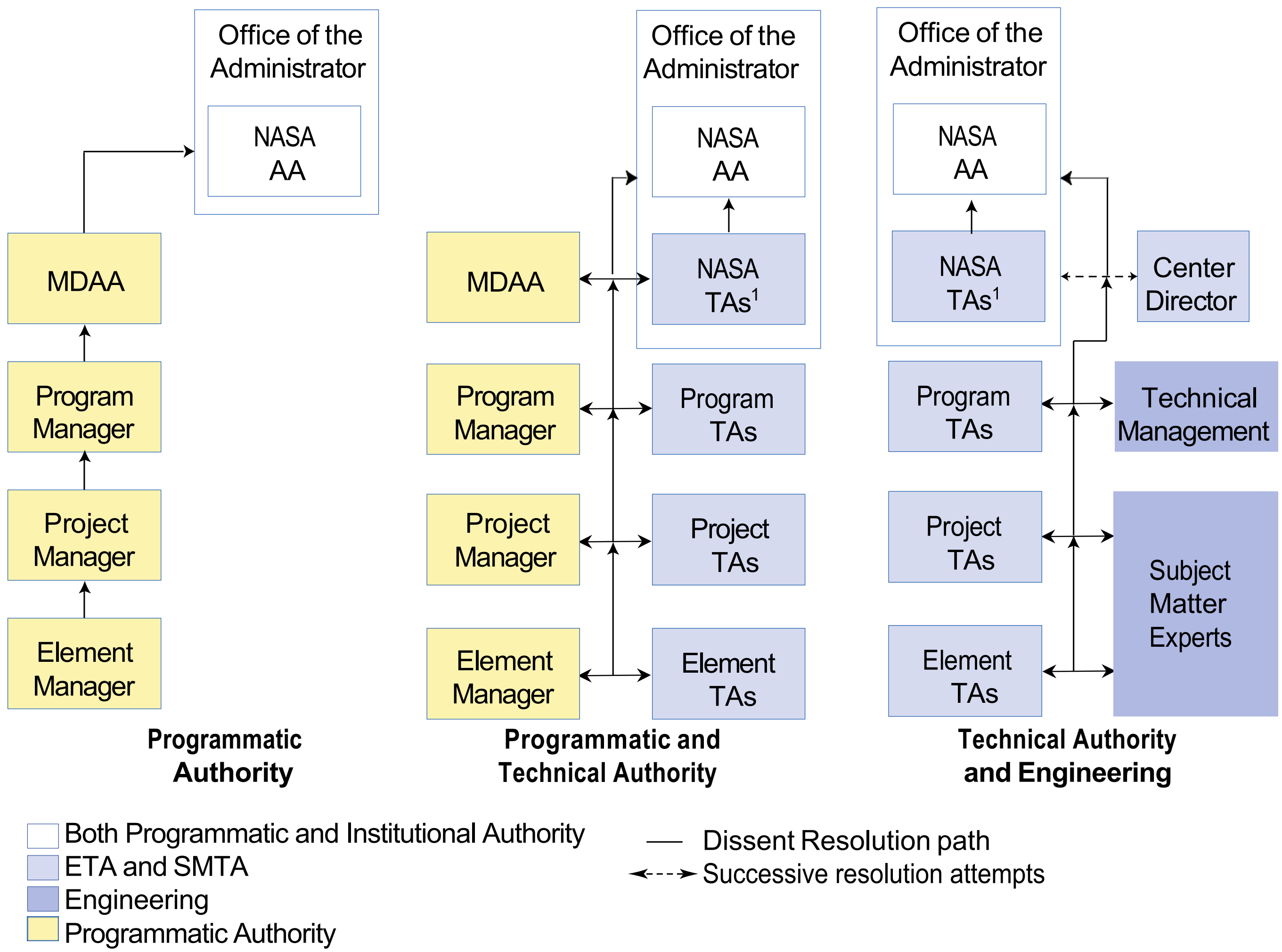
Finally, the center figure shows the flow for a dissent between the Programmatic Authority and the TA. An example is an element manager who wants to waive a TA requirement for a lower factor of safety on a pressure vessel design to save cost. If the element manager and the element chief engineer cannot agree, then the dissent rises to the project manager and project chief engineer, then to the program manager and program chief engineer, and finally to the MDAA and NASA Chief Engineer if necessary.

Figure 5-7 illustrates a Formal Dissent resolution path in a multi-Center environment.

A Formal Dissent between authorities at the element level would rise to the project level with notification at the program level. Since two authorities are involved in the Formal Dissent process, both authorities would be involved at each step in the resolution path.

Before leaving Center B, resolution is typically attempted within Center B and a Center position is typically established. This does not mean that an individual raising the dissent could be overridden by the appropriate Center TA. If the appropriate Center TA did not agree with the position taken by the dissenter, this would become part of the information carried to the next level of the resolution process. After the project level, the next step in the resolution path would be at the program level with notifications to the MDAA.

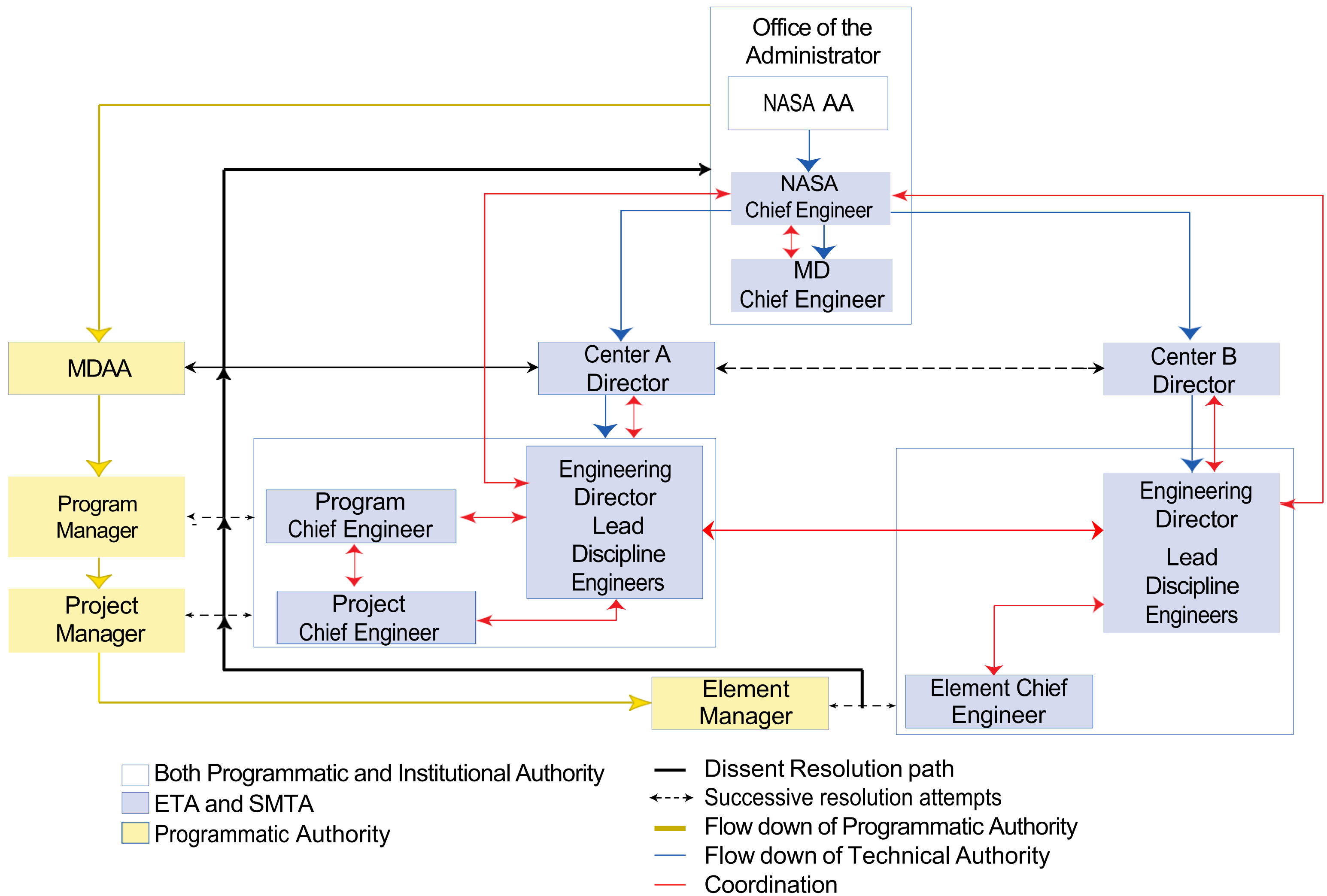
Note that the process flow described above complies with policy and, for graphic simplicity, the web of communications among entities is not shown. The essential nature of these communications is recognized and helps in a timely resolution of the issue at hand.



[1]NASA TAs represents TAs above Program level, including NASA Chief Engineer and Center Director.

Note: This figure is a simplified representation of levels of dissent and does not necessarily depict all involved parties. Resolution is attempted at each level. If not resolved, the issue rises to the next level. The formal dissent process can start at any level.

Figure 5-6 Simplified Potential Appeal Paths for Formal Dissent Resolution in a Single-Center Environment



Note: This figure is a simplified representation of levels of dissent and does not necessarily depict all involved parties. Resolution is attempted at each level. If not resolved, the issue rises to the next level. The formal dissent process can start at any level.

Figure 5-7 Formal Dissent Resolution Path in Multi-Center Environment

Figure 5-8 illustrates the multi-Center communications framework for Orion/LAS[98] ETA. The communications framework was an effective construct for day-to-day operations and execution. It also served as a method to ensure that the ETA at various levels in the projects and Centers were informed and engaged in issue resolution at the right time and venue.

This figure shows an example where the LAS Deputy Chief Engineer (DCE) has a Formal Dissent about a technical matter. The DCE first works with the LAS Chief Engineer to resolve the issue and informs the next level up of the issue. If they cannot resolve the issue, they then meet with the Orion Chief Engineer to discuss the issue and seek solutions.

If the Joint LAS and Orion Chief Engineers can resolve the dissent at their level to the satisfaction of the originator of the Formal Dissent (the LAS DCE in this example), this is communicated to one level above them for information, and actions are then executed to resolve the issue.

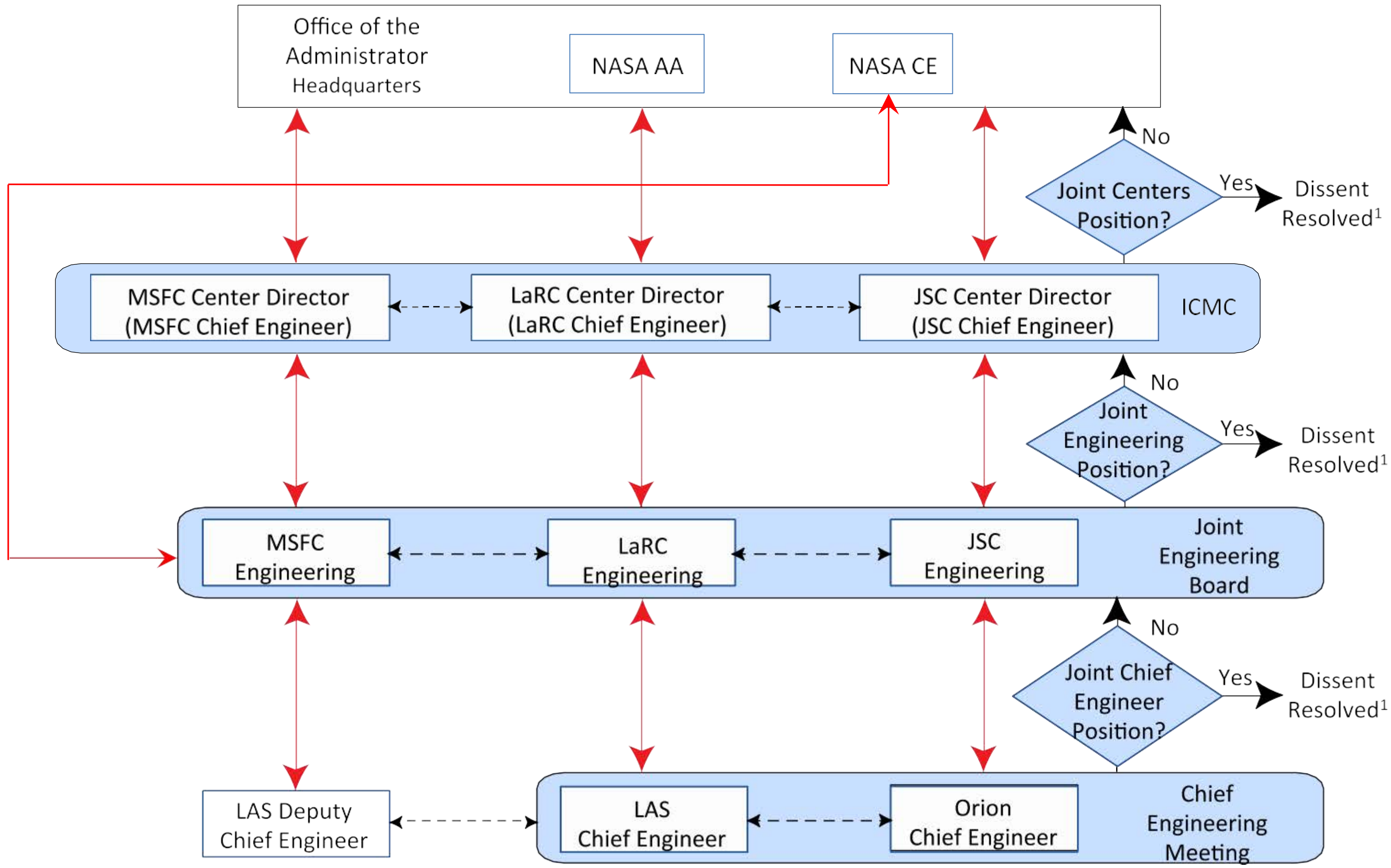
If the Joint LAS and Orion Chief Engineers cannot come to a joint agreement, the Formal Dissent is next presented to a Joint Engineering Board comprised of senior engineering personnel from all the Centers involved, and the next level up is made aware of the issue. If the Joint Engineering Board can resolve the issue to the originator's satisfaction, they inform the next level up and then execute the resolution.

If the Joint Engineering Board cannot resolve the issue at their level, it is taken to an Integrated Center Management Council (ICMC) comprised of the Center chief engineers and Center Directors as needed. If they can resolve it to the originator's satisfaction, they inform the next level up and execute the resolution.

If the ICMC cannot resolve the issue, it is taken to the NASA Chief Engineer for discussion and resolution in a similar manner. If necessary, the issue may be brought to the NASA Administrator for final arbitration.

HMTA Formal Dissents for human space flight programs follow the flow path shown in Figure 5-4.

[98] LAS is Launch Abort System, a subsystem of Orion.



LAS = Launch Abort System, which is a subsystem of Orion.

←--→ Dissent Resolution path
—— Coordination

[1]Inform all parties, including one level up from the deciding board and the original dissenter.

Figure 5-8 Specific Example Formal Dissent Process in a Multi-Center Environment (Orion/LAS ETA Communication Framework)

5.3.4 Notifications During the Formal Dissent Resolution Process

During the Formal Dissent resolution process, NPR 7120.5 requires that the management of both dissenting parties be informed. Specifically, the level of management above the dissenting parties, are provided with the joint documentation developed by the dissenting parties (preferably written but may be oral in cases of urgency), and the second-higher level of the involved authorities is notified of the specifics of the disagreement.

When the disagreement cannot be resolved at the level of management above the disagreeing parties, the second-higher level is provided with the joint documentation, and the third-higher level is notified of the specifics of the disagreement. This process continues until this disagreement is resolved.

When the disagreement reaches a Center's Director of Engineering or Safety and Mission Assurance or the Chief Medical Officer, if one is assigned, notification of the disagreement to the second-higher level includes both the Center Director and the NASA Headquarters TA counterpart (i.e., NASA Chief Engineer; Director, SMA; or Chief, HMO depending on the discipline of the disagreement).

A Center Director may request an expedited escalation of a Formal Dissent at the Agency level up to and including the NASA Administrator based on his or her judgment that a rapid resolution of the Formal Dissent is in the best interests of the Agency and the dissenting individual or organization.

Once the disagreement has been resolved, management's decision on the dissent memorandum (or oral presentation) is documented and provided to the dissenter and to the managers involved in assessing and adjudicating the disagreement, including the level above the authority where the decision was ultimately resolved.

If an authority chooses to either overrule a lower-level authority's decision or nonconcur with any Formal Dissent, transparency in decision making requires that the authority explain his or her choice to the person raising the issue and to those above them in the authority chain.

5.4 Tailoring Requirements

The tailoring process supports NASA's goal of Technical Excellence by providing and maintaining a sound basis for the requirements imposed on NASA's space flight programs and projects. The principles can be viewed as another piece of providing proper balance between organizational elements by having a check and balance system as described in *NPD 1000.0, NASA Governance and Strategic Management Handbook*.

It is NASA policy to comply with all prescribed requirements, directives, procedures, and processes unless relief is formally granted by the designated party. However, NASA policy also recognizes the need to accommodate the unique aspects of each program or project to achieve mission success in an efficient and economical manner.

Tailoring is the process used to adjust or seek relief from a prescribed requirement to accommodate the specific needs of a task or activity (e.g., program or project). Relief from a requirement may be granted in the form of a ruling that a requirement is non-applicable or in the form of a waiver or a deviation. Tailoring is both an expected and accepted part of establishing the proper requirements for a program or project. A secondary benefit of a formalized and disciplined approach to granting relief from prescribed requirements is that in time and with proper feedback, it will result in improved prescribed requirements.

The two terms "waiver" and "deviation" provide a temporal indicator that allows separating requirement tailoring proposed before the requirement was put under configuration control ("seeking permission") from those made after ("seeking forgiveness"). Definitions of these two terms are:

- ***Waiver****. A documented authorization releasing a program or project from meeting a requirement after the requirement is put under configuration control at the level the requirement will be implemented.*
- ***Deviation****. A documented authorization releasing a program or project from meeting a requirement before the requirement is put under configuration control at the level the requirement will be implemented.*

5.4.1 Delegation of Tailoring Approval Authority

Delegation of tailoring approval authority is done formally. The individual with tailoring approval authority for a particular requirement has the responsibility to consult with the other organizations that were involved in the establishment of the specific requirement and to obtain the concurrence of organizations having a substantive interest.

Following are examples of how delegation of approval authority has been formally implemented for HQ-originated requirements:

- The Office of the Chief Engineer (OCE) periodically issues a letter documenting the delegation of authority for granting relief from requirements for which OCE is responsible. This includes requirements contained within NASA Policy Directives (NPDs), NASA Procedural Requirements (NPRs), and technical standards. The delegation letter can be found in NODIS on the OCE tab under the "Other Policy Documents" menu.

- NASA's Safety and Mission Assurance (SMA) requirements come from a variety of sources which include Federal laws and regulations, interagency agreements, and Presidential Directives. To ensure NASA's compliance with these requirements and other external SMA requirements and direction, the office of the NASA Chief, SMA has defined the process for determining the delegation of authority for granting relief from requirements for which the NASA Headquarters Office of SMA (OSMA) is responsible in *NPR 8715.3, NASA General Safety Program Requirements*. This includes requirements contained within NPDs, NPRs, and technical standards.
- The Office of the Chief Health and Medical Officer (OCHMO) promulgates mandatory human system technical standards for human space flight programs and projects. OCHMO has defined the process for determining the delegation of authority for granting relief from HMTA standards and other requirements for which OCHMO is responsible in *NPR 7120.11, NASA Health and Medical Technical Authority (HMTA) Implementation.*
- Program and project managers can also work with the Center representative of the responsible organization (e.g., OCE, OSMA, OCHMO) to determine if tailoring authority has been delegated to a Center person and, if so, who the delegated authority is.

When a Center Director or designee formally delegates tailoring approval authority, the delegation is documented in accordance with Center processes. The Types of Requirements box provides more information.

Types of Requirements

Programmatic Requirements. Focus on space flight products to be developed and delivered that specifically relate to the goals and objectives of a particular program or project. They are the responsibility of the Programmatic Authority.

Institutional Requirements. Focus on how NASA does business independent of a particular program or project. They are the responsibility of the applicable Institutional Authority.

Allocated Requirements. Established by dividing or otherwise allocating a high-level requirement into lower-level requirements.

Derived Requirements. Arise from:

- Constraints or consideration of issues implied but not explicitly stated in the higher-level direction originating in Headquarters and Center institutional requirements or
- Factors introduced by the architecture and/or the design.

These requirements are finalized through requirements analysis as part of the overall systems engineering process and become part of the program or project requirements baseline.

Technical Authority Requirements. A subset of institutional requirements invoked by the Office of the Chief Engineer (OCE), the Office of Safety and Mission Assurance (OSMA), and the Office of the Chief Health and Medical Officer (OCHMO) documents (e.g., NASA Procedural Requirements (NPRs) or technical standards cited as program or project requirements or contained in Center documents). These requirements are the responsibility of the office or organization that established the requirement unless delegated elsewhere.

Additional types of requirements are defined in Appendix A.

5.4.2 Tailoring NPR 7120.5 Requirements

NPR 7120.5 requires that all space flight programs and projects follow the tailoring process delineated in the NPR. The foundations for this process are the tailoring principles that flow down from *NPD 1000.0, NASA Governance and Strategic Management Handbook*.

The organization at the level that established the requirement approves the request for tailoring that requirement unless this authority has been formally delegated elsewhere. The organization approving the tailoring disposition consults with the other organizations that were involved in the establishment of the specific requirement and obtains the concurrence of organizations having a substantive interest. The Considering Other Stakeholders in Tailoring Requirements box provides more information.

Considering Other Stakeholders in Tailoring Requirements

The organization that establishes a requirement (or formally delegated designee) is in the best position to know why the requirement was established and to assess a request for relief and its associated justification. In addition, this interaction of the user and the party responsible for establishing a requirement provides important feedback to the organization responsible for the requirement that can be used to determine whether the requirement needs reassessment.

In many instances, several organizations may have played a significant role in establishing a requirement or may be affected by tailoring the requirement. Consultation with these organizations is essential to avoid adverse unintended consequences as these organizations may have background and/or insights that may not be readily apparent. The organization responsible for the document that contains the requirement being considered for tailoring is the organization from which tailoring approval is sought unless this authority has been formally delegated elsewhere. The organization with the tailoring authority is responsible for consulting with the other organizations involved in establishing the requirement and for obtaining the concurrence of organizations having a substantive interest.

The involved management at the next higher level is informed in a timely manner of the request to tailor a prescribed requirement.

The next higher level may be counting on the original requirement in a manner that is not known to the lower level (e.g., the requirement may have been used in a higher-level analysis of which the lower level is not aware.) Timely interaction among management levels supports a philosophy that contributes to mission success: specifically, the goal of "no surprises."

Each program and project is required by NPR 7120.5F to complete and maintain a Compliance Matrix (see Appendix C in the NPR). In addition, requests for tailoring of NPR 7120.5 requirements may be submitted by using a documented waiver request individually or in groups. The Compliance Matrix provides a streamlined process for documenting the program or project's compliance with the NPR's requirements or how the program or project is tailoring the requirements in accordance with Paragraph 3.5 of NPR 7120.5F. The Compliance Matrix tailoring includes signatures from the organizations responsible for requirements that are not already required signatories to the Formulation Agreement or Program or Project Plan, including the Office of the Chief Engineer (OCE) and the Office of the Chief Financial Officer (OCFO).

The Compliance Matrix is attached to the Formulation Agreement for projects in Formulation and/or the Program or Project Plan. Once the Formulation Agreement or Program or Project Plan is signed by the required signatories, the tailoring in the matrix is approved, and a copy is forwarded to the OCE. No other waiver or deviation documentation is required.

If the Compliance Matrix changes or if compliance is phased for existing programs or projects, updated versions of the Compliance Matrix are incorporated into an approved updated Formulation Agreement or Program or Project Plan revision. (See NPR 7120.5 for phasing requirements.)

Guidance and resources to assist programs and projects in tailoring NPR 7120.5 requirements have been established and/or developed by the Agency, Mission Directorates, and Centers. Appendix C of NPR 7120.5 and/or the Agency Tailoring Website at https://appel.nasa.gov/npr-7120-5-tailoring-resources provide:

- The Compliance Matrix, which includes the NPR requirements, the organization or individual responsible for each requirement with authority for approving tailoring, and whether tailoring authority for the requirement is delegated or held at HQ.
- Instructions for completing the Compliance Matrix, including the process for documenting and obtaining approval for tailoring.
- Information on different options related to the Compliance Matrix, including pre-customized Compliance Matrix templates that eliminate non-applicable requirements for specific types of programs and projects.
- Consultation and assistance for tailoring, including Points of Contact for NPR 7120.5 requirement owners and some Mission Directorates for consulting with and assisting programs and projects in developing their tailoring approach and in obtaining approval for tailoring.
- Information on how the NASA Program and Project Management Board (PPMB) may assist programs and projects in tailoring requirements and provide guidance through the tailoring process.
- Resources for developing the tailoring approach, including guidance and implementation plans provided by some requirements owners such as OCE and OCFO and Mission Directorates for developing a tailoring approach; summary information on tailoring approaches common across multiple programs and projects and requirements that are frequently tailored; examples of how specific programs and projects have tailored NPR 7120.5 requirements; and information on tailoring tools at some Centers.

5.4.3 NPR 7120.5 Tailoring Process Documentation

If programs or projects find a need to submit a waiver or deviation later in the life cycle, the attributes and data needed for tracking are included in requests to expedite processing and support requirement compliance tracking. (If the Compliance Matrix is used to request tailoring, the process is streamlined upfront when requirements are flowed down; however, inclusion of attributes in the documentation of tailoring is still helpful.) If requested separately from the Compliance Matrix, requests for tailoring, to be approved, need to be recommended by the MDAA, concurred with by the Center Director, and approved by the requirement owner or as delegated.

The specific format or form in which the attributes and tracking data are submitted is the responsibility of the requesting activity but must be usable by the receiving organization. All requirement relief requests (deviations or waivers) are also copied to the SMA TA at the program or project level for risk review.

For NPR 7120.5F requirements owned by OCE, requests for relief separate from the Compliance Matrix use the "Waiver/Deviation Request Process for NPR 7120.5F Requirements" document on the Agency Tailoring Website, which contains the OCE-specific process and required data elements. Attributes to include in the request are provided in the list below and approval authority for these waivers or deviations is depicted in Table 5-2.

- Descriptive title and date for the waiver or deviation request.
- Name of project, program, Center, and Mission Directorate involved in the request, as applicable.
- Name of responsible person and the organization submitting the request and contact information.
- Identification of the source document of the request (e.g., *NPR 7120.5F, NASA Space Flight Program and Project Management Requirements*, standards associated with OCE requirements such as *NASA-STD-1006, Space System Protection Standard*).
- Complete identification of requirement for which the waiver or deviation is requested (e.g., NPR section number and text).
- Description of the type, scope and nature, and duration of the request.

  Type: Non-applicable, Technically equal or better, Requires acceptance of additional risk, Involves non-conforming product, or Involves non-compliant requirement

  Scope and Nature: e.g., identification of the system, parts, lot, or serial numbers

  Duration: Permanent, Temporary, Recurring, or Recurring with need for corrective action to prevent recurrence
- Description of the requirement(s), specification(s), drawing(s), and other baselined configuration, documentation, or product(s) affected due to this request.
- Identification of other organizations, systems, or components that may be affected.
- Identification, characterization, and quantification of increased risk associated with acceptance of the waiver or deviation request, if any.
- Justification for acceptance and reference to all material used to support acceptance.
- If appropriate, description of or reference to the corrective action taken or planned to prevent future recurrence.
- Risk evaluation. If acceptance increases risk, include the names and signatures of the Technical Authority(ies) who has(have) agreed that the risk has been properly characterized and is acceptable and the names and signatures of the Programmatic Authority(ies) who has(have) agreed to accept the risk.
- If applicable, description of any dissent, including rationale for dissent and name of dissenting responsible individual and their organization and contact information.

Table 5-2 Waiver/Deviation Approval Authority for NPR 7120.5F OCE Requirements

	Project Manager	Program Manager	Center Director	MDAA	Chief Engineer	NASA AA
Programs		Recommends	Concurs[2]	Recommends	Approves	Informed
Category 1, 2, and 3 Projects	Recommends	Recommends	Concurs[2]	Recommends	Approves	Informed
Reimbursable Space Flight Projects	Recommends		Concurs[2]	Recommends[1]	Approves	Informed
Waivers or deviations with dissent						Approves

[1] As applicable.

[2] Unless otherwise delegated.

For requests for relief from requirements that are the responsibility of the Chief, SMA, *NPR 8715.3, NASA General Safety Program Requirements* contains the SMA-specific process. For requests for relief from requirements that are the responsibility of the Chief, HMO, *NPR 7120.11, NASA Health and Medical Technical Authority (HMTA) Implementation* contains the HMTA-specific process.

Guidance for requests for relief from requirements that are the responsibility of some other organizations such as OCFO is available on the Agency Tailoring Website. Programs and projects may also contact the organization's Point of Contact listed on the Agency Tailoring Website for guidance.

5.4.4 Tailoring a Derived Requirement

"Derived requirements" are established by a Programmatic Authority arising from:

- Constraints or consideration of issues implied but not explicitly stated in the higher-level direction originating in Headquarters and Center institutional requirements or
- Factors introduced by the architecture and/or the design.

The tailoring principles apply to derived requirements, so a Programmatic Authority at the level that established the derived requirement approves a request for tailoring the derived requirement unless this authority has been formally delegated elsewhere.

An organizational entity seeking relief from a derived requirement submits a request for a waiver or deviation to the organization at the level that established the derived requirement or to its designee. If the source organization established the derived requirement, it has the authority to disposition the request for the derived requirement relief. However, if the source organization was flowing the derived requirement down from a higher authority and was not delegated the authority to grant relief from the derived requirement, the source organization forwards the request to the higher authority for dispositioning. This process illustrates the need for programs and projects to be able to trace the origin of their requirements.

The Tailoring of a Derived Requirement: Example box provides an example illustrating the tailoring of a derived requirement.

Tailoring of a Derived Requirement: Example

A project determines that it needs to specify a pressure vessel.

In the design implementation, the project decides to use a Composite Overwrapped Pressure Vessel (COPV) that meets the Agency-level requirement for a safety factor of N. Because of a perceived technology risk, the project decides to impose a higher safety factor of N+m.

The extra increment on the safety factor is a derived requirement and is the responsibility of the Programmatic Authority at the level that established it.

If the project decides to change the design from a COPV to a metallic pressure vessel, the associated changes in specified requirements can be approved at the project level with notification to the next higher level and to others who would be impacted by the change.

Similarly, if the project decides to eliminate the extra added safety factor (+m), the requirement can be changed at the project level as this is the organization and level that established the requirement.

However, if the project proposes that the new metallic tank need only meet a safety factor of N-x (less than the Agency requirement), the tailoring principles would require the approval of the appropriate Technical Authority.

5.4.5 Tailoring a Technical Authority Requirement

Technical Authority requirements invoked by OCE, OSMA, or OCHMO documents (e.g., in NPDs, NPRs, and/or NASA standards) are usually flowed down in Center institutional documents. Tailoring of these requirements is the responsibility of the office or organization that established the requirement unless delegated elsewhere.

Technical Authorities at the program or project level ensure that the approval for tailoring TA requirements is obtained from the Technical Authority that established the requirement or designee. It follows from basic principles that a program- or project-level Technical Authority cannot approve relief from a TA requirement unless that Technical Authority has been formally delegated the authority to do so.

5.4.6 Non-Applicable Prescribed Requirements

A prescribed requirement that is not relevant and/or not capable of being applied to a specific program, project, system, or component (e.g., producing a Human-Rating Certification Package for a robotic project) can be characterized as non-applicable and can be approved by the individual who has been delegated oversight authority by the organization that established the requirement. This approval can be granted at the level where the requirement was specified for implementation, e.g., the project-level Engineering Technical Authority (ETA) could approve a non-applicable designation for an engineering requirement applicable to the project level. The requirement owner's signature is not required in the Compliance Matrix for a non-applicable requirement. Only the rationale for determining that the requirement is non-applicable is entered in the Compliance Matrix. Signatures on the retrievable project documentation that includes the Compliance Matrix (the Formulation Agreement or Project Plan) constitute approval for non-applicable requirements. No other formal deviation or waiver process is required.

The non-applicable prescribed requirement provision was included to provide an efficient means to grant and document relief from a specific class of requirements for which the need for relief is obvious and the judgment is likely to be the same regardless of who makes the determination. The criteria of being "nonrelevant" or "not being capable of being applied" were selected to identify non-applicable requirements. This criterion allows approval to be handled by the designated oversight authority at the level the requirement was specified for implementation. Required documentation was also simplified for non-applicable prescribed requirements. The documentation of the decision (including identification by parties involved) is recorded for completeness.

5.4.7 Request for a Permanent Change

A request for a permanent change to a prescribed requirement in an Agency or Center document that is applicable to all programs and projects is submitted as a "change request" to the office responsible for the requirement's policy document unless formally delegated elsewhere. No special form or format for a change request is specified in NPR 7120.5. No special form or format is required to enable existing Center forms and processes to be used.

5.5 Maturing, Approving, and Maintaining Program and Project Plans, Baselines, and Commitments

This special topic discusses key aspects of NASA's policy for developing and managing a well-defined baseline state for space flight programs and projects. (For additional information see *NASA/SP-2016-3424, NASA Project Planning and Control Handbook*.[99]) The section discusses:

- The Agency Baseline Commitment (ABC).
- Maturing the program or project Life-Cycle Cost (LCC) or initial capability cost and schedule estimates during Formulation and establishing the program or project baseline at KDP C. (The Performance Measurement Baseline (PMB), which is established in Phase B, is covered in Section 5.14.)
- Relationships between the LCC or initial capability cost, the ABC, Unallocated Future Expenses (UFE), and the Management Agreement.
- Developing Phase E cost estimates and costs for major upgrades for single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point.
- Changing the program or project cost plan and ABC.
- Details of enabling and supporting topics:
  - The Decision Authority, who is the individual responsible for making the KDP determination on whether and how a program or project proceeds through the life cycle and for authorizing the key program cost, schedule, and content parameters that govern the remaining life-cycle activities.
  - The Decision Memorandum, which documents important Agency-level decisions related to programs and projects at and between KDPs.
  - The Management Agreement, documented in the Decision Memorandum, which defines the parameters, including cost and schedule and authorities for which the program or project manager has management control and accountability.

Several specific cost terms used by the Agency are referenced including formulation costs, development costs, Joint Cost and Schedule Confidence Level (JCL), LCC, initial capability cost, and ABC. Table 5-4 depicts the scope in terms of life-cycle phases for each of these terms.

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[99] https://www.nasa.gov/content/project-planning-control-handbook

Table 5-4 Phases Included in Defined Cost Terms

Definition	Formulation			Implementation				
	Project Phases							
	Pre-Phase A	A	B	C	D	E	Extended Operations	F
Formulation Cost		■	■					
Development Cost				■	■			
JCL Scope at KDP B			■	■	■			
JCL Scope at KDP C				■	■			
JCL Scope at CDR				◨	■			
JCL Scope at KDP D					■			
Life-Cycle Cost		■	■	■	■	■		■
Agency Baseline Commitment		■	■	■	■	■		■

Notes:
The ABC is not established until KDP C and will include the actual Phase A and B costs.
The ABC is the same scope as the LCC except in the case of single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point. For these programs and projects, the ABC is the same scope as the initial capability. Initial capability is defined during Phase A and documented by KDP B. Initial capability is the first operational mission flight (or as defined in the KDP B Review Plan) and is documented in the KDP B Decision Memorandum. The scope of the initial capability is also documented in the PCA, the Program Plan, and the Project Plan.

5.5.1 The Agency Baseline Commitment

Managing and overseeing a program or project requires establishing a known reference or baseline state by which future performance and future states can be measured and compared. Program and project baselines consist of an agreed-to set of requirements, technical content, Work Breakdown Structures (WBSs), LCC or initial capability cost, including all Unallocated Future Expenses (UFE) held within and outside the program or project, Joint Cost and Schedule Confidence Level (JCL) when applicable, schedules, and other resources such as workforce and infrastructure.

Unallocated Future Expenses (UFE) are the portion of estimated cost required to meet the specified confidence level that cannot yet be allocated to the specific WBS subelements because the estimate includes probabilistic risks and specific needs that are not known until these risks are realized. For programs and projects that are not required to perform probabilistic analysis, the UFE should be informed by the program or project's unique risk posture in accordance with Mission Directorate and Center guidance and requirements. The rationale for the UFE, if not conducted using a probabilistic analysis, should be appropriately documented and be traceable, repeatable, and defensible. UFE may be held at the project level, program level, and the Mission Directorate level.

The Joint Cost and Schedule Confidence Level (JCL) is the product of a probabilistic analysis of the coupled cost and schedule to measure the likelihood of completing all remaining work at or below the budgeted levels and on or before the planned completion of the development phase. The JCL is required for all single-project programs (regardless of LCC or initial capability cost) and for all projects with an LCC or initial capability cost greater than $250 million at KDP C. A JCL is also required for these single-project programs and projects in the event of a rebaseline during the Implementation phase. For single-project programs and projects with LCC or initial capability cost ≥ $1B, a JCL is also required at KDP B and CDR, and at KDP D if current reported development costs have exceeded the development Agency Baseline Commitment (ABC) cost by 5 percent or more. The JCL calculation includes consideration of the risk associated with all elements, whether they are funded from appropriations or managed outside of the program or project. JCL calculations include content from the milestone at which the JCL is calculated through the completion of Phase D activities. In accordance with NPR 7120.5, at KDP B (if applicable) and KDP C, Mission Directorates plan and budget single-project programs (regardless of LCC or initial capability cost) and projects with an estimated LCC or initial capability cost greater than $250 million based on a 70 percent JCL or as approved by the Decision Authority. At KDP C, Mission Directorates ensure that funding for single-project programs and these projects is consistent with the Management Agreement and in no case less than the equivalent of a 50 percent JCL or as approved by the Decision Authority.

LCC is the total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred in the design, development, verification, production, deployment, prime mission operation, maintenance, support, and disposal of a program or project, including closeout, but not extended operations. The LCC of a program or project or system can also be viewed as the total cost of ownership over the program or project or system's planned life cycle from Formulation (excluding Pre-Phase A) through Implementation (excluding extended operations). The LCC includes the cost of the launch vehicle.

The initial capability cost is the total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred within the scope of the project initial capability. For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the initial capability is the first operational mission flight or as defined as part of the KDP B Review Plan. The scope of the initial capability is documented in the KDP B Decision Memorandum. The initial capability cost does not include costs for prime mission operation beyond the first operational mission flight, maintenance, support, and disposal of a program or project, including closeout.

Single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, define an initial capability during Phase A and develop an initial capability cost that establishes the Agency Baseline Commitment (ABC) at KDP C. Initial capability is the first operational *mission flight (or as defined in the KDP B Review Plan) and is documented in the KDP B Decision Memorandum. Initial capability cost includes operations cost for the initial capability. The Phase E cost estimate for continuing operations and production is established separately as part of the Operational Readiness Review (ORR) and KDP E for the 5 years after initial capability and subsequently updated and documented annually for the next 5-year period. Upgrades during Phase E that meet the Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purposes of establishing their own development ABC outside the single-project program or project Phase E cost estimate. The single-project program or project Phase E cost estimate is updated to include production and operations costs associated with these upgrades. Development, production, and operations costs of other (i.e., non-major) upgrades are included in the single-project program or project Phase E cost estimate. (See Section 5.5.4 for additional information on developing the Phase E cost estimate.)*

A program or project baseline, called the Agency Baseline Commitment (ABC), is established at approval for Implementation (KDP C). Although required for projects and single-project programs, an ABC is not required for uncoupled programs, loosely coupled programs, and tightly coupled programs. The ABC forms the foundation for program or project execution and reporting done as part of NASA's performance assessment and Governance process.

The Agency Baseline Commitment (ABC) is an integrated set of program or project requirements, cost, schedule, technical content, and when applicable, the JCL. The ABC cost is equal to the program or project LCC or initial capability cost approved by the Agency at approval for Implementation. The ABC is the baseline against which the Agency's performance is measured during the Implementation Phase of a program or project. Only one official baseline exists for a program or project, and it is the ABC. The ABC for projects with an LCC or initial capability cost of $250 million or more and the ABC for single-project programs form the basis for the Agency's external commitment to the U. S. Office of Management and Budget (OMB) and Congress and serve as the basis by which external stakeholders measure NASA's performance for these programs and projects. Changes to the ABC are controlled through a formal approval process.

The program or project develops or updates the LCC or initial capability cost in preparation for each life-cycle review that immediately precedes a KDP. Prior to the KDP for approval for Implementation (KDP C), the program or project develops the ABC. The ABC and/or LCC or initial capability cost are assessed, along with other key parameters, during the life-cycle review process and are authorized as part of the KDP. The authorized ABC and/or LCC or initial capability cost are documented in the KDP Decision Memorandum.

The NASA Associate Administrator (AA) is informed on all ABCs for programs requiring an ABC, and projects with an LCC or initial capability cost greater than $250 million. The NASA Administrator is informed on all program and project ABCs with an LCC or initial capability cost greater than $1 billion, and on all Category 1 projects.

NASA uses the term "baseline" in many different contexts. "Baseline" as used in the context of the ABC is different from "baseline" used in a different context such as configuration management. A configuration baseline identifies an approved description of the attributes of a product at a point in time and provides a known configuration to which changes are addressed. While the configuration management context often allows for approval of baseline changes at a project- or program-level configuration control board, baseline changes in the context of the ABC require approval from the Decision Authority.

Section 5.5.3 provides a more detailed discussion of the relationship between the LCC or initial capability cost and ABC. Section 5.5.5 provides a more detailed discussion of processes and procedures for changing the cost plan (replanning) and changing the ABC (rebaselining).

5.5.2 Maturing the Program or Project LCC or Initial Capability Cost and Schedule Estimates during Formulation, and Establishing the Program or Project ABC

At the beginning of Formulation, there is a relative lack of maturity and broad uncertainties regarding the program or project's scope, technical approach, safety objectives, acquisition strategy, implementation schedule, and associated costs. During Formulation, these program or project parameters are developed and matured.

A major objective of the Formulation phase for single-project programs and projects is to develop high-fidelity cost and schedule estimates that enable the program or project to establish a sound, achievable baseline for Implementation at KDP C. The expected states of the program or project LCC or initial capability cost and schedule at KDPs A, B, and C reflect this maturation process. When Earned Value Management (EVM) is used, an additional objective of the Formulation phase is to begin EVM implementation and establish a Performance Measurement Baseline (PMB) in Phase B to enable EVM reporting.

Major objectives of the Formulation phase for loosely coupled and uncoupled programs and tightly coupled programs are to develop credible cost and schedule estimates, supported by a documented Basis of Estimate (BoE), that are consistent with the available funding and schedule profile, and to demonstrate that proposed projects are feasible within available resources. The expected states of the program cost and schedule estimates at KDPs 0 and I reflect this maturation process.

5.5.2.1 Project and Single-Project Program Formulation

The Formulation Agreement is developed during Pre-Phase A. At KDP A, the Formulation Agreement is finalized, approved for Phase A, and preliminary for Phase B. It identifies the activities necessary to characterize the complexity and scope of the project or program, increase understanding of requirements, and identify and mitigate significant risks. It identifies and prioritizes the work required to determine and mitigate high-risk drivers. This work enables the development of high-fidelity LCC or initial capability cost and schedule estimates, or high-fidelity LCC and schedule range estimates (for projects with an LCC or initial capability cost greater than $250 million and single-project programs) at KDP B, and high-fidelity LCC and schedule commitments at KDP C. Single-project programs and projects with a LCC or initial capability cost greater than or equal to $1B establish a high and low value for cost and schedule with the corresponding JCL value at KDP B. (This does not apply to two-step AO missions.)

At KDP A, the LCC or initial capability cost is provided as a preliminary estimate or range estimate. The schedule is risk-informed at the project level and includes a planned date for KDP B and a preliminary date or range for Phase D completion. Internal planned dates for other project milestones may also be included. Once authorized by the Decision Authority, the preliminary LCC or initial capability cost estimate or range estimate, the preliminary schedule range estimate, and the Management Agreement are documented in the KDP A Decision Memorandum. The cost in the Management Agreement is the authorized formulation cost. (Section 5.5.6 provides a more detailed description of the Decision Memorandum and Management Agreement.)

At KDP B, the Formulation Agreement is finalized and approved for Phase B, and a preliminary version of the Program or Project Plan is provided. High-fidelity LCC or initial capability cost and schedule estimates or range estimates are provided. The LCC or initial capability cost estimate or range estimate is risk-informed. The schedule is risk-informed at the subsystem level and includes a preliminary date or range for Phase D completion. A preliminary Integrated Master Schedule (IMS) is also provided.

- Single-project programs with an estimated LCC or initial capability cost under $1 billion and projects with an estimated LCC or initial capability cost greater than $250 million and under $1 billion provide a range of cost and a range for schedule, each range (with confidence levels identified for the low and high values of the range) established by a probabilistic analysis and based on identified resources and associated uncertainties by fiscal year.[100] (Separate analyses of cost and schedule, each with associated confidence levels, meet the requirement. A JCL is not required but may be used.)
- Single-project programs and projects with an estimated LCC or initial capability cost greater than or equal to $1 billion develop a JCL and provide a high and low value for cost and schedule with the corresponding JCL value (e.g., 50 percent, 70 percent).[101] The JCL is informed by a probabilistic analysis of development cost and schedule duration.

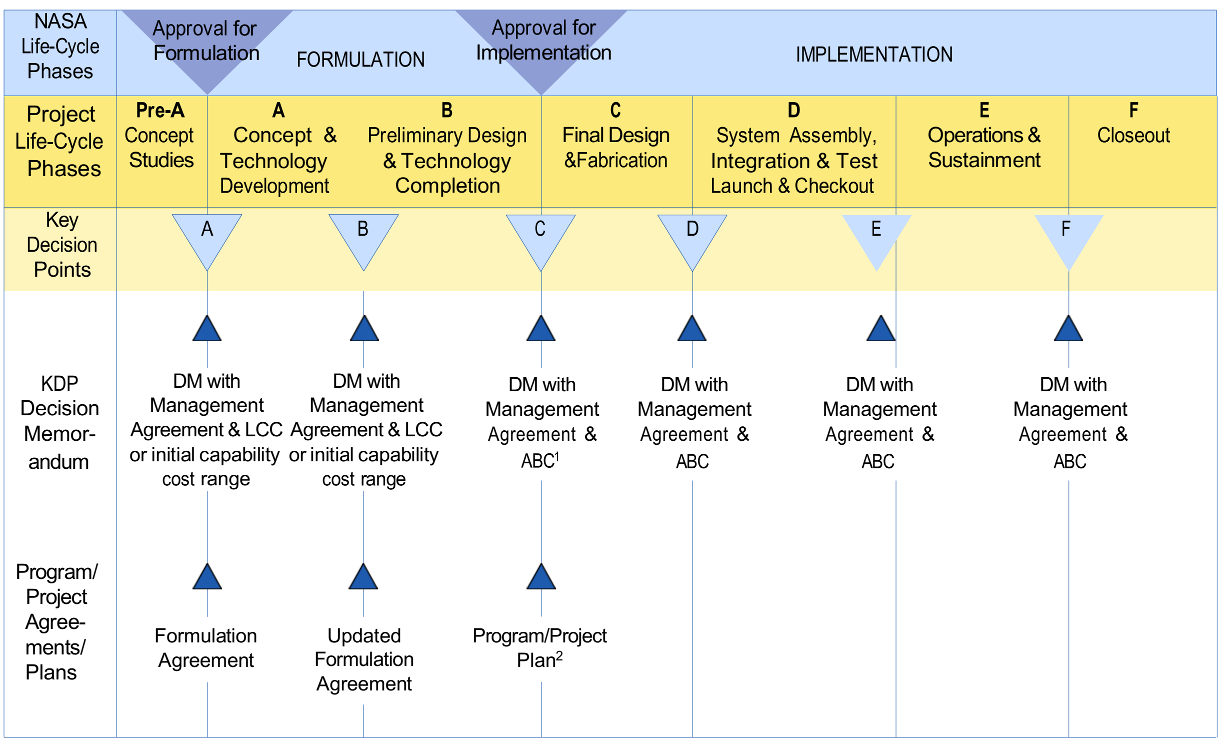
Once authorized by the Decision Authority, the preliminary LCC or initial capability cost and preliminary schedule estimates or range estimates, cost and schedule confidence levels (if required), and the Management Agreement are documented in the KDP B Decision Memorandum. When applicable, the LCC or initial capability cost range estimate serves as

[100] The methodology for JCL analysis at KDP B is not limited to a probabilistic analysis of the coupled cost and schedule specified for KDP C. Other parametric and bivariate methodologies may be applied.
[101] This is not applicable to two-step AO missions due to acquisition down-selection serving as KDP B.

the basis for coordination with the Agency's stakeholders. The cost in the Management Agreement is the authorized Formulation cost.

At KDP C, the Program or Project Plan is finalized and approved. The work identified in the Formulation Agreement has been completed, enabling the program or project to define high-fidelity LCC or initial capability cost and schedule estimates. The LCC or initial capability cost is a risk-informed single number. The schedule is risk-informed and cost-loaded and is no longer provided as a range. An IMS and JCL (if required) are also provided. The fidelity of the LCC or initial capability cost and schedule estimates and the maturity of the program or project planning enable the establishment of the program or project ABC baseline. Once authorized by the Decision Authority, the ABC, including the LCC or initial capability cost and schedule, the JCL (if required), and the Management Agreement are documented in the KDP C Decision Memorandum.

Figure 5-9 illustrates the development, approval, and documentation of Decision Memoranda, Management Agreements, Formulation Agreements, Program or Project Plans, LCC or initial capability cost ranges, the LCC or initial capability cost, and the ABC throughout the life cycle for projects and single-project programs.



[1]Changes in the ABC after this point may require a rebaseline review.
[2]Program/Project Plans are updated as needed during Implementation.

Figure 5-9 Approval of Plans and Baselines

5.5.2.2 Projects and Single-Project Program Implementation

At the Critical Design Review (CDR), single-project programs and projects with as estimated LCC or initial capability cost greater than or equal to $1B update their KDP C JCL and communicate the updated JCL values for the ABC and Management Agreement to the Agency Program Management Council (APMC) for informational purposes.

At KDP D, the LCC or initial capability cost estimate and the IMS are updated. Single-project programs and projects with an estimated LCC or initial capability cost greater than or equal to $1B also update their JCL if current reported development costs have exceeded the development ABC cost by 5 percent or more and document the updated JCL values for the ABC and Management Agreement in the KDP D Decision Memorandum.

At KDP E, the LCC or initial capability cost and the IMS are updated. At KDP F, the LCC and the IMS are updated.

The Agency expects a program or project to meet the commitments it made at KDP C, and for the LCC or initial capability cost and ABC authorized at KDP C to remain the same throughout Implementation. For single-project programs and projects with a LCC or initial capability cost greater than $250 million, development cost or schedule growth that exceeds development cost or schedule in the ABC may trigger external reporting requirements and may require the ABC to be rebaselined. (For more information on rebaseline, see Section 5.5.5.)

5.5.2.3 Loosely Coupled, Uncoupled, and Tightly Coupled Program Formulation and Implementation

During program Formulation, the Program Plan is finalized and approved, initial cost and schedule estimates are developed, and the program develops credible risk-informed program implementation options that fit within the desired schedule and available funding profile. Instead of an LCC range, the cost estimate may be represented merely as an annual funding limit consistent with the budget. The program is not required to develop program cost and schedule confidence levels. If KDP 0 is required, once authorized by the Decision Authority, the initial cost and schedule estimates and the Management Agreement are documented in the KDP 0 Decision Memorandum.

At KDP I, credible cost and schedule estimates are established, supported by a documented Basis of Estimate (BoE). These estimates are consistent with driving assumptions, risks, system requirements, conceptual designs, and the available funding and schedule profile. Tightly coupled programs document their LCC estimate in accordance with the life-cycle scope defined in the Formulation Authorization Document (FAD) or Program Commitment Agreement (PCA), and other parameters in their Decision Memorandum at KDP I and update it at subsequent KDPs. The program demonstrates that proposed projects are feasible within available resources. The program is not required to develop a JCL or an ABC.

Once authorized by the Decision Authority, the cost and schedule estimates and the Management Agreement are documented in the KDP I Decision Memorandum.

During program Implementation at KDP II (and subsequent KDPs), the program provides updated, credible cost and schedule estimates that are supported by a documented BoE and are consistent with driving assumptions, risks, project implementation, and the available funding and schedule profile.

During the Implementation phase, tightly coupled programs continue to have program life-cycle reviews tied to the projects' life-cycle reviews to ensure that program implementation products such as cost and schedule estimates are informed by the analogous project implementation products.

During Formulation and Implementation, the program provides analysis that provides a status of the program's risk posture. This status is presented to the governing PMC as each new project reaches KDP B and C or when a project's ABC is rebaselined. (For more information on rebaseline, see Section 5.5.5.)

5.5.3 Relationships Between the LCC or Initial Capability Cost, ABC, UFE, and Management Agreement

Figure 5-10 illustrates the constituent cost elements of a project's LCC or initial capability cost estimate developed for Formulation and Implementation, and the relationship between the LCC estimate, the ABC, UFE, and the Management Agreement. The constituent elements are analogous for programs.

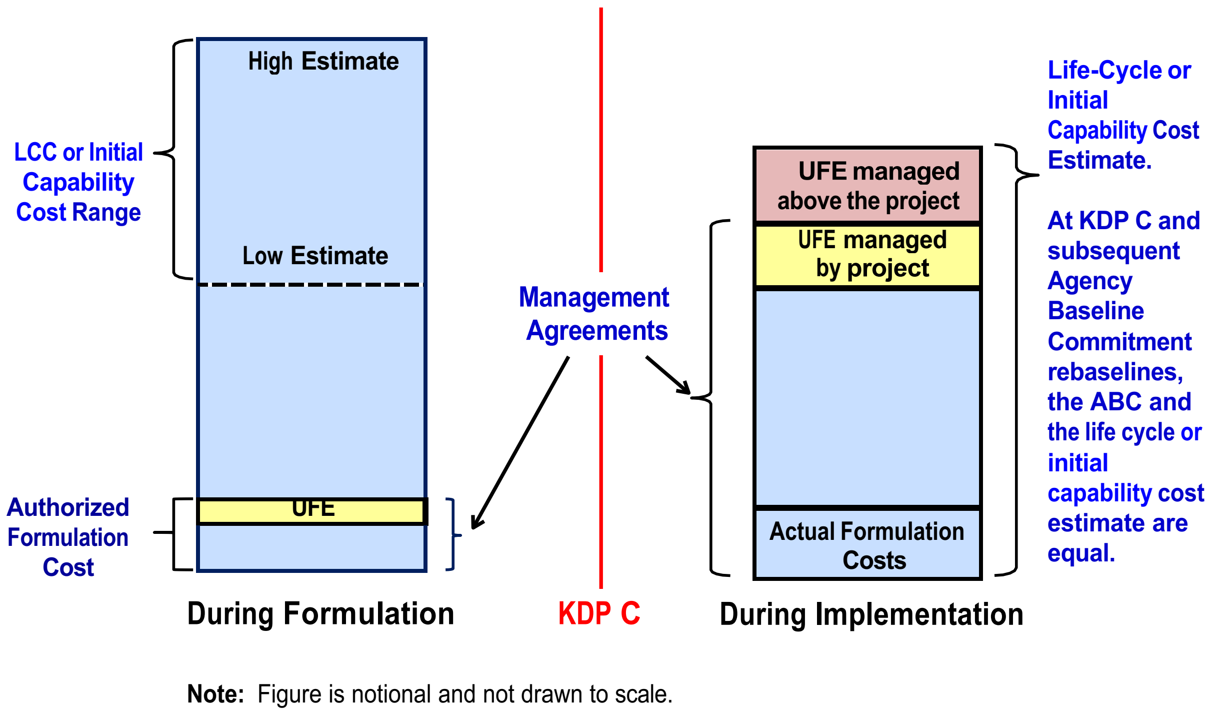


Figure 5-10 Constituent Parts of a Project's Cost Estimate for Formulation and Implementation

The left side of Figure 5-10 shows the constituents of the project's LCC or initial capability cost range estimate during Formulation. The bottom of the left side of the figure shows the authorized Formulation cost,[102] which is the total authorized cost for Formulation activities required to get to KDP C. When the Formulation Agreement is approved at KDP A, this is the authorized cost for Phase A and Phase B. At KDP B, the Formulation cost includes the actual cost for Phase A and the updated cost estimate for Phase B. Since not all costs can be explicitly identified in Formulation, an allowance may be included for UFE, generally at the project level during Formulation. The Formulation cost and the UFE constitute the project's Management Agreement during Formulation. The final constituent is the LCC or initial capability cost range estimate. During Formulation, the project develops both a low and a high estimate for the project's LCC or initial capability cost. The expectation is that the final LCC or initial capability cost will fall within this estimate range.

[102] Formulation cost is defined as the total of all costs incurred while the program or project is in Formulation, even if some of the individual project elements have initiated development activities. Pre-Formulation costs (i.e., Pre–Phase A costs) are not included in Formulation costs.

For projects with an LCC or initial capability cost greater than $250 million, both a low and a high estimate are developed in accordance with Section 5.5.2.1 in recognition of the relative lack of maturity and broad uncertainties regarding the technical approach and associated costs at this early stage of a project. This range is refined as Formulation proceeds, making trades and improving estimates, and helps support the establishment of a sound achievable cost estimate for Implementation at KDP C.

The right side of Figure 5-10 shows the constituents of the project's LCC or initial capability cost estimate during Implementation. At KDP C for Implementation, the Formulation cost is actual cost and is shown at the bottom of the right side. The remaining LCC or initial capability cost is divided between the estimated cost that can be allocated to a specific WBS subelement, and the unallocated future expenses (UFE), which are those costs that are expected to be incurred but cannot yet be allocated to a specific WBS subelement. The UFE is divided into UFE included in the Management Agreement under the project manager's control and UFE managed above the project (e.g., the program and MDAA). The estimated LCC or initial capability cost is equal to the project's Management Agreement plus the UFE managed above the project, and this estimated LCC or initial capability cost becomes the cost part of the ABC at KDP C.

5.5.4 Developing Phase E Cost Estimates

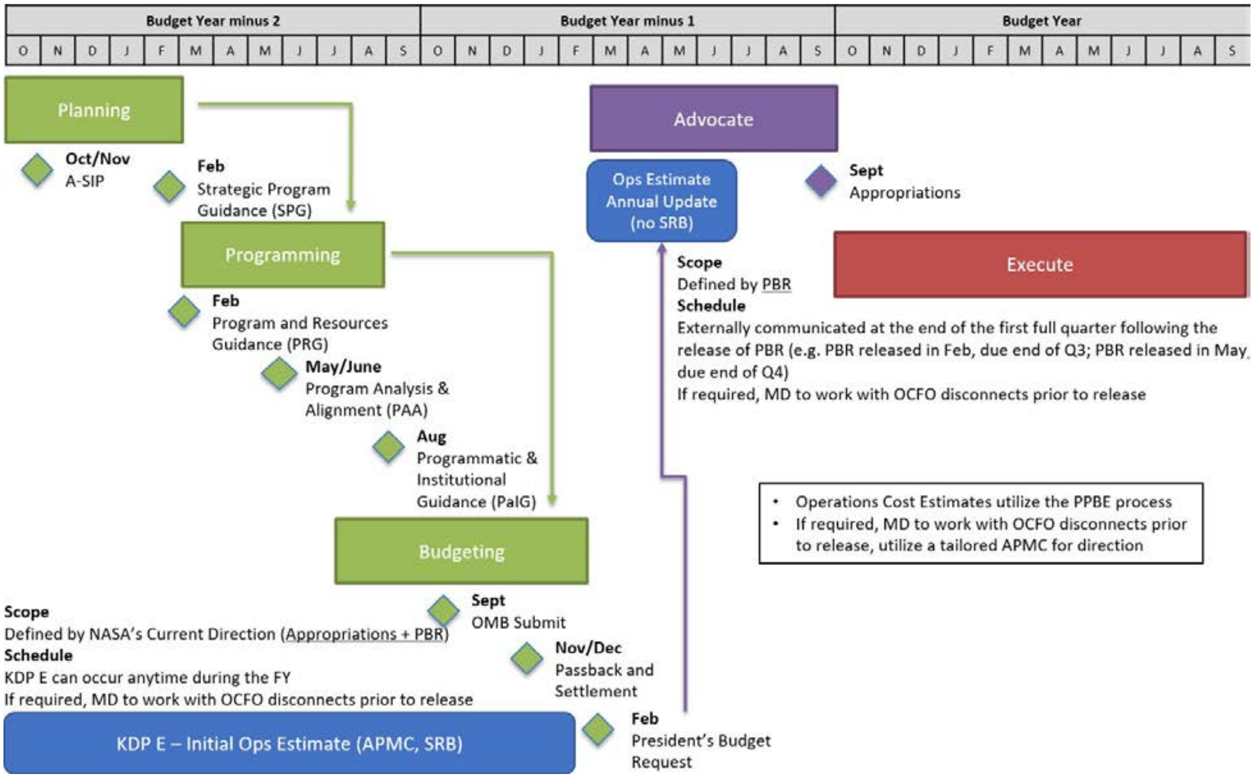
NPR 7120.5F outlines the approach for providing a reasonable cost estimate for single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point. In accordance with NPR 7120.5F, these programs and projects define an initial capability during Phase A. The initial capability and associated cost that establishes an ABC at KDP C includes the operations cost for the first operational mission flight of the initial capability (or as defined as part of the KDP B Review Plan and documented in the KDP B Decision Memorandum).

The Phase E cost estimate for the continuing operations and production is established separately as part of the Operational Readiness Review (ORR) and KDP E for the 5 years after initial capability and subsequently updated and documented annually for the next 5-year period. Upgrades during Phase E that meet the Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purposes of establishing their own development ABC outside the Phase E cost estimate. The program or project Phase E cost estimate is updated to include the production and operations costs associated with the upgrade. Development, production, and operations costs of other (i.e., non-major) upgrades are included in the program or project Phase E cost estimate.

Figure 5-11 provides a graphical representation of the implementation approach for the Phase E cost estimates for these programs and projects in terms of the Planning, Programming, Budgeting, and Execution (PPBE) cycle. The budget year is in reference to the PPBE budget year. In other words, if the current FY is 2021, the PPBE Budget Year is

2023. (See *NPR 9420.1, Budget Formulation* for more information on the PPBE process.) The Initial Phase E cost estimate is developed at KDP E consisting of a 5-year operations and production window with the schedule driven by the program or project and may occur at any time during the PPBE cycle. The scope is defined by NASA's current direction as stated in the current year Appropriations and the President's Budget Request (PBR). As part of the standard KDP E process, if required, the Mission Directorate and/or program or project may need to coordinate with OCFO on potential disconnects. Until Phase E ends, the Phase E cost estimate is updated annually to reflect the estimated cost of the next 5 years of operations and production. These annual updates are documented and communicated in the External Reporting Quarterly at the end of the first full quarter following the release of the PBR to ensure the scope is defined by the most recent PBR. The quarterly template will be updated by the OCFO Strategic Investments Division (SID) and distributed to programs and projects as appropriate. The scope of the annual updates is consistent with the Agency PBR communication. If required, the Mission Directorate and/or program or project may need to coordinate with OCFO on potential disconnects prior to external release of the quarterly data. A tailored APMC may be conducted for direction, if necessary, at the discretion of the NASA AA.[103]

[103] Tailored APMC attendance to include the key principles necessary to discuss and resolve disconnects.



Graphical representation of the updated NPR 7120.5F implementation approach for Phase E cost estimates for programs/projects with continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point in terms of the Planning, Programming, Budgeting, and Execution (PPBE) cycle.

Figure 5-11 Implementation Approach for Phase E Cost Estimates

Programs and projects with a defined Phase E end point are not subject to this implementation approach for Phase E cost estimates.

5.5.5 Replanning and Rebaselining

NASA has established policies and made a series of management improvements to strengthen its baseline performance. For example, it has introduced the JCL and UFE and has established links between NPR 7120.5 requirements and future budgeting decisions. The Agency expects a single-project program or project to meet the commitments it makes at KDP C, and that the LCC or initial capability cost and ABC authorized at these KDPs will remain the same throughout Implementation. Failure to meet these commitments may impact the Agency's portfolio.

Replanning[104] and rebaselining, in the context of this section, are driven by changes in program or project cost parameters. Replanning and rebaselining are differentiated by the

[104] The program or project manager may also replan for many other reasons unrelated to cost that could involve workforce, schedule, or other resources or organization. These other types of replanning are not addressed in this section.

magnitude of the changes in cost parameters, in particular in the program or project's development cost, and by the program or project's life-cycle phase at the time the cost growth is identified. Replanning may occur during any life-cycle phase, including Formulation. Rebaselining occurs only in Implementation after the single-project program or project has baselined the ABC at KDP C.

- Certain changes in program or project cost parameters that do not require changes to the program or project ABC, LCC or initial capability cost, or development cost are not considered cost growth. Replanning is the process by which a program or project implements and documents this type of change. An example of this type of change is reallocation or distribution of UFE to a WBS account, whether that UFE is within or outside of the Management Agreement.
- Cost growth that results in exceeding the ABC after KDP C may necessitate a replan if the development cost growth is between 15 and 30 percent or a rebaseline of the ABC if the development cost growth exceeds 30 percent.

The need to rebaseline is an anomalous situation, and for single-project programs and projects with a LCC or initial capability cost greater than $250 million, is reported to Congress as a breach. In such cases, congressional reauthorization is required to enable the program or project to continue. The Agency, Mission Directorate, Center, and program or project manager need to vigilantly monitor and control the scope and performance to maintain the cost parameters within the ABC. As soon as the potential for a breach is identified, the program or project, Center, Mission Directorate, and Agency need to develop and implement corrective actions to avoid the breach. Periodic reviews (e.g., monthly reviews, a BPR, etc.) have a role in monitoring program and project performance and identifying corrective actions to mitigate the risk of breaching.

Growth in LCC or initial capability cost or development cost[105] may trigger external reporting requirements. For projects with an LCC greater than $75 million, a 10 percent growth in LCC triggers external reporting. Growth of 15 percent of the development cost in the ABC or an extension in schedule of 6 months or more (based on the schedule in the ABC) may also trigger additional external reporting. (See Section 5.12 for more detail on external reporting.)

Figure 5-12 illustrates different scenarios involving changes in project cost parameters that require either replanning or rebaselining. (These scenarios are also applicable to programs.)

- The left-most portion of Figure 5-12 illustrates the original KDP C Decision Memorandum with project UFE within the Management Agreement and UFE held above the project level.

[105] Development cost is defined as the total of all costs from the period beginning with approval to proceed to Implementation (KDP C for projects and single-project programs) through the end of Phase D.

- Going from left to right, the second portion of Figure 5-12 illustrates distribution of UFE within the Management Agreement to WBS accounts. This replan does not require a change to the project's Management Agreement.

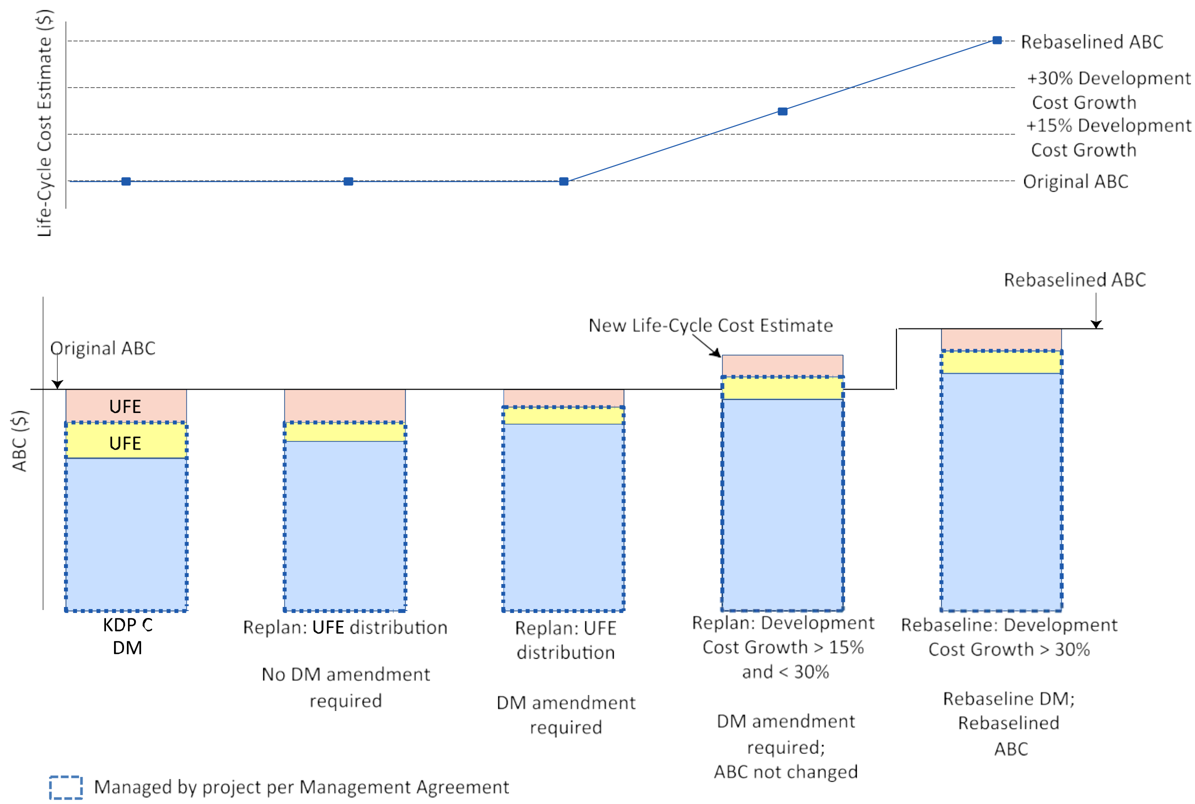


Figure 5-12 Distribution of UFE Versus Cost Growth Scenarios

- The third portion of Figure 5-12 illustrates distribution of UFE held above the project to WBS accounts. This replan requires a change to the project's Management Agreement since responsibility for additional UFE in the ABC has been transferred to the project's control. The change to the project's Management Agreement requires an amendment to the Decision Memorandum. (The Decision Memorandum is amended by the signing parties (including the Decision Authority) between KDPs, if necessary, to reflect changes to the Management Agreement.) The replan Decision Memorandum records any changes to scope, schedule, cost, or cost profile.
- The fourth portion of Figure 5-12 illustrates a scenario in which development cost exceeds the development cost in the ABC by less than 30 percent but more than 15 percent. (See the upper part of the figure.) This increase in development cost is tracked as cost growth, necessitates a replan, and requires a change to the project's Management Agreement since additional funding has been added to the project's control. The change to the project's Management Agreement requires an amendment to

the Decision Memorandum. The replan Decision Memorandum records a new, increased project LCC or initial capability cost, but the project ABC is not increased. The Decision Memorandum also records any changes to scope, schedule, cost, or cost profile.

- The right-most portion of Figure 5-12 illustrates a scenario in which development cost exceeds the development cost in the ABC by more than 30 percent. (See the upper part of the figure.) Cost growth of this magnitude necessitates a rebaseline of the project's ABC. If the project's LCC or initial capability cost is greater than $250 million, congressional reauthorization is also required. The criteria and process for rebaselining an ABC and the associated documentation requirements are described in the next section.

5.5.5.1 Rebaseline Review

Rebaselining the ABC is required under the following circumstances:

- The estimated development cost exceeds the development cost portion of the ABC LCC or initial capability cost by 30 percent or more;
- The NASA Associate Administrator (AA) judges that events external to the Agency make a rebaseline appropriate; or
- The NASA Associate Administrator (AA) judges that the program or project scope defined in the ABC has been changed or a single-project program or project has been interrupted.

ABCs are not rebaselined to reflect cost or schedule growth that does not meet one or more of these criteria.

Rebaseline Reviews are conducted when the ABC needs to be rebaselined. To establish a new baseline, the Decision Authority institutes a review to examine the previously baselined gate products. The Standing Review Board (SRB), at the discretion of the Decision Authority, participates in the review in accordance with NASA SRB procedures. The objective of the review is to determine if the program or project can proceed to a new baseline. The Decision Authority determines the scope and depth of the Rebaseline Review for the extant phase to be reexamined. As part of this process, an independent cost and schedule assessment is performed. When a single-project program (regardless of LCC or initial capability cost) or a project with an estimated LCC or initial capability cost greater than $250M is rebaselined, a JCL is also calculated and evaluated as a part of the rebaselining approval process. The results of the Rebaseline Review are documented and presented to the Decision Authority. If the rebaseline is approved by the Decision Authority, a new Decision Memorandum records the new ABC and any changes to project scope, schedule, LCC or initial capability cost, JCL, cost profile, and Management Agreement.

5.5.6 Decision Authority

The Decision Authority is the Agency individual who is responsible for making the KDP determination on whether and how a program or project proceeds through the life cycle and for authorizing the key program cost, schedule, and content parameters that govern the remaining life-cycle activities, including, for single-project programs and for projects, the ABC baseline at KDP C.

For programs and Category 1 projects, the Decision Authority is the NASA Associate Administrator (AA). The NASA AA may delegate this authority to the Mission Directorate Associate Administrator (MDAA) for Category 1 projects. For Category 2 and 3 projects, the Decision Authority is the MDAA. (See Chapter 4 for more information on categorization.) The MDAA may delegate to a Center Director Decision Authority to determine whether Category 2 and 3 projects may proceed through KDPs into the next phase of the life cycle. However, the MDAA retains authority for all program-level requirements, funding limits, launch dates, and any external commitments.

The Decision Authority is the individual authorized by the Agency to make important decisions on programs and projects under his or her purview. The Decision Authority makes the KDP decision by considering a number of factors, including technical maturity; continued relevance to Agency strategic goals; adequacy of cost and schedule estimates; associated probabilities of meeting those estimates (confidence levels); continued affordability with respect to the Agency's resources; maturity and the readiness to proceed to the next phase; and remaining project risk (safety, cost, schedule, technical, management, and programmatic). The NASA AA signs the Decision Memorandum as the Decision Authority for programs and Category 1 projects at the KDP. The MDAA signs the Decision Memorandum as the Decision Authority for Category 2 and 3 projects at the KDP. This signature signifies that, as the approving official, the Decision Authority has been made aware of the technical and programmatic issues within the program or project, approves the mitigation strategies as presented or with noted changes requested, and accepts technical and programmatic risk on behalf of the Agency.

The limitation on delegation by the MDAA to a Center Director is necessary to preserve the separation of the roles of the Programmatic and Institutional Authorities as required by NASA Governance.

All delegations are documented and approved in the Program Commitment Agreement (PCA) or Program Plan, depending on which Decision Authority is delegating.

The Decision Authority's role during the life cycle of a program and project is covered in more detail in NPR 7120.5, Section 2.3, Program and Project Oversight and Approval and in Chapters 3 and 4 of this handbook.

5.5.7 Decision Memorandum

The Decision Memorandum and associated documentation provide a summary of key decisions made by the Decision Authority at a KDP, or, as necessary, in between KDPs. Its purpose is to ensure that major program or project decisions and their basis are clearly documented and become part of the retrievable records. The Decision Memorandum also provides the basis for NASA to meet various internal and external cost and schedule tracking and reporting requirements.

When the Decision Authority approves a program or project's entry into the next phase of its life cycle at a KDP, the Decision Memorandum documents this approval, the key program or project cost, schedule, and content parameters authorized by the Decision Authority that govern the remaining life-cycle activities, and any actions resulting from the KDP. These parameters include the LCC or initial capability cost and schedule estimates, or when applicable, cost and schedule range estimates, cost and schedule confidence levels, and the JCL. The UFE and schedule margin held by the project or program and the UFE and schedule margin held above the project or program level are also included. The Decision Memorandum also describes the constraints and parameters within which the Agency and the program or project manager will operate in the next phase of the life cycle and the extent to which changes in plans may be made without additional approval. If the Decision Authority determines that the program or project is not ready to proceed to the next life-cycle phase, the Decision Memorandum documents the Decision Authority's direction concerning the way forward.

The Decision Memorandum documents two key agreements: the Management Agreement and, when applicable, the Agency Baseline Commitment (ABC).

The Management Agreement is documented in the Decision Memorandum at every KDP. It defines the parameters and authorities over which the program or project manager has management control. The Management Agreement includes the schedule and cost (by year) at which the Agency agrees that funding[106] will be made available to the program or project and at which the program or project manager and the Center agree to deliver the content defined in the Program or Project Plan. UFE and schedule margin available within the Management Agreement are also documented. The Management Agreement should be viewed as a contract between the Agency and the program or project manager. Both the Agency and the program or project manager are accountable for compliance with the terms of the agreement. The Management Agreement may be changed between KDPs as the program or project matures and in response to internal and external events. This requires an amendment to the Decision Memorandum.

The ABC is documented in the Decision Memorandum at approval for Implementation for projects and single-project programs (KDP C) and subsequent KDPs. The UFE and schedule margin held above the project by the program and/or the Mission Directorate and, for

[106] Agency policy does not permit Mission Directorates to hold back portions of these amounts.

programs, the UFE and schedule margin held above the program by the Mission Directorate are documented in the Decision Memorandum and constitute the difference between the Management Agreement and the ABC. (An example of schedule margin held above the project level would be a Launch Readiness Date (LRD) in the ABC that is later than the LRD in the Management Agreement. This provides the Agency with flexibility to adjust launch manifests, to adapt to changing priorities, or to mitigate unanticipated technical issues.) During planning and execution of the program or project as risks are realized, the UFE or schedule margin may be released to the program or project through a change to the Management Agreement, which requires amending the Decision Memorandum.

The Decision Memorandum may be amended by the signing parties, including the Decision Authority, between KDPs to reflect changes to the Management Agreement, Life-Cycle Cost Estimate (LCCE), or ABC. This includes changes in the estimated cost or schedule associated with the approved scope, changes in the budget or funding profile that may drive a change in schedule or cost, or a change to the program or project scope.[107] Amendments to the Decision Memorandum also identify any significant changes in program or project risk. The NASA Associate Administrator (AA) is notified of Decision Memorandum amendments that reflect a growth in the program or project LCC or initial capability cost, development cost, or schedule estimate beyond the ABC for any programs and projects that are subject to external reporting.

Section 5.5.7.1 describes the content required in the Decision Memorandum and Section 5.5.7.2 describes the process for preparing and completing the Decision Memorandum.

5.5.7.1 Decision Memorandum Contents

The content prescribed by Decision Memorandum templates supports compliance with Decision Memorandum requirements in NPR 7120.5 Section 2.4:

- **Summary.** Which program or project, which KDP, which governing PMC, date of meeting, and which governing NPR.
- **Decision.** Whether the program or project is approved, conditionally approved, or disapproved to proceed to the next phase and any specific direction to the program or project.
- **Technical content.** Content as described in the Formulation Authorization Document (FAD), the Program or Project Plan, and/or the KDP briefings, as modified by actions issued at the KDP.
- **Cost and Schedule Tables.** Approved cost and schedule estimates or range estimates, ABC, if applicable, cost and schedule within the Management Agreement, cost phased by year, and, if applicable, any associated confidence levels (cost and schedule) or JCL.

[107] "Project scope" encompasses the approved programmatic content and deliverables.

- **Key Assumptions.** Supporting data and information to support the basis of estimates, including but not limited to applicable definitions, methodology, tools, scope, allowances, exclusions, and any tailoring deviations.
- **Actions.** Any actions resulting from the KDP.
- **Signatures.** Concurrence signatures of NASA officials responsible for relevant policies and requirements; approval signature of the Decision Authority.

Supporting Datasheet. This document provides a supporting breakout of the cost and schedule information in the Decision Memorandum as well as key contracts. It ensures that everyone is on the same page at the start of each phase and provides a basis for tracking during the phase. It also provides a means of providing Congress and OMB with correct, up-to-date cost information as required:

- **Cost.** The cost plan by year, by phase, and by WBS breakout is provided, as well as project- and Mission Directorate-held UFE by year. These tables also break out any Construction of Facilities (CoF) costs, which are part of the project cost estimate but are reported in a separate programmatic CoF budget to Congress.
- **Schedule.** Key NPR 7120.5F schedule milestones along with key procurement, delivery, integration, and/or testing milestones.
- **Contract.** Provides the current value of key contracts and contract options.

Note 1: Decision Memorandum datasheets record program or project costs associated with Pre-Phase A and extended operations to maintain traceability to the financial records. These costs are not included in the program or project LCC estimate.

Note 2: Construction of Facilities (CoF) cost is usually included by projects in the most relevant WBS element. The Decision Memorandum datasheet, however, provides for breakout of CoF costs because, while CoF *is* included in the project's LCC estimate, it *is not* included in the project's budget as presented to Congress.

Baseline Report (for projects with LCC greater than $250 million). This is a narrative that provides a high-level description of the approved Project Plan. It is simply an update of the project pages in the most recent NASA budget to Congress (a link to which is found at the bottom of every NASA web page). If the project has not been featured in the budget (projects are typically not featured until they reach KDP B), the format for the Baseline Report is the same as the budget pages. In these cases, the Baseline Report serves as the basis for the project pages in future budgets.

5.5.7.2 Preparing and Completing the Decision Memorandum

The Decision Memorandum process and supporting templates are managed by the Office of the Chief Financial Officer (OCFO) Strategic Investments Division (SID). The SID point of contact assists the Mission Directorate's Program Executive (PE) or equivalent in navigating this process. The Decision Memorandum information required varies for each

KDP reflecting the changing requirements for each KDP. Current templates may be found at NASA's OCFO community of practice site (https://max.omb.gov/community/pages/viewpage.action?pageId=646907686).

The Decision Memorandum templates are designed to support an array of NASA policy requirements and management strategies with respect to program or project life cycles, planning and replanning, and baselining; Work Breakdown Structure (WBS); cost estimation; cost and schedule confidence levels, if applicable, and UFE. In addition, the datasheet facilitates the comparison of cost estimates with project budget and financial systems.

Decision Memorandum content includes very high-level summaries of the detailed Program or Project Plan (including the schedule and cost plan) assessed during the life-cycle review preceding each KDP. The PE or equivalent is responsible for preparing and updating the Decision Memorandum and obtaining signatures. For programs and projects that do not have a PE, the Mission Directorate identifies the person responsible for developing and coordinating the Decision Memorandum. Even though it is not signed until reviewed by the governing Program Management Council (PMC), preparation of the Decision Memorandum and supporting materials is initiated at the beginning of the life-cycle review and KDP process:

- While preparing for the LCR, the PE meets with SID to determine whether any desired tailoring of the templates can be approved.
- The PE completes the Decision Memorandum template summarizing information contained in the Program or Project Plan. The information used is consistent with what is provided to the SRB (or other reviewing body) prior to the LCR leading up to the KDP. The PE provides the draft Decision Memorandum to the project, program, SRB, and SID.
- The PE updates the Decision Memorandum draft, if necessary, to reflect any changes to the Program or Project Plan, schedule, cost estimate, and if applicable, confidence levels as a result of the LCR or ensuing management briefings.
- The PE shares the updated Decision Memorandum draft with the signatories or their Points of Contact at least two weeks prior to the governing PMC meeting and addresses any questions individual signatories may have. This advanced discussion facilitates signatory agreement on the Decision Memorandum at the governing PMC meeting.

The PE provides the completed Decision Memorandum materials to the governing PMC Executive Secretary along with other materials for the KDP meeting. The Decision Memorandum is nominally signed at the end of the governing PMC meeting. Some changes to the Decision Memorandum may be required during the meeting based on the discussions that take place at the meeting. If required changes are extensive or additional discussion and/or information is needed before the members of the governing PMC sign, the PE makes the necessary changes, pre-coordinates the changes with the signatory Points of Contact, and acquires the Decision Memorandum signatures after the meeting. If the

Decision Authority determines that the program or project is not ready to proceed to the next phase, the Decision Memorandum documents the Decision Authority's direction concerning the program or project's next steps. The signed document is provided to SID to be archived.

5.5.7.3 Decision Memorandum Signatories and Their Commitments

The **NASA Associate Administrator** (AA) signs the Decision Memorandum in the case of programs and Category 1 projects as the Decision Authority approving the Program or Project Plan at the specified KDP. This signature signifies that the approving official has been made aware of the technical and programmatic issues within the program or project, approves the mitigation strategies as presented or with noted changes requested, and accepts technical and programmatic risk on behalf of the Agency.

The **Mission Directorate AA** (MDAA) signs the Decision Memorandum in the case of Category 2 and 3 projects as the Decision Authority approving the Project Plan at the specified KDP. In the case of a Category 2 project, this signature signifies that the approving official has been made aware of the technical and programmatic issues within the program or project, accepts the mitigation strategies as presented or with noted changes requested, and accepts technical and programmatic risk on behalf of the Mission Directorate and Agency.

In all cases, the MDAA signs the Decision Memorandum to certify that the proposed program or project satisfies the requirements of the underlying mission and can execute the mission within the resources provided; that independent analysis of programmatic risk has been conducted and used in a fashion consistent with Agency policies, and that this analysis was presented and used in a way that informed the Agency decision process; and to commit funding for the mission at the proposed levels in all future budgeting exercises.

The **Chief Engineer** signs the Decision Memorandum to certify that the programmatic and engineering policies and standards of the Agency have been followed in bringing the program or project to the governing PMC and that the technical and programmatic risk are acceptable.

The **Chief, Office of Safety and Mission Assurance** (OSMA) signs the Decision Memorandum to certify that all Agency policies and standards related to safety and mission assurance have been followed by the program or project, and that the residual safety and mission success risks are acceptable.

If the program or project involves areas and issues under the auspices of the Health and Medical Technical Authority (HMTA), the **Chief Health and Medical Officer** (CHMO) signs the Decision Memorandum to certify that all Agency policies and standards related to human health and medical care have been followed by the program or project and that the residual health risk is acceptable.

The **Chief Financial Officer** signs the Decision Memorandum to certify that any description of past funding, present obligations, commitments on budgets, schedules, LCC estimates, and JCL estimates provided to entities outside of NASA (e.g., OMB, Congress) are accurate and consistent with previous commitments; that the decision is clear and unambiguous with respect to the financial commitment being made; and that it complies with all authorization and appropriation law and other external reporting requirements.

The **host Center Director** signature reflects a commitment to provide the necessary institutional staffing and resources to make the program or project successful. This signature certifies that the appropriate Agency and Center policies, requirements, procedures, practices, and technical standards are in place and are being met. Further, this signature reflects concurrence with all aspects of the plan approved at the governing PMC. The Center Director's signature also represents the consent to accept residual institutional safety risk in accordance with established Center procedures and policies. In the event the host Center is not the sole implementing Center, the implementing Center Director(s) signature(s) conveys consent to accept residual institutional safety risk in accordance with all participating Centers' procedures and policies.

If the mission is one led by a **Principal Investigator** (PI), the PI signs the Decision Memorandum certifying that the proposed mission concept and mission systems will meet the Level 1 Requirements. This signature also represents a commitment to execute within the approved cost and schedule given the identified risks.

The **program and project manager's** signatures represent a commitment to execute the plan approved at the governing PMC.

5.6 Cost and Schedule Analysis Work to Support Decisions

5.6.1 Cost and Schedule Estimates

Cost and schedule estimates have an essential role in program and project management and must have a sound documented basis. All programs and projects develop cost estimates and planned schedules for the work to be performed in the current and following life-cycle phases. As part of developing these estimates, the program or project documents the Basis of Estimate (BoE) in retrievable program or project records. The BoE documents the ground rules and assumptions and drivers used in cost and schedule estimate development and includes applicable model inputs and outputs, rationale or justification for analogies, and details supporting bottom-up cost and schedule estimates. The BoE is contained in material available to the Standing Review Board (SRB) and management as part of the life-cycle review and Key Decision Point (KDP) process. Good BoEs are well-documented, comprehensive, accurate, credible, traceable, and executable. Sufficient information on how the estimate was developed needs to be included to allow review team members, including independent cost analysts, to reproduce the estimate if required. Types of information can include estimating techniques (e.g., bottom-up, vendor quotes, analogies, parametric cost models), data sources, inflation, labor rates, new facilities costs, operations costs, sunk costs, etc. (For additional information, see *NASA/SP-2016-3424, NASA Project Planning and Control Handbook.*[108])

Program and project planning must be consistent with:

- Coverage of all costs associated with obtaining a specific product or service, including:
  - Costs such as institutional funding requirements, technology investments, and multi-Center operations;
  - Costs associated with Agency constraints such as workforce allocations at Centers; and
  - Costs associated with the efficient use of Agency capital investments, facilities, and workforce.
- Resources projected to be available in future years based on the Agency's strategic resource planning. This includes the periodic portfolio reviews and resulting direction and the NASA budget process (i.e., Planning, Programming, Budgeting, and Execution (PPBE)).
- Cost and schedule risk analysis established by a probabilistic analysis of the Project Plan and based on identified resources, risks, and associated uncertainties by fiscal year. This includes the Joint Cost and Schedule Confidence Level (JCL) and separate risk analyses for either cost or schedule. (See NPR 7120.5F Sections 2.4.3.1 to 2.4.3.5 for the specific probabilistic analysis required at Key Decision Points (KDPs).)

[108] https://www.nasa.gov/content/project-planning-control-handbook

- Decisions and direction documented in the program or project's approved Decision Memorandum.
- Unallocated Future Expenses (UFE) as approved in the program or project's Management Agreement and funded schedule margin.

  Margins are the allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, or memory) to account for uncertainties and risks. Margins are allocated in the Formulation process based on assessments of risks and are typically consumed as the program or project proceeds through the life cycle.

- Evaluation of suppliers' qualifications and past performance and the realism embodied in the suppliers' cost and schedule proposals.
- Independent estimates, with an understanding of any differences, when independent estimates are required by the Decision Authority. This includes Independent Cost Estimates (ICEs) and Independent Schedule Estimates (ISEs).

5.6.1.1 Cost by Year

Federal agencies have a unique three-step process for spending money with funds having to be appropriated and obligated before being spent. Cost estimates are based on the content to be completed and therefore paid for in each fiscal year. Cost estimates are captured in the Cost Analysis Data Requirement (CADRe) and other project LCR documents based on the expected year of expenditure. The Decision Memorandum and datasheet, however, are designed to ensure that the cost estimate is phased based on when NASA needs to request New Obligation Authority (NOA) so that there is time to get the funds obligated before they are spent. This will typically require a slight shift to the left of the cost profile (Figure 5-13) in the Decision Memorandum compared to the CADRe and other cost estimation profiles.

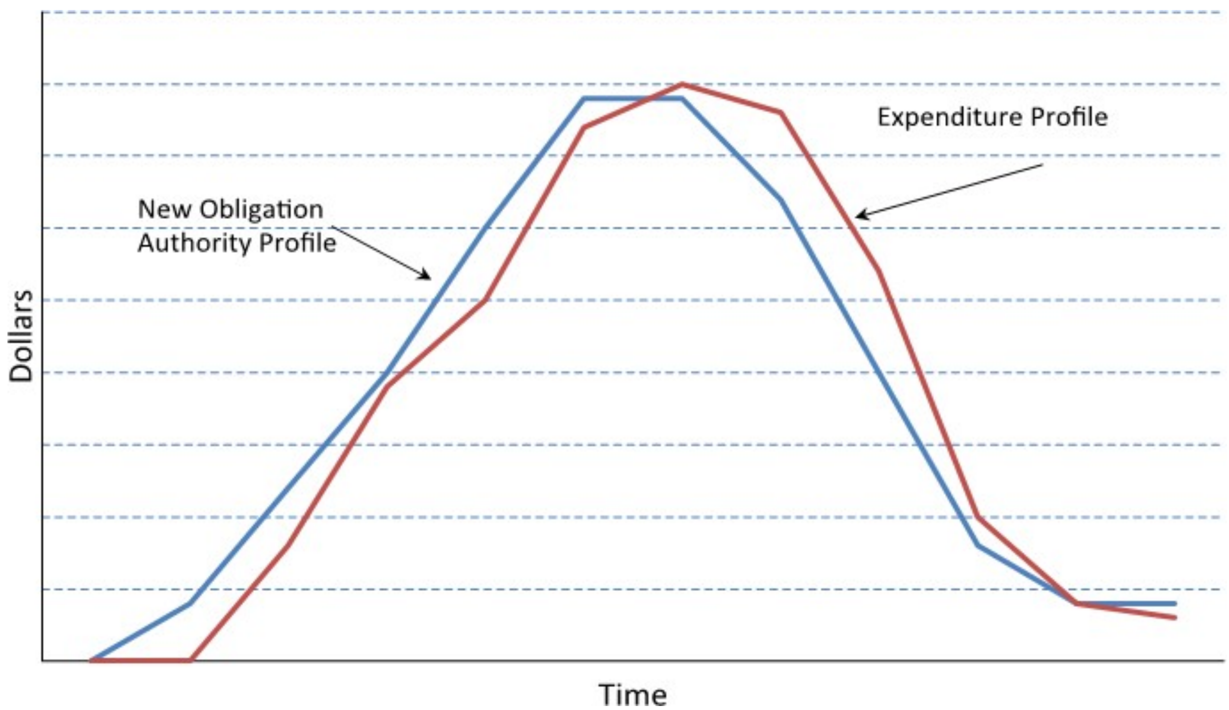


Figure 5-13 Example NOA Profile in a Decision Memorandum Compared to the CADRe and Other Expenditure Profiles

5.6.1.2 CADRe (Cost Analysis Data Requirement)

5.6.1.2.1 CADRe Introduction

The Cost Analysis Data Requirement (CADRe) is a formal project document that describes the programmatic, technical, life-cycle cost, and risk information of a project. CADRe is NASA's unique response to the need to improve cost and schedule estimates during the Formulation and Implementation process by providing a common description of a project at a given point in time. The CADRe is prepared by NASA Headquarters' OCFO Strategic Investment Division (SID) using existing project data prepared during the life-cycle review. By capturing key information, the CADRe tracks and explains changes that occur from one milestone to the next, which helps the project manager record all the internal and external events that occurred during the project in an Agency document. The CADRe is not used to assess or evaluate the current project, as it only serves to capture data needed to help plan future projects and develop realistic cost and schedule baselines.

5.6.1.2.2 CADRe Purpose

The CADRe initiative satisfies the foundational cost-estimating need of providing historical cost data that are vital to performing estimates for future missions. The CADRe delivers information to support programmatic analyses including foundational technical information to enable estimators to better predict the cost and schedule of future analogous projects. This coordinated effort ensures important data are captured across all major flight projects at NASA.

5.6.1.2.3 CADRe Secure Location and Limited Distribution

Completed CADRes are available on the One NASA Cost Engineering (ONCE) database,[109] a secure, web-based application providing user authentication through the NASA Account Management System (NAMS) for civil servants and support contractors with current NASA identities. ONCE allows for easy retrieval and fast analysis of CADRe data across multiple projects and milestone events. The utilization of CADRe data helps analysts examine important project attributes and enables projects to develop improved programmatic estimates and to help deliver projects within cost, schedule, and technical margins.

CADRes for any mission that has not yet launched (referred to as Pre-Launch CADRes) are only viewable by HQs and the lead Center. Once a mission completes development and is in operations, the development milestone CADRes (SRR, PDR, CDR, SIR, LRD) are visible to NASA civil servants and support contractors with current NASA ID. Requests from prime contractors, universities, companies, students, foreign nationals, and other government entities are considered "External Requests" and are subject to a more rigorous leadership approval process before being granted access. Access to ONCE is tightly controlled by NAMS and is subject to regular security reviews. Any individual lacking current NASA credentials will be unable to access ONCE.

5.6.1.2.4 CADRe Composition

Composed of three parts, the CADRe captures detailed programmatic, technical, and cost data using standardized templates provided by SID. The document is prepared six times during the life cycle of a project at major milestones (SRR, PDR, CDR, SIR, launch, End of Mission (EOM)). See Figure 5-14.

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[109]To access the ONCE database, go to the ONCE website www.oncedata.com and click on the "request access" link on that page. The key requirement for access is to have a NASA identity in NASA's IDMAX system.

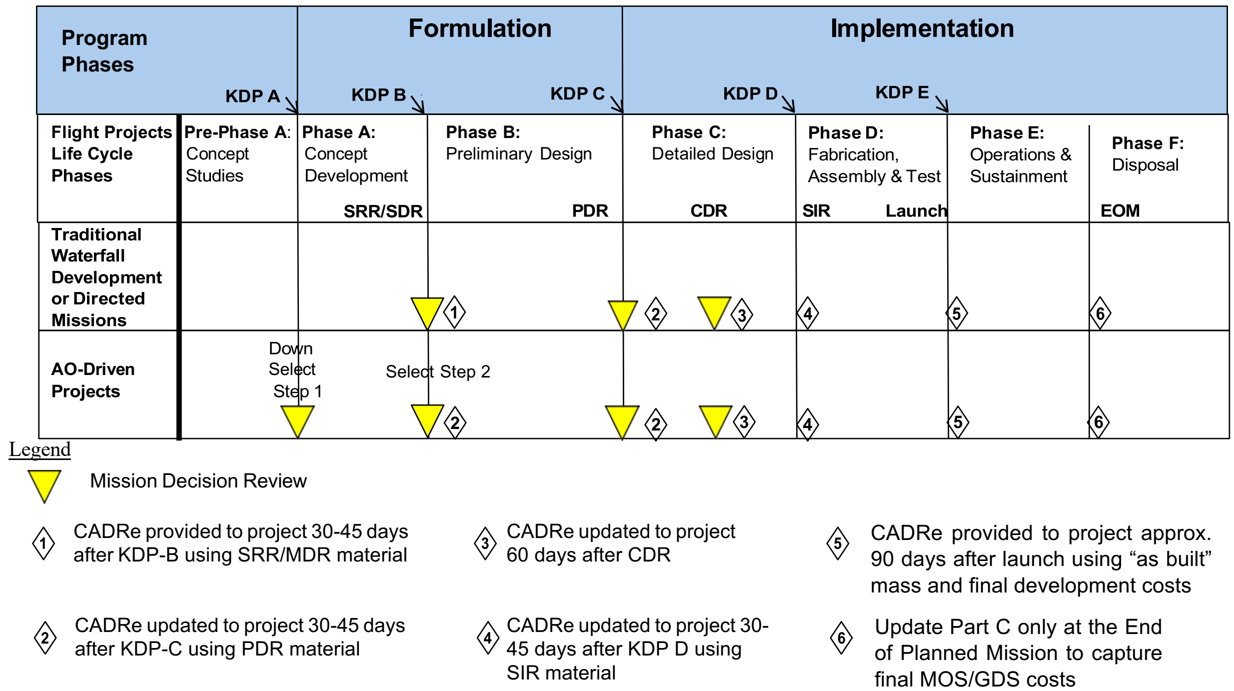


Figure 5-14 Frequency of CADRe Submissions

The three parts of a CADRe are:

- **PART A** describes a NASA project at each milestone (SRR, PDR, CDR, SIR, launch, and EOM) and describes significant changes that have occurred. This part includes essential subsystem descriptions, block diagrams, and heritage assumptions needed for cost analysis purposes. The templates for all three parts for space flight missions can be found at: https://www.nasa.gov/offices/ocfo/functions/models_tools/CADRe_ONCE.html
- **PART B** captures in an Excel Workbook the key technical parameters that are considered to drive costs such as mass, power, data rates, and software metrics. The formats of this template follow standard NASA terminology such as Current Best Estimates and Current Best Estimate Plus Contingency.
- **PART C** contains the Life Cycle Cost Estimate (LCCE), which is the total actual costs to date as well as the estimate to complete the project. The project's LCCE is captured in an Excel Workbook with the costs shown in two separate tabs in the workbook. The first tab shows the native project Work Breakdown Structure (WBS) and the second tab shows the NASA Standard Cost Estimating WBS. Part C also has additional tabs that show the Project Schedule, Project Risks, WBS Dictionary, and Ground Rules and Assumptions.

5.6.1.2.5 CADRe Ownership

The CADRe is a project-owned document and is approved by the project manager; therefore, it does not include any independent assessments, evaluations, or opinions about the project. It simply records the known configuration at specific milestones. Although it is a project requirement, SID provides the necessary funding and support to prepare the document on behalf of the project, using existing project documentation prepared during the life-cycle review process. In the few cases where a CADRe is prepared for a previously launched mission, SID will determine whether there are enough data. If there are sufficient data, SID will prepare a single launch or EOM CADRe. These CADRes are also useful for historical benchmarking and understanding cost, schedule, and technical trends over time.

5.6.1.2.6 CADRe Development Process

1. After a kickoff with the project manager, the SID CADRe team collects the relevant project documentation as it matures leading up to the life-cycle review milestone.
2. Concurrent with the life-cycle review process, the SID CADRe team prepares the CADRe using the most recently available data and existing project documentation that provides descriptive information, mass statements, power statements, schedules, risk list, and life-cycle cost estimates as well as any other technical parameters that tend to drive costs.
3. The SID CADRe team delivers the document for the project manager's review and signature shortly after the capstone KDP briefing, such as the APMC or DPMC, when the cost and schedule positions are finalized.
4. Project managers are expected to review and approve their CADRes within 1-2 month(s) from the time of receiving the initial version.

5.6.1.2.7 CADRe Utilization

Since CADRes represent snapshots of a project at successive key milestones, the ONCE database captures all the changes that occurred in previous projects and their associated cost and schedule impacts. The resulting information provides enhanced insight and management of historical cost and technical data, which helps advance costing practices and analyses across the Agency. With a large historical archive of project data, it is possible to determine trends that can be very useful to project managers. For example:

- Cost engineers use CADRe to estimate the cost of future systems based on known technical parameters such as mass and power. The CADRe data are also used to help the Science Office for Mission Assessments (SOMA) evaluators assess Announcement of Opportunity (AO) proposals for new missions.
- System engineers use CADRe information to perform mass architecture trades early in concept design by using time-tagged mass data on all major NASA projects.

- CADRe data can be used to conduct research to help understand cost and schedule trends and patterns over time and across projects. The results of this research help NASA analysts, including review boards and proposal teams, better plan for cost and schedule risks.

These are just a few examples of how CADRe data can be used to help program and project managers. The use of CADRe has captured data of key historical missions looking back approximately 16 years, where the data were available, and has supported several NASA studies. As the number of CADRes continue to grow, NASA can perform more robust analyses resulting in more advanced costing practices and tools.

5.6.2 Probabilistic Analysis of Cost and Schedule

Probabilistic analysis of cost and/or schedule estimates is required for single-project programs (regardless of life-cycle cost or initial capability cost) and projects with an LCCE or initial capability cost estimate greater than $250 million. When the probabilistic analysis is developed for only one parameter (i.e., cost or schedule) or when generally referring to a probabilistic assessment of the level of confidence of achieving a specific goal, the analysis is referred to merely as a "confidence level." When the probabilistic analysis is developed to measure the likelihood of meeting both cost and schedule, the analysis is referred to as a joint cost and schedule confidence level (JCL). A JCL is defined as the probability that actual cost and schedule will be equal to or less than the targeted cost and schedule. For example, a 70 percent JCL is the point on the joint cost and schedule probability distribution curve where there is a 70 percent probability that the project or program will be completed at or lower than the estimated cost and on or before the estimated schedule. (See *NASA Cost Estimating Handbook* at https://www.nasa.gov/content/cost-estimating-handbook.)

5.7 Realistic Cost and Schedule Estimating and the JCL

A Joint Cost and Schedule Confidence Level (JCL) is a quantitative probability statement about the ability of a program or project to meet its cost and schedule targets. Put simply, the JCL is the probability that a project or program's actual cost will be equal to or less than the targeted cost *and* its schedule will be equal to or less than the targeted schedule date. The process of developing a JCL requires that the program or project combine its cost, schedule, and risk into a complete, integrated quantitative picture that helps the decision makers understand the program or project's prospects for success in achieving its cost and schedule goals. A JCL is more than just an output confidence level; it is a systematic framework process for integrating a program or project's cost, schedule, and risk artifacts. The technique identifies specific risks and allows decision makers to better understand those risks and the context for the program or project's phased funding requirements. (For additional information see *NASA/SP-2016-3424, NASA Project Planning and Control Handbook.*[110])

More than just a policy requirement, the JCL is also a valuable management tool that helps enforce some best practices of program and project management, planning, and control as well as potentially enhancing vital communication among various stakeholders.

The joint cost and schedule confidence level (JCL) is the product of a probabilistic analysis of the coupled cost and schedule to measure the likelihood of completing all remaining work at or below the budgeted levels and on or before the planned completion of the development phase. The JCL is required at KDP C for all single-project programs (regardless of Life-Cycle Cost (LCC) or initial capability cost) and for all projects with a LCC or initial capability cost greater than $250 million. A JCL is also required for these single-project programs and projects in the event of a rebaseline during the Implementation phase. For single-project programs and projects with LCC or initial capability cost ≥ $1B, a JCL is also required at KDP B and Critical Design Review (CDR), and at KDP D if current reported development costs have exceeded the development Agency Baseline Commitment (ABC) cost by 5 percent or more. The JCL calculation includes consideration of the risk associated with all elements, whether they are funded from appropriations or managed outside of the program or project. JCL calculations include content from the milestone at which the JCL is calculated through the completion of Phase D activities. Per NPR 7120.5, at KDP B, if applicable, and KDP C, Mission Directorates plan and budget single-project programs (regardless of LCC or initial capability cost) and projects with an estimated LCC or initial capability cost greater than $250 million based on a 70 percent JCL or as approved by the Decision Authority. At KDP C, Mission Directorates ensure that funding for single-project programs and these projects is consistent with the Management Agreement and in no case less than the equivalent of a 50 percent JCL or as approved by the Decision Authority.

110 https://www.nasa.gov/content/project-planning-control-handbook

5.7.1 Overview of Policy and JCL Methodologies

Currently, NASA uses a variety of cost analysis methodologies to formulate, plan, and implement single-project programs and projects. The methodology required depends on the life-cycle phase and the estimated LCC or initial capability cost of the single-project program or project.

5.7.1.1 Overview of Policy

At KDP B, single-project programs with an estimated LCC or initial capability cost under $1B and projects with an estimated LCC or initial capability cost greater than $250M and under $1B are required to provide a range of cost and a range for schedule, each range (with confidence levels identified for the low and high values of the range) established by a probabilistic analysis and based on identified resources and associated uncertainties by fiscal year. Separate analyses of cost and schedule, each with associated confidence levels, meet the requirement. A JCL is not required but may be used.

At KDP B, single-project programs and projects with an estimated LCC or initial capability cost greater than or equal to $1B establish a high and low value for cost and schedule with the corresponding JCL value. The JCL is informed by a probabilistic analysis of development cost and schedule duration.

At KDP C, single-project programs, regardless of LCC or initial capability cost, and projects with LCC or initial capability cost greater than $250 million develop a JCL. If the single-project program or project is rebaselined during the Implementation phase, these programs and projects are required to calculate a JCL as part of the rebaselining approval process. (For more information on rebaseline, see Section 5.5.5.) In addition, single-project programs and projects with an LCC or initial capability cost greater than or equal to $1 billion also update their KDP C JCL at CDR and, if current reported development costs have exceeded the development ABC cost by 5 percent or more, update their JCL at KDP D.

5.7.1.2 JCL Methodologies

There are two fundamental ways to generate a JCL:

1. Bivariate distributions and
2. Probabilistic Cost-Loaded Schedule (PCLS); i.e., probabilistically cost loading a probabilistic schedule.

Both methodologies will produce a JCL; however, to fulfill the intent of the NASA JCL policy requirement (at KDP C and beyond), it is intended that a single-project program or project performs a PCLS. Section 5.7.2 provides an overview of the PCLS JCL process at KDP C, CDR, KDP D, and rebaselines.

Programs and projects may not have detailed plans available to support an in-depth PCLS JCL analysis at KDP B, so the expectation of how to conduct the JCL has been expanded to accommodate the maturity of a single-project program or project in Phase B. Essentially, for KDP B, conducting a JCL utilizing bivariate distributions is considered an acceptable methodology. Section 5.7.3 provides an overview of the JCL process at KDP B.

5.7.2 JCL Process Flow (Overview) for JCL Requirements at KDP C, CDR, KDP D, and Rebaselines

The JCL implementation requirement at KDP C, CDR, KDP D, and rebaselines is for a single-project program or project to conduct a PCLS. The reason the Agency focuses on the PCLS methodology for programs and projects at KDP C and beyond is to force the program or project and the review entity to focus on the Program or Project Plan. This focus improves program or project planning by systematically integrating cost, schedule, and risk products and processes. It also facilitates transparency with stakeholders on expectations and the probabilities of meeting those expectations. Lastly, it provides a cohesive and holistic picture of the program or project's ability to achieve cost and schedule goals and enables the determination of UFE and funded schedule margins required by the program or project.

In summary, JCL helps answer fundamental questions such as:

- Does the program or project have enough funds?
- Can the program or project meet the schedule?
- What areas of risk affect successful execution of the program or project?
- What risk mitigation strategies provide the best program or project benefit?

In general, a JCL is developed in five steps with one prerequisite step:

0. Identify goals for the JCL.
1. Build a JCL schedule/logic network.
2. Cost load the schedule.
3. Implement the risk list.
4. Conduct an uncertainty analysis.
5. View the results and iterate.

Illustrations depicting the various steps start with Figure 5-15 below.

5.7.2.1 Identify Goals of JCL

As stated previously, a JCL is a policy requirement. But it can also be a valuable management tool. While certain quality standards must be met to satisfy policy, depending on goals and expectations of the JCL analysis, the JCL analysis may be set up to assist and be synergistic with other products and processes. When setting up the JCL process, especially the schedule, it is important to think about what questions the JCL should answer, who the primary users and beneficiaries will be, and what fundamental insight is desired. The program or project manager, as a primary user and beneficiary, must be engaged in the setup of the JCL process to understand and shape the underlying programmatic assumptions, including the BoE; to understand characteristics of the JCL analyses techniques, including the potential for double counting of risk (Sections 5.7.2.2 and 5.7.2.5); and to identify the questions and insights to be addressed by the JCL.

The JCL is a valuable management tool. While the JCL is a methodology to quantify the amount of program or project budget and UFE that will be required to achieve a certain confidence level, the process of developing a JCL encourages communication between the programmatic planners, the technical community, and management as assumptions and risks are documented. It encourages communication between Agency leadership and the program or project management, affording leadership an opportunity to consider the underlying programmatic assumptions; to discuss the analysis techniques; and ultimately, to build consensus around the conclusions (budget levels, amount of UFE, risks involved, probability of meeting commitments, etc.). The JCL is a tool to help people understand the implications of the calculations and assumptions and make adjustments.

5.7.2.2 Schedule Network

The backbone of the entire JCL analysis is the schedule. Having a quality schedule (with logic networking) is key to a successful JCL. Figure 5-15 shows a simple schedule with two parallel activity streams, one with three activities and one with two activities, converging on a single integration activity. Once that integration activity is complete, the project is complete.

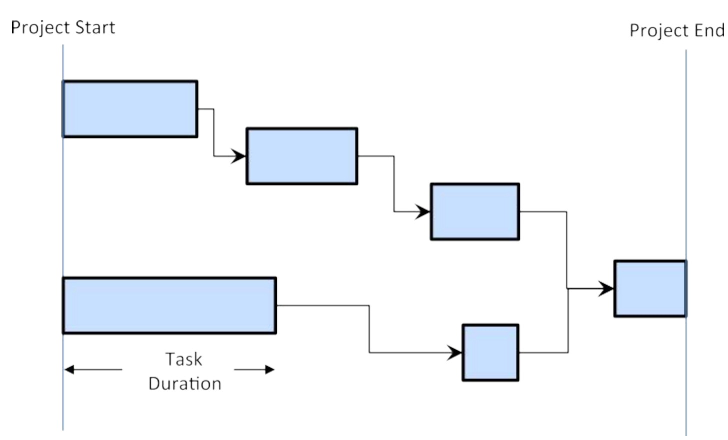


Figure 5-15 A Simple Schedule with Two Parallel Activity Streams

The schedule is logically linked, meaning that the predecessors and successors can be seen for every task. The project's milestone, in this case Project End, is linked into the schedule network, allowing an understanding of how the completion of that milestone is impacted when the duration of a predecessor changes.

It is a recommended practice that schedule margin, based on risks, duration uncertainty, and historical norms be clearly identifiable when included within the IMS. Schedule margin may also be referred to as "schedule contingency." The program or project manager owns and controls the schedule margin to the extent designated in his or her Management Agreement. Factors that may contribute to determining the amount of schedule margin include a) expert judgment, b) rules of thumb, c) percentage of overall program or project (or activity) duration, and d) calculation by the expected value of risk impacts or through insight gained from a probabilistic schedule risk assessment. Note that schedule float (slack), which is a calculated value based on network logic, should not be considered as schedule margin. Schedule margin and slack need to be considered separately to avoid double counting risk.

5.7.2.3 Cost Loading

Once a robust schedule that accurately portrays the project workflow is available, the schedule can be cost-loaded. "Cost loading" refers to mapping cost to schedule. The cost effort for each activity needs to be loaded in groups of activities. To do this, cost is differentiated into two characteristics: Time Dependent (TD) and Time Independent (TI) costs.

TD costs are associated with program or project effort that is based on the duration of an activity. In cost estimating vernacular, TD costs are sometimes called "Fixed Costs" in that their periodic (i.e., daily, monthly, quarterly, and annual) values are fixed in nature and the resulting total cost is the total duration multiplied by the appropriate periodic value (burn rate). Many activities on a program or project display this behavior. Common examples are rent, utilities, facility maintenance, sustaining operations, program management, system engineering, quality assurance, other periodic fixed expenses, and other activities that display a Level-of-Effort (LOE) nature.

TI costs are associated with the total effort required for an activity without regard for overall duration. This term refers to the behavior of the cost type and not to any impact that the costs have on time; in fact, for TI costs, the causal relationship is inverse to TD costs. The overall duration of TI costs is primarily a factor of three variables:

1. Scope of work to be conducted.
2. Productivity of the staff performing the work.
3. Achievable staffing level based on resource and fund availability.

Thus, for TI elements, the overall duration of the task is determined by the effort required for its completion and the costs are not a function of time but rather scope while for TD elements, cost is a direct function of duration. Many activities on a program or project display TI element behavior. Common examples are materials, completion-form tasks, design and development activities, tests, and one-time expenses.

TD costs can spread over separate tasks. An example is shown in Figure 5-16.

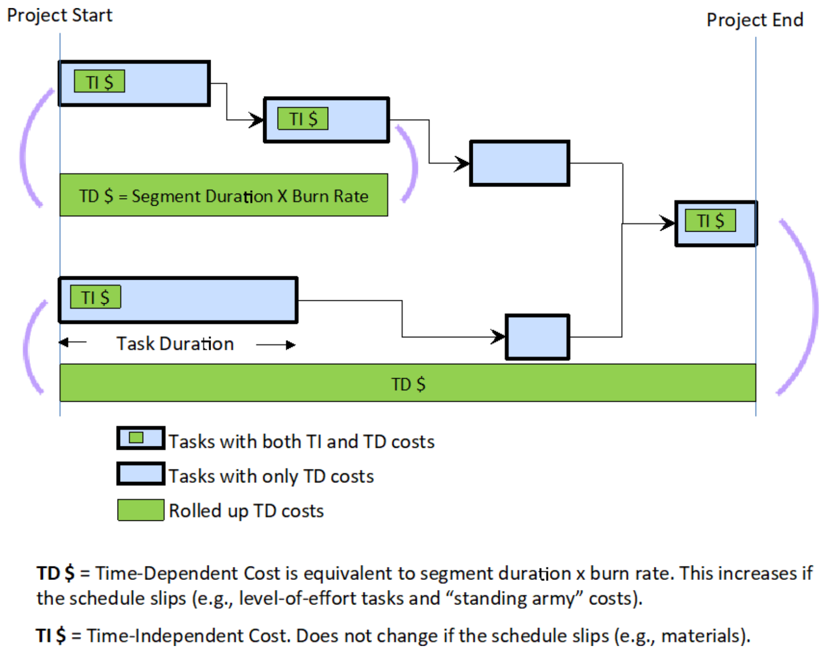


Figure 5-16 Example of Costs Spread Over Separate Tasks

This example shows two sets of TD costs. One set expands across the entire project, which implies that there is a "standing army" of personnel that will follow the project regardless of where it is in the life cycle (i.e., project management). Another observation is that the two tasks that do not have TI costs still have TD costs, and it shows that these tasks are LOE tasks that are executed by the TD resources or costs.

5.7.2.4 Inclusion of Risk in the Analysis

So far, the schedule represents the baseline plan for the project (cost and schedule). All durations and cost assumptions may have risk mitigation costs and schedule imbedded in the plan, but risk realization from the risk management system has not been incorporated. Traditionally, NASA programs and projects use their risk management system to help populate the risk activities; however, a JCL analysis does not have to be limited by what is currently being managed in the risk management system. For example, there may be a programmatic risk that does not "make it" into the risk management system but is still of concern to the project manager. The JCL analysis allows the project to model the programmatic consequences and expected value of these risks.

Risk is included in the JCL calculation by describing the uncertainty for each activity (for example, a triangle distribution showing optimistic, pessimistic, and most likely values for the cost and schedule inputs), and by including discrete risks by making use of known liens and threats. Liens and threats come under the category of "known unknowns." They are currently causing an impact on the project or are anticipated, though the full cost may not yet be known. Some examples of liens include workforce levels that are not adequate to meet the schedule, additional tasks added to the development process, rework of failed components, replacement of damaged hardware, and additional testing. Threats are events that have a potential negative impact on the project cost and schedule that may happen and can be considered based on the probability they will occur. The primary difference between liens and threats is that liens are happening or expected and threats have a lesser probability of happening. Examples of a threat include cost impact associated with potential failed tests, failed technology development and design changes, or potential launch vehicle changes and/or impacts. Threats and liens are entered into and managed in a program or project's risk management and budget systems, usually with an associated probability.

Figure 5-17 demonstrates how discrete risks are incorporated into the system. From a schedule perspective, a risk event is treated the same way as an activity; however, in the schedule, the risk event activity only occurs within a certain amount of time. Capturing risks and adding them into the schedule introduces the first probabilistic aspect of a JCL. From a static viewpoint, it looks like the risk is just an activity; but when simulations begin, the risk event will only occur x percent of the time. When the risk event does not occur, the activity and associated dollars will essentially default to zero; however, when the risk does occur, the activity takes on a duration and dollar impact. The duration impact when the risk occurs can be considered the duration consequence of that risk. There may be only TI associated costs with the risk. These costs would be the direct cost impact of the occurring risk. The duration impact of the risk affects the start date of the successor task. This impact could cause the timeframe of the TD costs on the bottom to expand. This potential expansion captures the indirect risk dollars associated with the discrete risk. When a project identifies risks for a JCL analysis, it is important to identify the activities that the risks affect, the probability of occurrence of the risk, and the consequence (in both direct cost and direct schedule) of the risk happening. Having a quality schedule with tasks that are linked logically is key to a successful JCL.

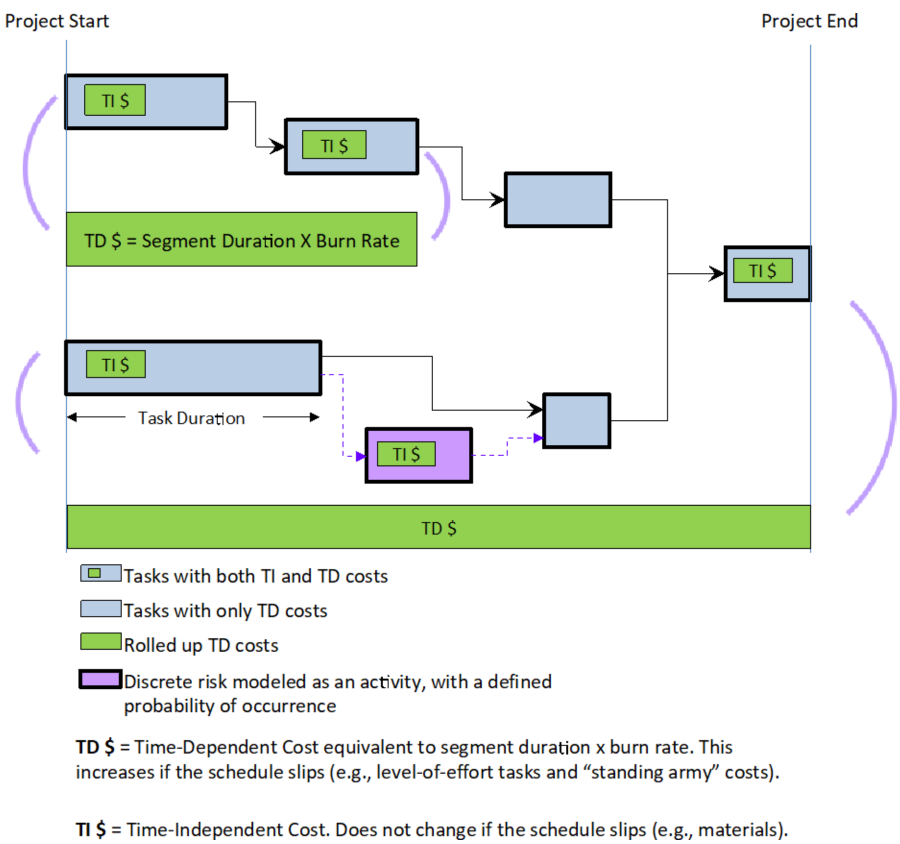


Figure 5-17 Demonstration of How Discrete Risks are Incorporated into the System

5.7.2.5 Implementation of Uncertainty Analysis

The next step in performing a JCL is identifying and implementing the uncertainty.

Up to this point in the JCL process, the primary driver of the JCL results is the quantitative risk assessment and the effect it has on the risk-adjusted cost and schedule. While the risk assessment provides a snapshot in time of potential future events that may cause the project to overrun, it does not account for two key facets that can drive cost and schedule:

- **Unknown-unknowns.** Although NASA's Continuous Risk Management (CRM) process aims to create as comprehensive a risk register as possible, it is not feasible to predict all events that could possibly increase cost or schedule.
- **Uncertainty in the baseline estimate.** Disregarding risks altogether, it is impossible to precisely predict the time or budget required to complete various segments of space-vehicle research, development, and production.

Recognizing these two facets, JCL analysts need to account for uncertainty in their baseline cost and schedule plans.

Risk and uncertainty are distinct inputs to the JCL model. The two terms overlap. The indefiniteness about a project's baseline plan is partially caused by risks to the project. In traditional, input-based cost-risk analysis, discrete risks are not included as inputs since they would likely cause double counting when uncertainties in the technical inputs and cost outputs are accounted for. In JCL analysis, however, risks from the project's risk register are modeled alongside uncertainties applied to the baseline plan. This is done to increase the usefulness of the JCL analysis to a project manager: being able to discern the effect each risk has on a project's cost and schedule allows for the development of risk mitigation plans.

For JCL analysis, risk and uncertainty are defined as follows:

- ***Cost or Schedule Risk****. A scenario that may (with some probability) come to pass in the future causing an increase in cost or schedule beyond a project's plan.*
- ***Uncertainty****. The indefiniteness about a project's baseline plan. It represents the fundamental inability to perfectly predict the outcome of a future event.*

To avoid double counting, JCL analysts need to segregate uncertainty caused by risks already being modeled in the JCL simulation from the underlying uncertainty of the project's plan once these risks have been discounted. Although this segregation can never account for all aspects of double counting, the benefit to project managers of seeing their risk outweighs the potential for slight errors in the analysis. History and experience have shown that the variance in a typical JCL model is driven significantly more by the uncertainty inputs than the discrete risks. With this said, it is essential to consider uncertainty when conducting a JCL analysis.

There are various methods for selecting and applying cost and schedule uncertainty distributions to the JCL model. Typically, uncertainty is modeled using a three-point estimate. The low value represents the low extreme of the cost or duration associated with the uncertainty, the middle value represents the "most likely" value, and the high value represents the high extreme. Although the baseline plan may not be any one of these numbers (low, middle, or high), it needs to be within the range of low and high. (Refer to Figure 5-18 for a visual representation.)

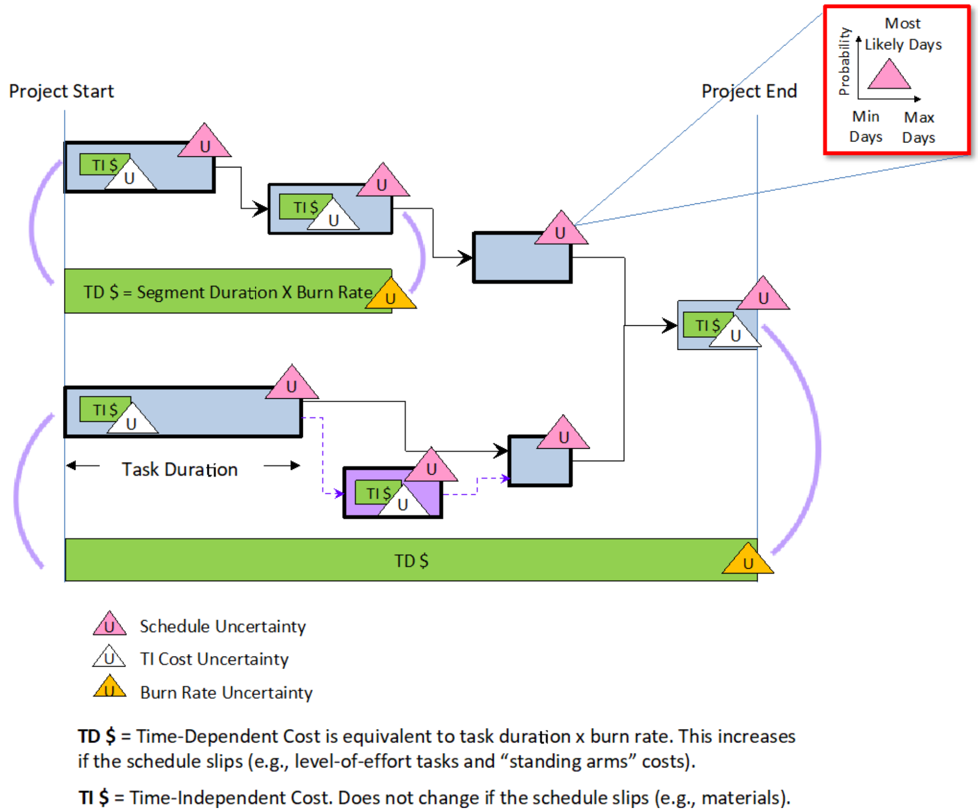


Figure 5-18 Visual Representation of an Uncertainty Model Using a Three-Point Estimate

5.7.2.6 Visualization and Results

The process shown in Figure 5-18 is considered iterative. However, at any point in the JCL iteration process, the final and key step is interpreting the results of the analysis. Although an exhaustive list of possible output reports is not shown for brevity purposes, it is important to explain the most used JCL chart, the scatter plot. A JCL calculation result, commonly referred to as a scatter plot, is often graphically depicted as shown in Figure 5-19.

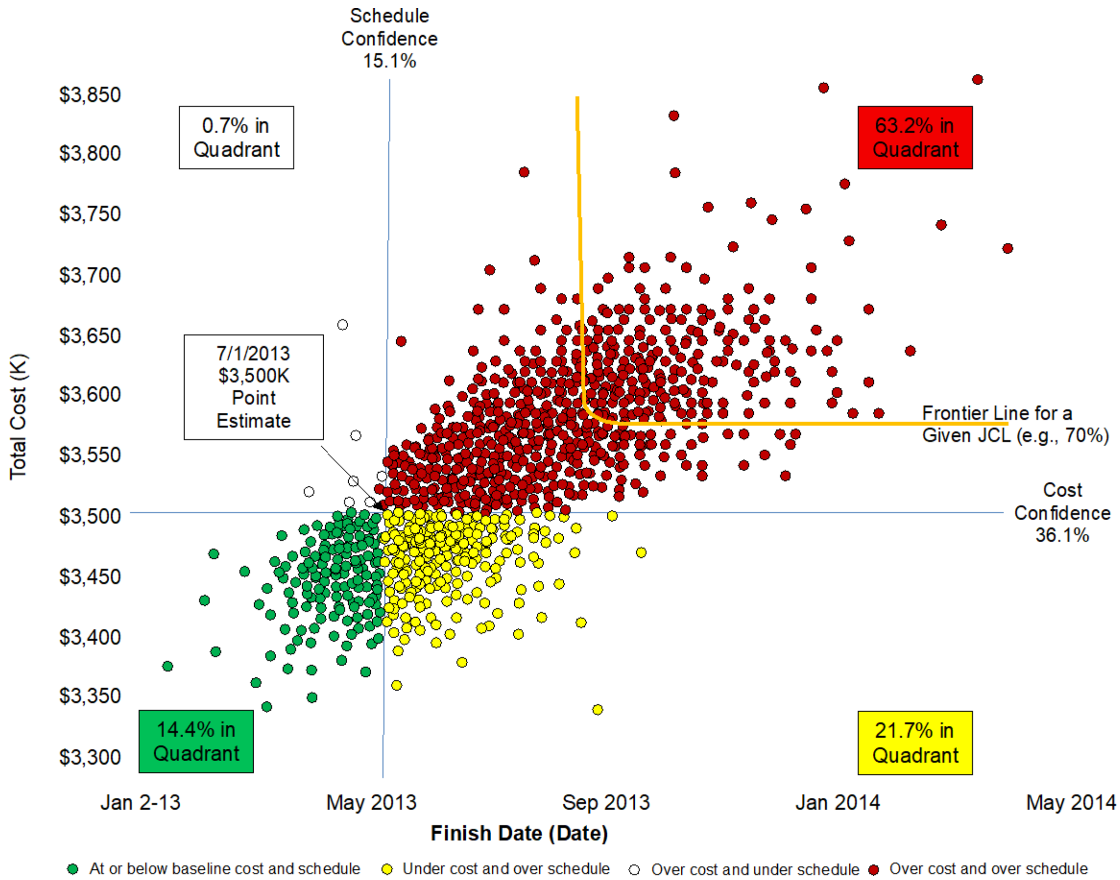


Figure 5-19 JCL Calculation Result, or Scatter Plot

The scatter plot shows iterations of cost and schedule risk analysis. Each dot in the scatter plot represents a specific result, or scenario, from the simulation calculation (cost and schedule). The x-axis represents the final completion date, and the y-axis represents the final cost through that completion date. In this example, the blue lines (the crosshairs) intercept at the project's point estimate (baseline plan). To the bottom left, the red dots represent all the scenarios that are at or below the baseline cost and schedule. If the red dots are divided by the total number of dots, the result would be 19.6 percent of the dots are within cost and schedule or put another way, a JCL of 19.6 percent. The crosshairs can be moved to another date and cost to obtain the JCL for that combination. The horizontal bar of the crosshairs indicates the cost confidence level whereas the vertical bar of the crosshairs indicates the schedule confidence level.

The yellow line in Figure 5-19 represents the "frontier line" or indifference curve, which specifies all the cost and schedule combinations that will meet a targeted JCL. In this example, the frontier curve represents a JCL of 50 percent. As a cautionary note, the asymptotic tails shown are purely academic; it is best to be as close as possible to the centrode of the cluster for a given frontier curve.

Note that the scatter plot is only valid for the current project baseline plan and is considered a snapshot in time. Changes to the project baseline plan due to cost growth or a schedule slip will fundamentally change the project's risk posture rendering the JCL invalid. If changes to the project's ABC result in the need to rebaseline, the JCL will need to be recalculated.

5.7.3 JCL Process Flow (Overview) for JCL Requirement at KDP B

NASA has augmented its JCL policy to include single-project programs and projects with an LCC or initial capability cost over $1B to conduct a JCL analysis in support of KDP B. This requirement replaces the KDP B cost and schedule range estimate requirement. It is acknowledged that programs and projects do not have detailed plans available to support an in-depth PCLS JCL analysis, so the expectation of how to conduct the JCL has been expanded to accommodate the maturity of a single-project program or project in Phase B. Essentially, for KDP B, conducting a JCL utilizing bivariate distributions is considered an acceptable methodology.

In general, a JCL at KDP B is developed in four steps:

1. **Conduct a Schedule Risk Analysis** (SRA), which can be done using the same methodologies that are currently documented within the *NASA/SP-2010-3403, NASA Schedule Management Handbook*;[111] i.e., parametric utilizing schedule estimating relationships, traditional SRA conducted from IMS, or a combination of both.
2. **Conduct a Cost Risk Analysis** (CRA), which can be done using the same methodologies that are currently documented within the *NASA Cost Estimating Handbook*;[112] i.e., parametric based, analogy based, bottom up with quantitative risk analysis, or a combination.
3. **Implement Known and Unknown Risks**. Depending on methodology used in steps 1 and 2 above, additional specific program or project risk items can be added to the SRA and CRA.
4. **Convolve SRA and CRA** distributions together.

5.7.4 Unallocated Future Expenses

The development of a JCL allows decision makers to better understand the probability of success for a proposed program or project baseline and enables them to visualize the amount of risk that they are being asked to take with the proposed baseline cost and schedule. They can make budget decisions considering the individual risks and the context of the risk within the entire portfolio of programs.

[111] https://www.nasa.gov/content/schedule-management-handbook and https://nasa.gov/evm/handbooks
[112] https://www.nasa.gov/content/cost-estimating-handbook

Any reductions to the UFE will reduce the ability of the program or project to achieve its cost and schedule targets. When the UFE is a product of the probabilistic JCL analysis, any reduction in the UFE will reduce the probability of achieving the program or project cost and schedule targets in a manner that can be explicitly quantified. The UFE approach typically results in a more informed dialog between both external and internal decision makers and the program or project.

For programs and projects that are not required to perform a probabilistic analysis, the UFE should be informed by the program or project's unique risk posture in accordance with Mission Directorate and Center guidance and requirements. The rationale for the UFE, if not conducted using a probabilistic analysis, should be appropriately documented and be traceable, repeatable, and defensible.

5.8 Federal Budgeting Process

NASA's program and project budget planning process is shaped by the Federal budgeting process. There is only one job that Congress must do every year, and that is appropriate the Federal budget, per the Constitution. (See Figure 5-20 for an example of the Federal budget cycle.)

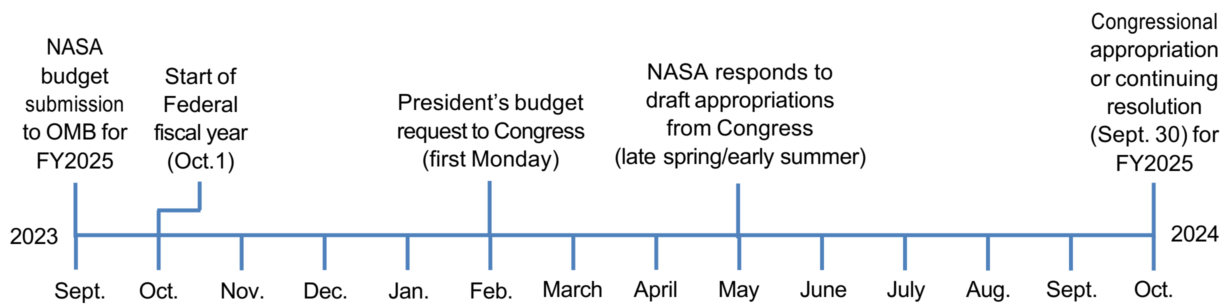


Figure 5-20 Example of the Federal Budget Cycle for FY 2025 Budget

The Federal budgeting process sets national priorities for the money the Government spends. Much national policy, and hence priority, is demonstrated by the President's and Congress's response to different items in NASA's budget request.

The Federal budgeting process can be seen as a one-year process that starts with the delivery of the President's Budget Request (PBR) to Congress and ends with the appropriation provided to a Federal agency. But the budget process at NASA starts well before that. To get to the PBR, there is a long process both at the Agency and at the Office of Management and Budget (OMB).

The Executive Branch (the President and Federal agencies) submits a budget request to Congress on or before the first Monday in February. The PBR includes funding requests for all Federal agencies and cabinet departments for the coming Federal Fiscal Year (FY), which begins on October 1 after Congress appropriates funds. NASA submits its portion of the PBR to OMB in September, preceding the President's February budget submittal. So NASA submits its budget request in September for the fiscal year that starts the following October 1. (For example, in September 2025, NASA submits its portion of the PBR that starts October 2026 for FY 2027.)

The significant external drivers to NASA's budget process are:

- Producing a budget request to go into the PBR to Congress in February and
- The appropriation of funds every October 1st to begin a new fiscal year.

All appropriations bills are to be signed before the October 1 beginning of the Federal fiscal year. If Congress reaches the start of the fiscal year without a budget in place, it usually passes a Continuing Resolution (CR) that temporarily funds the Federal Government at the level of the previous fiscal year. The program or project manager needs to consider the possibility of a CR, which might mean working to the previous year's funding. This may result in decreased funding, or in funding provided later in the fiscal year than planned. A CR, especially one that lasts an entire year, may be particularly problematic for a program or project that was planning on increased funding, e.g., a program or project transitioning from Formulation to Implementation. Depending on the magnitude of the decrease in funding, or the length of the delay in funding, the Decision Memorandum and Management Agreement may need to be renegotiated and amended.

5.8.1 NASA's Interface with the Federal Budget Process

NASA's budget planning process takes into account that at any given point in time, NASA is involved in multiple budget years. Each winter (January/February) just preceding the release of the PBR from the White House to Congress, all Federal agencies develop funding requirements for work that will be performed two fiscal years in the future. For example, in January 2026, Federal agencies focus their work on the budget request that will be submitted in September 2026 for funds for the fiscal year that starts October 2027 (FY 2028). That is two years ahead of the current "year of execution" or "performance year," which started October 2025. So, while work is being executed during FY 2025 (October 1, 2024, to September 30, 2025), NASA starts work in January 2025 to develop the budget request they will submit in September 2025 that goes into the PBR submitted in February 2026 for FY 2027. NASA's internal processes and products are aligned with this Federal cycle and justifying its request to Congress.

The full NASA budgeting process is the Planning, Programming, Budgeting, and Execution (PPBE) process. The PPBE process takes into account differing time spans, the complex interactions of external and internal requirements, external and internal assessments, and the specific needs of a multifaceted organization. The full PPBE process is explained in *NPR 9420.1, Budget Formulation*. (See also Section 5.8.3.)

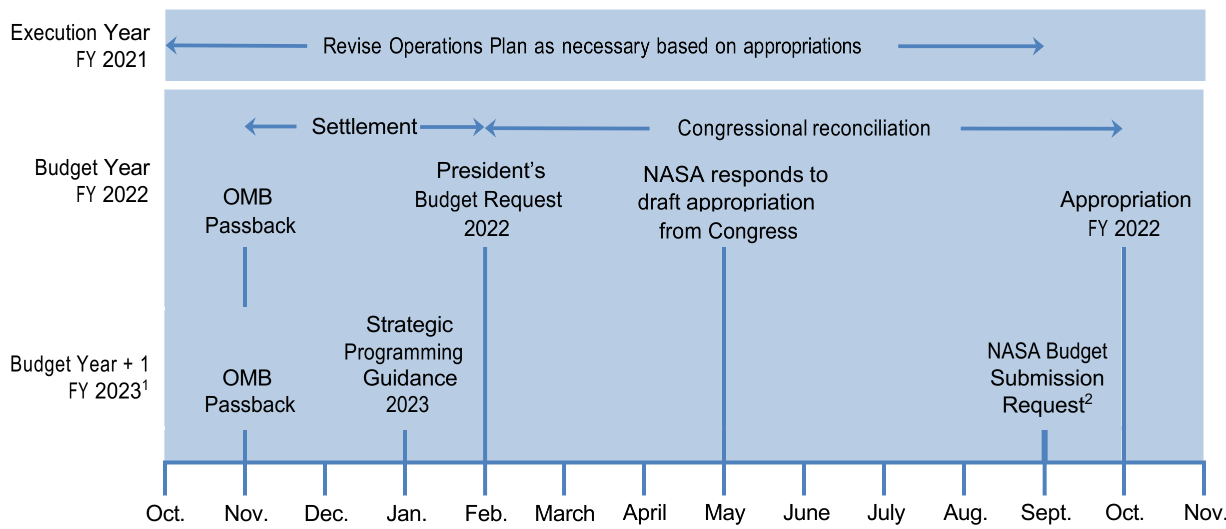
5.8.2 OMB Passback

NASA's budget planning process has a 5-year horizon. The planning process starts with the OMB passback for the previous fiscal year and covers the budget year and four additional outyears.

Each year, OMB provides guidelines on the content of NASA's proposed budget through the passback in late November. The passback gives Federal agencies guidance on what the White House will and will not accept for inclusion in the PBR. NASA manages projects across their multiyear life cycle, but for the budget cycle, it submits a one-year request plus four years out. OMB comments on the single year but is also sensitive to the full program or project life cycle. In the passback, OMB provides control numbers for NASA budget accounts for a 5-year span. In the next budget cycle, these control numbers provide the starting point for the new budget development cycle.

As shown in Figure 5-21, when NASA receives the passback from OMB in November 2020, the Agency is engaged in three phases of the budget planning cycle in parallel:

- Spending the money appropriated for the execution year FY 2021 (October 2020 to September 2021),
- Negotiating the budget for NASA that will appear in the PBR to Congress in February 2021 (for FY 2022), and
- Planning the budget for FY 2023 and the four out years beyond that.



[1]Includes planning for four out years (i.e., 2023 – 27).
[2]This request will reflect any change to the trajectory from previous year.

Figure 5-21 Simultaneous Multi-Year Budget Process

The time between submitting NASA's budget request to OMB in September and receiving the actual funding appropriated by Congress in October of the following year is a year and a half, longer if the appropriation is delayed. The amount of the budget request may be altered by other considerations at any point during that time. When the appropriated funds are received, any difference in the amount appropriated from what was requested requires an immediate revision to Operations Plans,[113] which impacts the budget request being negotiated for the next year.

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[113] The Congressional Operating Plan (COP), and Agency Operating Plan (AOP) are used as the basis for ensuring that appropriated funds are used in compliance with Agency intent and Congressional mandates. The COP sets forth a high-level plan for how NASA intends to apply Agency financial resources during the fiscal year to fulfill its mission. Typically, the COP is at the program level. While not subject to statutory controls, the COP establishes a common understanding between NASA, OMB, and the Congress. The AOP is an internal plan based on the COP that provides greater detail and includes all programs and projects. When Agency programs and projects are changed or when new requirements become known, the AOP must be revised to reflect the new direction. If the change exceeds the limitations established in the current COP, NASA must submit a new plan to Congress.

5.8.3 PPBE Process

The NASA PPBE process comprises four phases: Planning, Programming, Budgeting, and Execution. Figure 5-22 shows an overview of this process. The following sections provide a high-level view of each of these phases. (See *NPR 9420.1, Budget Formulation* for more information.)

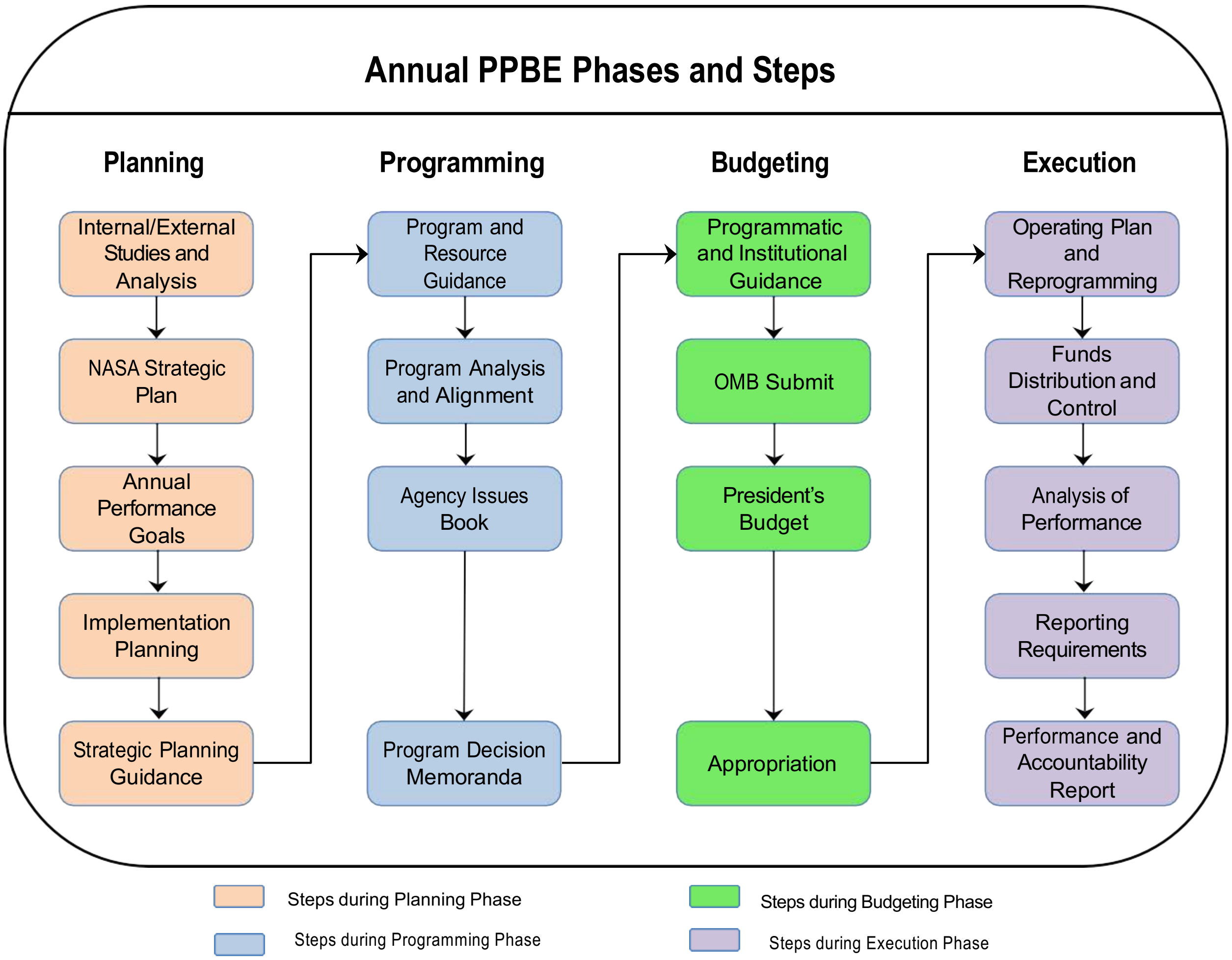


Figure 5-22 Annual PPBE Phases and Steps

5.8.3.1 Planning

NASA's PPBE process starts with planning. All of NASA's budget planning flows from NASA's strategic mission planning with the goal of acquiring or procuring the funding to either start or continue working on NASA's mission, programs, and projects and their supporting capabilities and infrastructure. Setting strategy is an iterative, interactive process. Mission ideas are rolled up into goal statements and feed resource requests, and strategy is translated down into programs and projects to execute the mission. Mission planning precedes resource requests and detailed planning follows resource allocation at both the mission level and the program or project level. In addition to the programmatic planning, the institutional side of the Agency plans the capabilities that will be needed to support the mission.

At the highest level, strategic planning produces the NASA Strategic Plan (NPD 1001.0), which guides all other Agency planning. It is updated every three years and defines NASA's vision and the strategic goals that support, drive, and justify NASA's mission execution and research and development activities.

The Strategy Implementation Planning (SIP) process guides specific budget and acquisition decisions. The SIP process allows the evaluation, short-term assessment, and long-term alignment of issues such as the appropriate application of White House priorities, Agency strategic planning, and new initiatives in a portfolio of programs and projects in the context of budget availability. The SIP process is implemented through select reviews conducted at the direction of the NASA Administrator, resulting in guidance to inform the strategic acquisition process.

This guidance is incorporated into the Strategic Programming Guidance (SPG) and applied to decisions made in Acquisition Strategy Meetings (ASMs). The SPG is produced annually and consolidates all the strategic information that will be used to develop the NASA budget and allocate resources across the Agency. Agency-level planning also includes the development of the Operations Plans that are generated after NASA receives its appropriation. These plans adjust resources in the current execution year based on the funding actually appropriated. The SPG is translated into planning on the Mission Directorate, mission support, and institutional level and into program- and project-level planning to execute the mission:

- Planning at the Mission Directorate level develops input for the Strategic Plan and supports resource allocation to the Mission Directorate's programs over their life cycles.
- Planning at the mission support and institutional level includes the infrastructure necessary to execute programs and projects over their life cycles.
- Program- and project-level planning encompasses all life-cycle planning done by programs and projects to support the execution of their mission.

Controlled by the Strategic Management Council (SMC), the SPG is the official, high-level guidance for use in developing the Agency's portion of the PBR. The SPG includes both programmatic and institutional guidance, consolidating the information from the Strategic Plan, existing implementation plans, priorities, studies, assessments, and performance measures. Publication of the SPG officially kicks off the process whereby NASA builds the Agency's budget request to OMB and Congress and the subsequent management of resources allocated to programs and projects. The SPG consolidates all relevant strategic guidance for developing a programmatic and financial blueprint for the budget year plus four outyears.

The SPG provides uniform strategic guidance for all involved in the budget process. This includes the Control Account Managers (CAMs) or managers within the program or project with responsibility to manage the inputs to the NASA budget process and directors of mission support offices or Administrator staff offices with cross-cutting responsibilities that address the institutional infrastructure. (See Appendix A for a definition of Control Account Manager.)

OCFO manages the SPG development, which begins after the OMB passback for the prior budget year and is finalized after completion of the President's budget in early February. (See Figures 5-21 and 5-23.) The SPG is developed with the input and involvement of the Mission Directorates, mission support offices, and Centers.

The SPG provides high-level funding and civil service (Full-Time Equivalent (FTE)) control totals by Center. The development of the SPG is roughly concurrent with the issuance of the Programming and Resource Guidance (PRG), which is another key piece of guidance needed for the programming phase of the PPBE process.

5.8.3.2 Programming

The programming phase of the PPBE process involves the analysis and strategic alignment of mission, constraints, and resources. This phase starts with the development of the following products:

- Programming and Resource Guidance (PRG), which translates the SPG guidance into programmatic guidance more relevant for the program or project managers and the Centers.
- Program Analyses and Alignment (PAA), which converts strategy into resourced programs and projects. The CAMs identify what their programs and projects intend to accomplish, identify any surplus or deficit capabilities and capacities, and identify the impact of funding reductions or any need for funding increases. The PAA is completed in mid-May.

Then Centers have an opportunity to analyze the SPG, PRG, and PAA information to determine possible institutional infrastructure issues. Any issues will be raised with the SMC through the Issues Book for decision before the budgeting phase begins. This step begins in mid-May and is completed in early June:

- Program Review/Issues Book reviews all previous guidance, inputs, analysis, and issues to identify critical issues that need to be brought to the SMC for a decision.
- The Decision Memorandum reflects the Executive Council decisions on the issues that were discussed at an SMC. The decisions document resource levels and FTE control totals for subsequent development of the budget.

5.8.3.3 Budgeting

In the budgeting phase, the OMB budget submission is developed under the guidance of the Office of the Chief Financial Officer (OCFO):

- **Programmatic and Institutional Guidance.** CAMs allocate resources at the project-level detail necessary for Centers to begin formulating the NASA full-cost budget.
- **OMB Budget.** CAMs develop the OMB budget submission under the guidance of the OCFO. This is the first step in the PPBE process in which information is distributed outside of NASA. However, it is still pre-decisional data and is provided to OMB only.
- **President's Budget.** The OCFO coordinates the Mission Directorates' responses to OMB questions on the budget submission, coordinates hearings with Mission Directorates, receives and responds to the OMB passback (OMB's formal response to the NASA budget submittal), and works appeals and settlement. Then the OCFO also manages the development of input to the PBR documents. The PBR, also known as the Congressional Budget Justification, is the annual NASA budget document that includes budget estimates at the program and project level, description and justification narratives, performance data, and technical descriptions.
- **Congressional Appropriation.** As discussed previously, this phase concludes with NASA receiving the resources and legislative guidance and adjusting its Operations Plans as necessary to respond to differences from the original budget request.

5.8.3.4 Execution

The execution phase in the budget process involves the implementation of the plans with associated monitoring, analysis, and control. In the context of programs and projects, execution is conducting the authorized work in accordance with the applicable 7120 series NPR.

5.8.4 Linkage Between Life Cycles

Figure 5-23 illustrates the points of connection between the program and project life-cycle planning and the budgeting cycle. (See Section 5.8.3.1 for more information on the relationship between program and project planning and the PPBE planning phase.) The program and project life cycle is not tied to a specific timeline but evolves with the development of the concept, mission, and technology. The program or project manager carries the new program or project idea forward along this cycle. The budget timeline is tied to specific annual events. Procurement personnel such as CAMs and the Resource Management Officer (RMO) take the program or project forward along this timeline. (See Appendix A for a definition of RMO.) Points of synchronization include the initial conception: the program or project is vetted at the first Agency-level strategic planning meeting, which feeds into the SPG in January. There is also formal linkage when the program or project enters the Implementation Phase of the life cycle (KDP I/KDP C). At this point, the program or project is subject to external oversight. The Program Commitment

Agreement (PCA) is approved (or not), the Integrated Budget Performance Document is developed, and the Acquisition Strategy is updated.

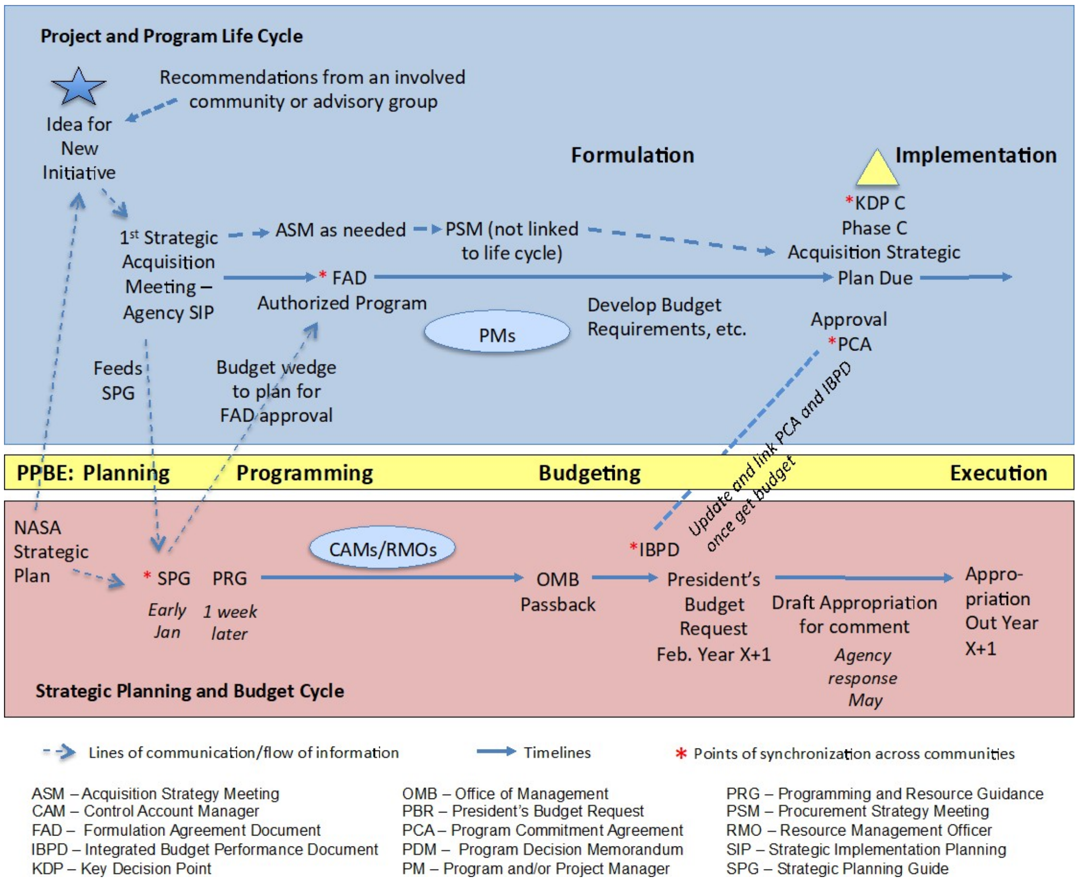


Figure 5-23 Linkages Between the Program and Project Life Cycles and the Budget Cycle

5.8.5 Program and Project Involvement in the Budgeting Process

Mission Directorates guide program and project involvement in the budget process based on the four general steps a Mission Directorate takes in developing its budget:

1. Develop budget guidelines for the Centers (programs and projects).
2. Conduct program or project reviews of the Center submittals.
3. Develop budget recommendations for the Mission Directorate Associate Administrator (MDAA).
4. Develop Mission Directorate budget recommendations for the NASA Administrator.

The Mission Directorate develops budget guidelines for the Centers in accordance with Agency-level strategic programming guidance. The MDAA defines the overall program priorities and budget strategy for the upcoming process. The Mission Directorate then prepares narrative and numeric guidance to the Centers (programs and projects) consistent with this direction. The final budget guidance is entered into the Agency budget database known as N2. The narrative guidance is usually posted on an Agency-level site where it can be seen by the Centers.

Once the program and projects receive this guidance from their Center financial office, they begin to develop their program or project's submission based on this guidance while incorporating any changes needed as a result of the previous year's performance. Each Center will have a different process for developing budgets, and program and project teams need to work with the appropriate Center staff as directed by the Center management. Depending on unique Center policies, the budgets may be submitted to the Mission Directorate by the Center directly or by the program or project team. A Center may request project teams to submit their budgets through their program office.

Once received by the Mission Directorate, Mission Directorate personnel conduct reviews of Center program or project submittals. These assessments may include an on-site program or project review and may occasionally include visits to contractors and other facilities. Data from the formal Center budget submittals combined with the information garnered from the program or project reviews are used to identify and resolve issues. Issues may include variances in the budget relative to the guidelines, milestone changes, technical problems, contract or subcontract growth, and UFE status. These issues form a basis for further investigation and analysis. Programs, projects, and Centers may be asked to provide additional options to resolve the issues.

Once all issues are resolved, Mission Directorate personnel develop budget recommendations for the NASA Associate Administrator (AA), who then submits them to the NASA Administrator.

5.9 The Work Breakdown Structure and Its Relationship to Agency Financial Processes

The Work Breakdown Structure (WBS) is a key element of program and project management. The purpose of a WBS is to divide the project into manageable pieces of work to facilitate planning and control of cost, schedule, and technical content. NPR 7120.5 requires that projects develop a product-based WBS in accordance with the Program and Project Plan templates. Figure 5-24 shows the standard template for space flight projects governed by NPR 7120.5.

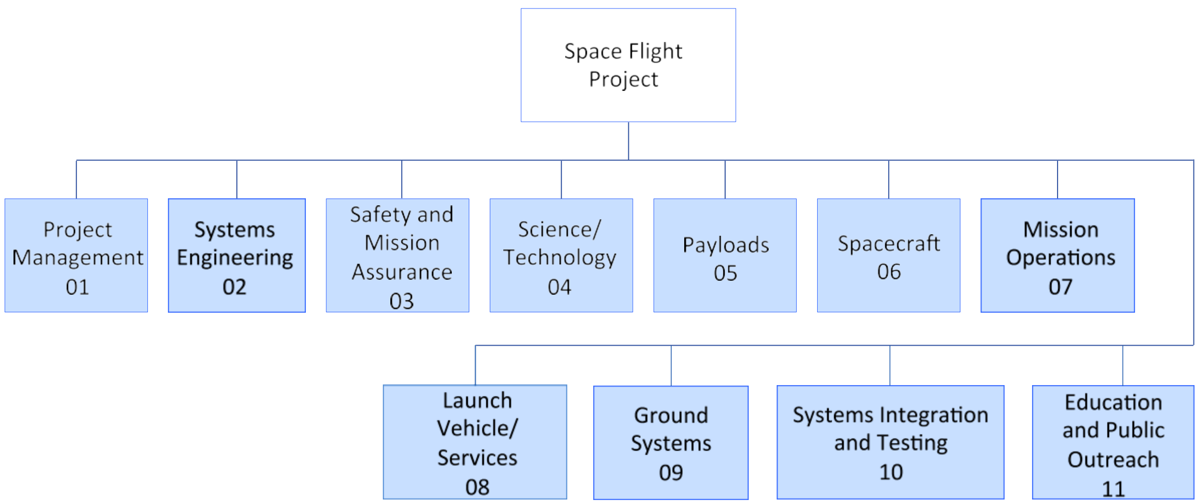


Figure 5-24 Standard Level 2 WBS Elements for Space Flight Projects

The WBS is developed as part of the Formulation activities to characterize the complexity and scope of the project after the Formulation Authorization Document (FAD) is issued at the end of Pre-Phase A. Developing the WBS is part of establishing the internal management control functions. Pre-Formulation activities are typically initiated by Mission Directorate Associate Administrators (MDAAs) or Center Directors or sometimes a program office and are not formally part of Formulation. Initial resources for pre-Formulation activities like Pre-Phase A Concept Studies are usually provided by the initiating organization and are not included in the Life-Cycle Cost (LCC), nor do they have their own unique project-level WBS element.

The WBS is a product-oriented family tree that identifies the hardware, software, services, and all other deliverables required to achieve an end project objective. The WBS then comprises the product tree plus the other enabling activities such as project or element management, systems engineering, safety and mission assurance, and others as necessary for completing the work. The generic structure is shown in Figure 5-25. The structure subdivides the project's work content into increasing levels of detail down to the work package or product deliverable level. The enabling activities can be applied to each of the product layers as needed to fully characterize the major work elements. Developed early in the project life cycle, the WBS identifies the total project work to be performed, which includes not only all NASA in-house work, but also all work to be performed by contractors, international partners, universities, or other performing entities. All work considered part of the project needs to be represented in the project WBS.

The elements of the project WBS are fundamental in many aspects of internal project management control. They form the basis for project funding and are the building blocks for cost estimating and analysis. Starting a project under a logical, accurate, and complete hierarchy that reflects the work of the project facilitates all aspects of project management as the project progresses through its life cycle.

NASA/SP-2016-3404, NASA Work Breakdown Structure (WBS) Handbook[114] provides program and project teams with the necessary instruction and guidance in the best practices for WBS and WBS dictionary development and use for project implementation and management control.

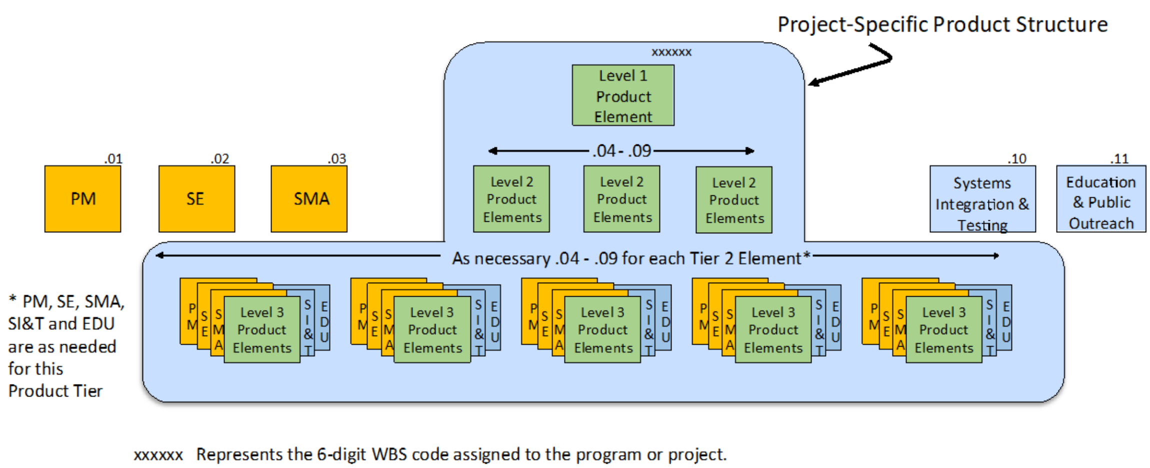


Figure 5-25 WBS Structure from Products and Enabling Activities

5.9.1 Developing the Program WBS

A program WBS is a product-oriented hierarchical decomposition that encompasses the total scope of the program and includes deliverables to be produced by the constituent components including projects and activities. The program WBS includes, but is not limited to, program management artifacts such as plans, procedures, standards, and processes, the major milestones for the program, program management deliverables, and program office support deliverables.

[114] https://ntrs.nasa.gov/citations/20180000844

The program WBS is a key to effective control and communication between the program manager and the managers of constituent projects: the program WBS provides an overview of the program and shows how each project fits in. The decomposition should stop at the level of control required by the program manager. Typically, this will correspond to the first one or two levels of the WBS of each constituent project. In this way, the program WBS serves as the controlling framework for developing the program schedule and defines the program manager's management control points that will be used for Earned Value Management (EVM), if applicable, as well as other purposes.

EVM is required for single-project programs (and other programs at the discretion of the MDAA) with a life-cycle cost (LCC) or initial capability cost greater than $250M.

The complete description of the program WBS components and any additional relevant information is documented in the program WBS dictionary, which is an integral part of the program WBS.

The program WBS does not replace the WBS required for each project within the program. Instead, it is used to clarify the scope of the program, to help identify logical groupings of work for components including projects and activities, and to identify the interface with operations and products. It is also a place to capture all non-project work within the program office, external deliverables such as public communications, and end-solution deliverables overarching the projects such as facilities and infrastructure upgrades.

5.9.2 Developing the Project WBS

The subdivisions of work in the project WBS need to reflect a logical, accurate, and compatible hierarchy of work. Level 1 of the project WBS is the name of the project. No Level 1 (the project) element can be put in place without a program above it. Project managers make the Level 2 and below elements correspond to the project products plus other enabling activities necessary for completing the work. Depending on the type of project being conducted, these elements may be required to conform to a standard template. Figure 5-24 shows the standard template for those space flight projects governed by NPR 7120.5. Additional guidance is provided in *NASA/SP-2016-3404, NASA Work Breakdown Structure (WBS) Handbook*[115] and NASA/*SP-2011-3422, NASA Risk Management Handbook*.[116]

The standardization of Level 2 WBS elements for space flight projects is driven by the need for consistency, which enables more effective cost estimating and assessment of project work across the Agency. When the program and project management tools align, it facilitates strategic thinking, increases NASA's credibility in answering Congress, aids program and

[115] https://ntrs.nasa.gov/citations/20180000844
[116] https://ntrs.nasa.gov/citations/20120000033

project management, and enables people to ask the right questions and get an answer. The standard WBS is intended to apply only to space flight projects, not programs.

Standard Level 2 elements that are not relevant to a particular project do not need to be used in the project WBS. If project content does not fit into the content of any existing standard Level 2 WBS element, new WBS elements may be requested through theOffice of the Chief Engineer (OCE) and the Office of the Chief Financial Officer (OCFO) through the Metadata Manager (MdM) as part of submitting the WBS. Below WBS Level 2, the subordinate (children) WBS elements (Level 3 and lower) are determined by the project. The Level 3 and lower elements may differ from project to project but need to roll up to the standard WBS dictionary definition of the Level 2 element.

Regardless of structure, all project WBSs have the following characteristics:

- Apply to the entire life cycle of the project, including disposal and decommissioning.
- Support cost and schedule allocation down to a work package or product deliverable level.
- Integrate both Government and contracted work.[117]
- Allow for unambiguous cost reporting.
- Allow project managers to monitor and control work package and product deliverable costs and schedule, including Earned Value Management (EVM) and cost reporting.
- Capture both the technical and the business management and reporting.

An example of a Level 2 and 3 Space Flight WBS is provided in Figure 5-26 for the James Webb Space Telescope (JWST) project.

[117] Project managers should work with industry and/or international partners to ensure consistent WBSs.

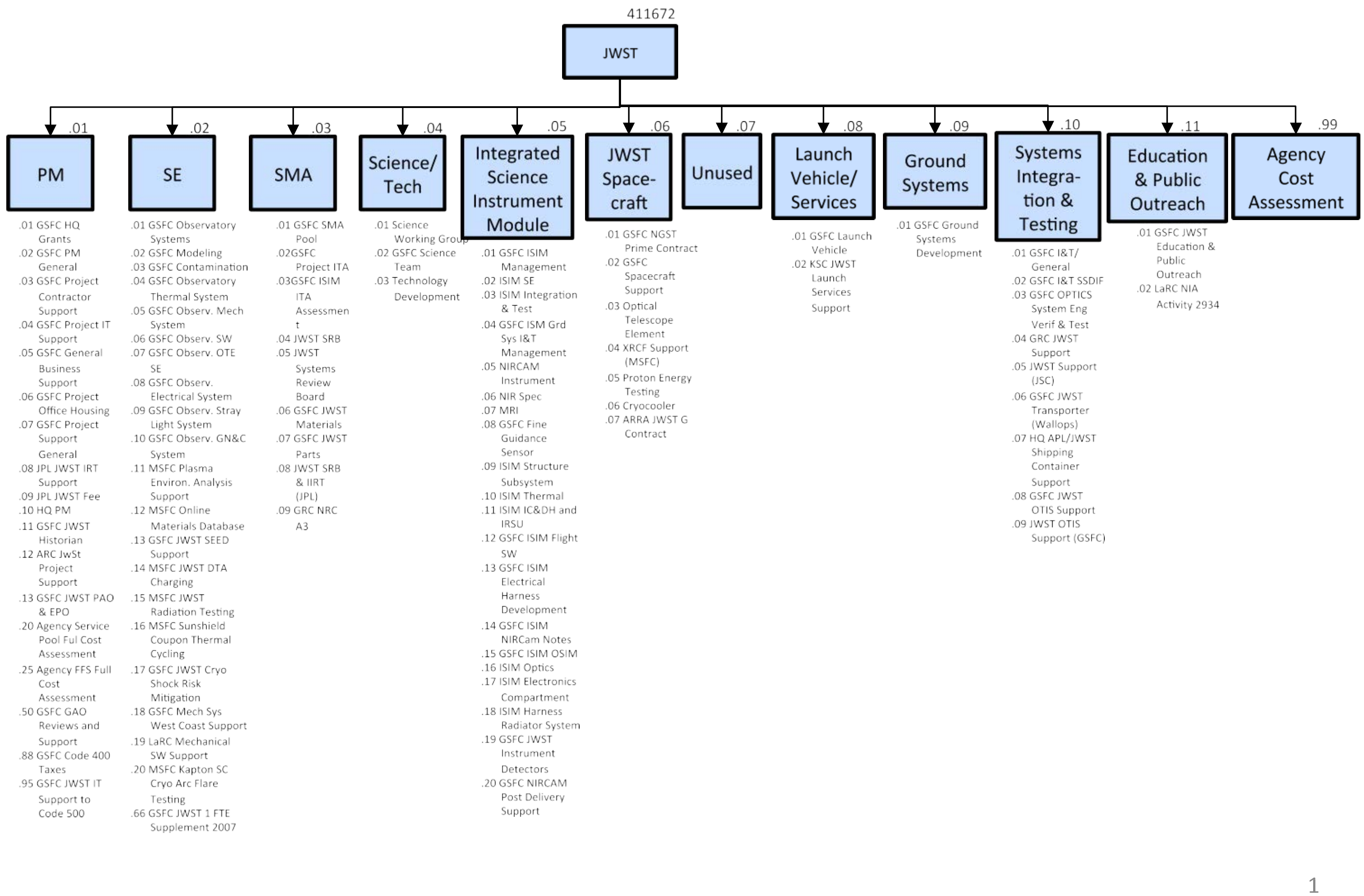


Figure 5-26 JWST 3 Level WBS Example

5.9.3 Space Flight Project Standard WBS Dictionary

When constructing the WBS, a dictionary or explanation of what is included in each of the elements is necessary to ensure all work is accounted for in a consistent and relevant manner. This dictionary should be widely available and understood by all reporting organizations. Examples of standard elements of the dictionary for a space flight project include:

Element 1: Project Management. The business and administrative planning, organizing, directing, coordinating, analyzing, controlling, and approval processes used to accomplish overall project objectives that are not associated with specific hardware or software elements. This element includes project reviews and documentation, non-project-owned facilities, and project UFE and funded schedule margins. It excludes costs associated with technical planning and management and costs associated with delivering specific engineering, hardware, and software products.

Element 2: Systems Engineering. The technical and management efforts of directing and controlling an integrated engineering effort for the project. This element includes the efforts to define the project space flight vehicle(s) and ground system and conduct trade studies. It includes the integrated planning and control of the technical program efforts of design engineering, software engineering, specialty engineering, system architecture development and integrated test planning, system requirements writing, configuration control, technical oversight, control and monitoring of the technical program, and risk management activities. Documentation products include requirements documents, Interface Control Documents (ICDs), the Risk Management Plan, and the master Verification and Validation (V&V) Plan. This element excludes design engineering costs.

Element 3: Safety and Mission Assurance. The technical and management efforts of directing and controlling the SMA elements of the project. This element includes design, development, review, and verification of practices and procedures and mission success criteria intended to assure that the delivered spacecraft, ground systems, mission operations, and payloads meet performance requirements and function for their intended lifetimes. This element excludes mission and product assurance efforts directed at partners and subcontractors other than a review or oversight function and the direct costs of environmental testing.

Element 4: Science/Technology. This element includes managing, directing, and controlling the science investigation aspects of the project as well as leading, managing, and performing the technology demonstration elements of the project. It includes the costs incurred to cover the Principal Investigator (PI), Project Scientist, science team members, and equivalent personnel for technology demonstrations. Specific responsibilities include defining the science or demonstration requirements; ensuring the integration of these requirements with the payloads, spacecraft, ground systems, and mission operations; providing the algorithms for data processing and analyses; and performing data analysis and archiving. This element excludes hardware and software for onboard science investigative instruments and/or payloads.

Element 5: Payload(s). This element includes the equipment provided for special purposes in addition to the normal Government Standard Equipment (GSE) integral to the spacecraft. This includes leading, managing, and implementing the hardware and software payloads that perform the scientific, experimental, and data gathering functions placed on board the spacecraft as well as the technology demonstration for the mission.

Element 6: Spacecraft. The spacecraft that serves as the platform for carrying payloads, instruments, humans, and other mission-oriented equipment in space to the mission destinations to achieve the mission objectives. The spacecraft may be a single spacecraft or multiple spacecraft or modules (i.e., cruise stage, orbiter, lander, or rover modules). Each spacecraft or module of the system includes the following subsystems, as appropriate: Crew, Power, Command and Data Handling, Telecommunications, Mechanical, Thermal, Propulsion, Guidance Navigation and Control, Wiring Harness, and Flight Software. This element also includes all design, development, production, assembly, test efforts, and associated GSE to deliver the completed system for integration with the launch vehicle and payload. This element does not include integration and test with payloads and other project systems.

Element 7: Mission Operations. Managing the development and implementation of personnel, procedures, documentation, and training required to conduct mission operations. This element includes tracking, commanding, receiving and processing telemetry, analyses of system status, trajectory analysis, orbit determination, maneuver analysis, target body orbit or ephemeris updates, and disposal of remaining EOM resources. This element does not include integration and test with the other project systems. (The same lower level WBS structure is often used for Mission Operation Systems during operations with inactive elements defined as "not applicable.")

Element 8: Launch Vehicle/Services. Managing and implementing activities required to place the spacecraft directly into its operational environment or on a trajectory towards its intended target. This element includes launch vehicle, launch vehicle integration, launch operations, any other associated launch services (frequently includes an upper-stage propulsion system), and associated ground support equipment. This element does not include the integration and test with the other project systems.

Element 9: Ground System(s). The complex of equipment, hardware, software, networks, and mission-unique facilities required to conduct mission operations of the spacecraft systems and payloads. This complex includes the computers, communications, operating systems, and networking equipment needed to interconnect and host the mission operations software. This element includes the design, development, implementation, integration, test, and the associated support equipment of the ground system, including the hardware and software needed for processing, archiving, and distributing telemetry and radiometric data and for commanding the spacecraft. This element also includes the use and maintenance of the project test beds and project-owned facilities. This element does not include integration and test with the other project systems and conducting mission operations.

Element 10: Systems Integration and Testing. This element includes the hardware, software, procedures, and project-owned facilities required to perform the integration and testing of the project's systems, payloads, spacecraft, launch vehicle and/or services, and mission operations.

Element 11: Education and Public Outreach. This element provides for the Education and Public Outreach responsibilities of NASA's missions, projects, and programs in alignment with the Strategic Plan for Education. It includes management and coordinated activities, formal education, informal education, public outreach, media support, and website development.

For major launch or mission operations ground development projects, the WBS may be different than for projects centered on a spacecraft. For example, the spacecraft element may be changed to reflect the ground project major deliverable product (such as a facility). Elements that are not applicable such as payload, launch vehicle and/or services, ground system(s), and mission operations (system) might not be used. A technology development space flight project's WBS would also look different.

5.9.4 Developing Level 3 and Subsequent Elements for the Project WBS

The elements that make up the third and subsequent levels of the project WBS should be selected to classify all the work associated with the Level 2 element from which it derives. There is no standard template for these lower levels, so the project should develop a structure that will fully characterize the work.

In accordance with *NASA/SP-2016-3404, NASA Work Breakdown Structure (WBS) Handbook*, Levels 3-7 should contain further definable subdivisions of the project-specific product structure contained in the Level 2 elements (e.g., subsystems, components, documents, functionality). There are numerous terms used to define Level 3 and succeeding levels of the WBS below the system level. Some typical examples used for hardware and software product elements are subsystem, subassembly, component, module, functionality, equipment, and part. Project management and other enabling organizational support products should use the subdivisions and terms that most effectively and accurately depict the hierarchical breakdown of project work into meaningful products.

5.9.5 Translating Work Breakdown into Funds

The following steps enable the project to translate work elements into the Agency's financial system:

- The Mission Directorate authorizes the project by issuing the **FAD**.
- The project team develops a high-level WBS, consistent with the NASA standard WBS, and documents the WBS in the **Formulation Agreement**.
- The project team inputs the project WBS into the Metadata Manager (MdM) database, which initiates the WBS process for approval of the WBS and allocation of funds.
- WBS approval enables resource management teams to allocate funds to specific WBS elements.

5.9.6 The Metadata Manager System

OCFO coordinates with the Mission Directorates to ensure the NASA programs and projects official list (The Agency Master Program/Project List (AMPL)) is maintained through MdM in accordance with *NPD 7120.4, NASA Engineering and Program/Project Management Policy*.

MdM is the Agency's official web-based tool for integrating master data across financial platforms. The codes representing all NASA programmatic and institutional WBS elements of programs and projects are established in MdM to be recognized as official NASA structures. The MdM system is a web-based Enterprise application that contains the Agency's official NASA Structure Management (NSM) data elements and associated attributes and codes. As the Agency's Enterprise repository for NSM data, MdM is used for identifying, creating, tracking, organizing, and archiving mission, theme, program, project, and WBS levels 2–7 NSM structural elements. As shown in Figure 5-27, MdM supplies NSM codes to the Agency's core financial system (Systems, Applications, and Products (SAP)), Agency budget database (N2), project management software system, and funds distribution systems (Work Instruction Management System) as they require coding structure data. WBS always refers to a structure starting with a 6-digit code, which occurs at Level 2 and below, within the Agency financial system.

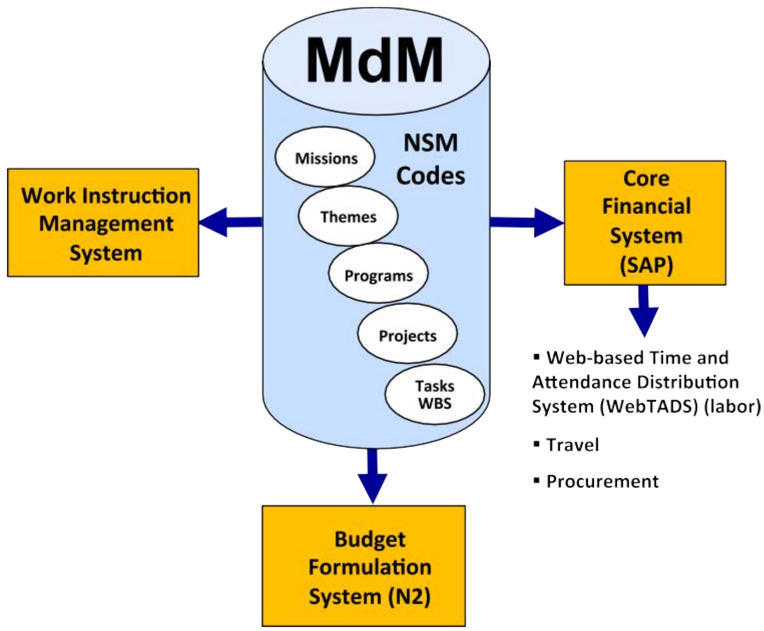


Figure 5-27 NASA's Central Repository for Enterprise Data, the Metadata Manager

MdM is the interface software application to load the WBS into SAP and the other applications including N2 for formulation. When a WBS element is approved in MdM it is automatically input into the SAP financial system. Approval for new WBS elements (including the project (Level 1)) is requested when the WBS is submitted. WBS requests to add new Level 1 and 2 elements are reviewed by several offices to ensure compliance with policy, guidance, and best practice. Programmatic WBS elements are governed by OCE (for NPR 7120.5 compliance) and the OCFO Budget Office. Institutional WBS elements are governed by the Mission Support Directorate (MSD) and the OCFO Budget Office. Each new WBS Level 1 or 2 request is routed to representatives from the affected Mission Directorate, the OCE, and then OCFO. Requests for MdM changes to WBS levels 3-7 are approved by the affected Mission Directorate.

WBS approval enables resource management teams to allocate funds to specific WBS elements, making them available for obligation of funds. The NSM data starts from the several appropriations and flows to the Mission Directorates, then themes, programs, and down to projects. Once funding is available, the business management software for NASA's financial transactions, the SAP software, and other Agency systems will recognize financial transactions to allocate funds to the WBS cost elements and enable civil servant labor and travel charges and acquisitions to proceed.

Table 5-5 shows the hierarchy of NSM coding. All obligations and costs can only be allocated at or below the 6-digit code level. As a way of identifying the difference between a project and an activity, the Agency financial system has the project manager, or equivalent, designate whether it is a project or activity when setting up a 6-digit code.

Table 5-5 NSM Coding Hierarchy and Description

NSM Code	NSM Specifications	NSM Example
Mission Code	4 alpha's, smart code*	SMD
Theme Code	2–4 alpha's, smart code	PROM
Program Code	4 alpha numeric (at least one alpha)	384A**
Project Code	6 digits, not smart coded	564815
WBS Level 2 Code	2 digits starting period delimiter Smart coded per NPR 7120.5	564815.11
WBS Level 3 Code	2 digits starting period delimiter	564815.11.01
WBS Level 4 Code	2 digits starting period delimiter	564815.11.01.13
WBS Level 5 Code	2 digits starting period delimiter	564815.11.01.13.21
WBS Level 6 Code	2 digits starting period delimiter	564815.11.01.13.21.09
WBS Level 7 Code	2 digits starting period delimiter	564815.11.01.13.21.09.02

* Smart codes refer to when the digits of the code have a meaning (e.g., are an acronym) rather than being random.

** Note there is no correlation between the program 4-digit codes and the first four digits of its project code.

5.9.7 Program WBS Work Elements

Programs are represented in the Agency financial system by 4-digit codes and do not have their own lower-level structure. The best practice for funding ongoing program functions is for the program to establish a separate 6-digit activity. There are no standard WBS data elements for activities. Program offices are appropriately different across the Agency depending on the missions. However, WBS guiding principles should be applied when a program manager establishes a carefully anticipated and planned program office WBS to support its functions. The program office can use the Level 2 (.01) code for "Program Management" or "Program Office." Common subordinate elements include Program Integration, Future Missions, Program Education/ Public Outreach, and Program Studies. Additional elements can always be added to a WBS. A WBS dictionary should be created to communicate the scope for each program WBS element.

5.10 Independent Standing Review Boards and Life-Cycle Reviews

This special topic provides program and project teams with an overview of the independent Standing Review Board (SRB), the Life-Cycle Review (LCR) and independent assessment processes, and the process for reporting the SRB's assessment of the program or project to the Decision Authority, typically in support of a Key Decision Point (KDP). NPR 7120.5F requires the program or project and an independent SRB to conduct most, but not all, LCRs as indicated with a red triangle in the life-cycle figures for each type of program and project in NPR 7120.5 and in Figures 3-1, 3-2, 3-3, and 4-1 in this handbook.[118,119] The program or project's Decision Authority, the MDAA, or the Center Director may also request an SRB to perform special reviews, such as Rebaseline Reviews or Termination Reviews. (For more information on Rebaseline Reviews, see Section 5.5.5.1.)

5.10.1 Standing Review Boards

The Agency assigns responsibility for independent reviews performed by SRBs to Mission Directorates (MDs) with support from the Centers. The MDs are responsible for independent reviews of all programs, all Category 1 projects, and Category 2 projects with a Life-Cycle Cost (LCC) greater than or equal to $365 million. Host Centers are responsible for independent reviews of Category 3 projects and Category 2 projects with a LCC less than $365 million. The Decision Authority may alter these criteria.

The SRB is a fundamental component of the Agency's checks and balances governance. The SRB is an independent advisory board in that it is chartered to assess programs and projects at specific points in their life cycle and to provide the program or project, the designated Decision Authority, and other senior management with a credible, objective assessment of how the program or project is doing relative to Agency criteria and expectations. The independent review also provides vital assurance to external stakeholders that NASA's basis for proceeding is sound.

The SRB is convened by the Convening Authorities specified in NPR 7120.5, Section 2.2.5.2, Table 2-2. Small Category 3, Class D projects with a LCC under $150 million may request tailoring of the Convening Authorities. This tailoring must be approved by the requirement owner, the Office of the Chief Engineer (OCE). Tailoring approval may be obtained using the project's compliance matrix or through a MD policy that has been coordinated with and approved by OCE. OCE approval should be noted in the MD policy and the MD policy should be referenced in the project's compliance matrix. (See Section 5.4 in this handbook for information on tailoring and the compliance matrix.)

[118] Life-Cycle Reviews (LCRs) that do not require an independent SRB are conducted by the Center Director or designee in accordance with Center practices.
[119] The Operational Readiness Review (ORR) is the last LCR the SRB routinely conducts. For supporting briefings after the ORR that lead to the KDP E, the SRB chair represents the SRB regarding the results of the ORR assessment.

The SRB is responsible for conducting assessments of the program or project at LCRs based on criteria defined in NPR 7120.5 and NPR 7123.1 and any additional criteria imposed by the Convening Authorities. The SRB is responsible for meeting all the evaluation objectives of the Convening Authorities at each LCR. The SRB's role in LCRs is assessment; it does not have authority over any program or project. The SRB's involvement with the programs and projects is minimal between LCRs.

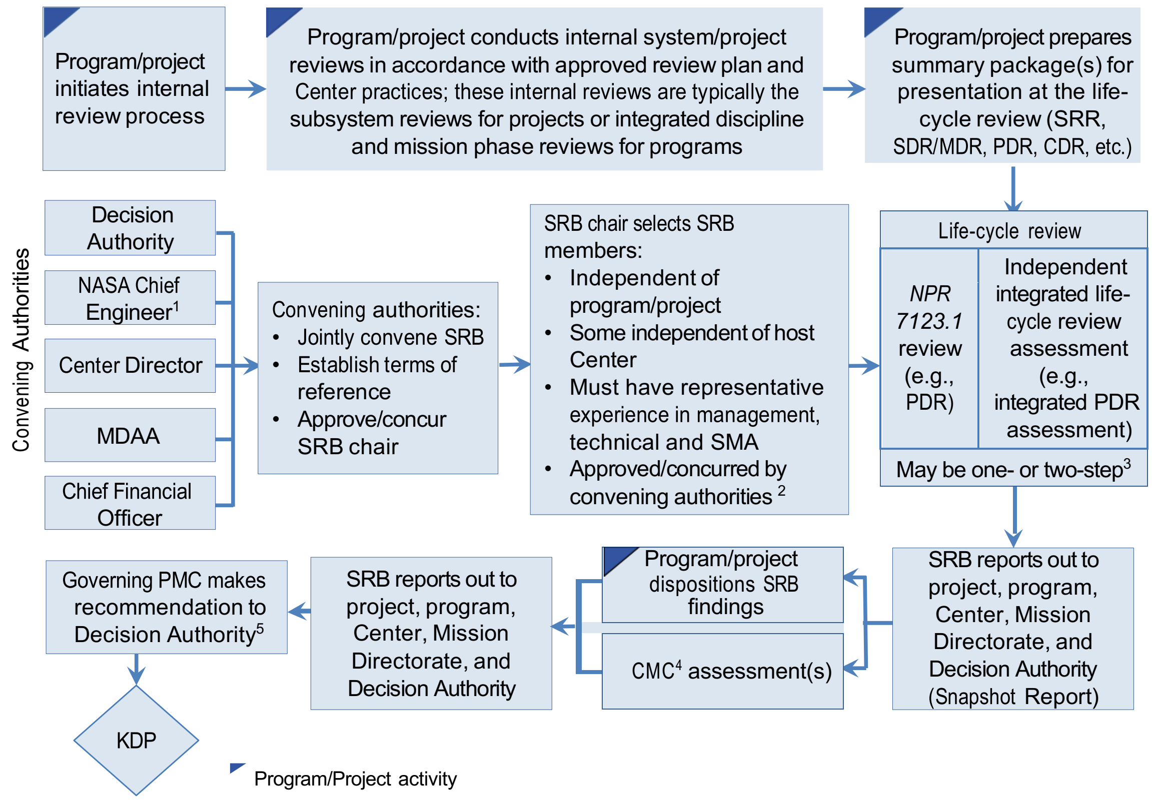
The independent SRB is a fundamental component of the Agency's checks and balances process. As former NASA Administrator Mike Griffin said, "You cannot grade your own homework." Independent experts review program and project "homework" with program and project members to find weaknesses that could turn into problems.

The scope, requirements, and assessment criteria for each LCR are documented in the Terms of Reference (ToR) approved by the Convening Authorities. The program or project works with the SRB in developing the ToR. For each LCR, the ToR describes the program or project's products that the SRB will use or review as part of its assessment and the timing of the delivery of the products. (See *NASA/SP-2016-3706, NASA Standing Review Board Handbook*[120] for a template of the ToR.)

The program or project manager, with assistance from the Mission Directorate and Technical Authorities, determines when the program or project will hold a LCR. The LCR assessment is based on the six assessment criteria defined in NPR 7120.5 and Sections 3.1.2 and 4.1.2 in this handbook, LCR entrance and success criteria defined in Appendix G of *NPR 7123.1, NASA Systems Engineering Processes and Requirements*, life-cycle products listed in Appendix I in NPR 7120.5F, and Tables 3-2, 3-3, 3-4, 3-5, 3-6, 4-6 and 4-7 in this handbook, and expected maturity states described in NPR 7120.5 and Appendix E of this handbook.

Figure 5-28 provides an overview of the SRB formation, program or project internal activities leading up to the LCR, and the LCR reporting activities leading up to the Key Decision Point (KDP).

[120] https://ntrs.nasa.gov/citations/20170000280



[1] The NASA chief engineer is not a convening authority for Category 3 projects.

[2]When applicable and at the request of the OCE, the OCHMO/HMTA determines the need for health and medical participation on the SRB.

[3]See Sections 3.1.2 and 4.1.2 for descriptions of one-step and two-step LCRs.

[4]May be an Integrated Center Management Council when multiple Centers are involved.

[5]Life-cycle review is complete when the governing PMC and Decision Authority complete their assessment.

Figure 5-28 Overview of Life-Cycle Review Process

Additional information on the SRB and on LCRs conducted by the SRB is provided in *NASA/SP-2016-3706, NASA Standing Review Board Handbook*, which provides guidance to the NASA program and project communities and the SRBs regarding the expectations, timelines, and working interfaces with NASA Mission Directorates, Centers, review organizations, and the program or project. The *NASA Standing Review Board Handbook* provides the philosophy and guidelines for the setup, processes, and products of the SRB, including SRB roles and responsibilities and processes for forming the SRB and vetting the SRB chair, board members, and expert consultants to the board for Conflicts of Interest. The *NASA Standing Review Board Handbook* is available on the OCE website. It can be accessed by going to NODIS, Office of the Chief Engineer's section under the "Other Policy Documents" tab.

5.10.2 Life-Cycle Reviews and Independent Assessment

Life-Cycle Reviews (LCRs) are designed to provide the program or project with an opportunity to ensure that it has completed the work of that phase and to provide an independent assessment of the program or project's technical and programmatic progress, status, and health against Agency criteria. The independent assessment serves as a basis for the program or project and management to determine if the work has been satisfactorily completed and if the plans for the following life-cycle phases are acceptable. If the program or project's work has not been satisfactorily completed or its plans are not acceptable, the program or project addresses the issues identified during the LCR or puts in place the action plans necessary to resolve the issues.

The program or project finalizes its work for the current phase during the LCR. In some cases, the program or project uses the LCR meeting(s) to make formal programmatic and technical decisions necessary to complete its work. In all cases, the program or project uses the results of the independent assessment and the resulting management decisions to finalize its work.

All life-cycle reviews assess the program or project's technical maturity, programmatic posture, and alignment with the Agency's six assessment criteria. The full assessment can be completed in one step, called a one-step review, or divided into two separate steps, called a two-step review. The program or project manager has the authority to determine whether to hold a one-step review or a two-step review. This determination usually depends on the state of the program or project's cost and schedule maturity. Any LCR can be either a one-step review or a two-step review. The program or project manager documents the review approach in the program or project Review Plan. The ToR also documents the type of review: one-step or two-step.

Descriptions of the one-step and two-step life-cycle review processes are provided in Sections 3.1.2 and 4.1.2 of this handbook and in *NASA/SP-2016-3706, NASA Standing Review Board Handbook*.

5.10.2.1 Conducting the Life-Cycle Review

As a prerequisite for scheduling a Life-Cycle Review (LCR), the program or project manager, the SRB chair, and the Center Director or designated Engineering Technical Authority (ETA) representative mutually assess the program or project's expected readiness for the LCR. This is a discussion, not a review. This assessment is conducted to ensure that the program or project is likely to reach the required state of maturity by the proposed date for the review. The program or project manager, the SRB chair, and the Center Director or designated ETA representative discuss the program or project's maturity with respect to entry criteria, gate products, and the expected states of maturity. The SRB chair's determination of readiness and any disagreements are reported to the Decision Authority for final decision. When the program or project manager judges that extenuating circumstances warrant proceeding with the LCR, even though some maturity expectations will not be met by the time of the review, the program or project manager is responsible for providing adequate justification to the Decision Authority for holding the LCR on the recommended date. The readiness assessment occurs approximately 30 to 90 calendar days prior to the proposed date for the LCR.

In preparation for the LCR, the program or project generates the appropriate documentation per NPR 7120.5 Appendix I, NPR 7123.1, and Center practices as necessary to demonstrate that the program or project's definition and associated plans are sufficiently mature to execute the follow-on life-cycle phase(s) with acceptable safety, technical, and programmatic risk.

During the LCR, the program or project presents its status through sequential briefings for each agenda topic, typically given by the program or project lead. The presenters answer questions from the SRB members in real time if possible. If further detail is required, the program or project may offer to provide the necessary information later in the review or arrange a splinter session in parallel with additional presentations.

The depth of a LCR is the responsibility of the program or project manager and the SRB. The depth needs to be sufficient to permit the SRB to understand whether the design holds together adequately and whether the analyses, development work, systems engineering, and programmatic plans support the design and key decisions that were made. The SRB reviews the program or project's technical and programmatic approach, cost and schedule estimates, risk, performance, progress against plans, and status with respect to success criteria and expected maturity states in NPR 7120.5F, NPR 7123.1, and this handbook.

5.10.2.2 Reporting the Results of the Life-Cycle Review

Rapid reporting to the Convening Authorities and the Decision Authority following the Life-Cycle Review (LCR) is essential to an efficient and effective review process. As a result, the SRB chair provides a summary of his or her preliminary findings to the Decision Authority no later than 48 hours after the LCR is concluded. This summary is known as the snapshot report (see Figures 3-4, 4-3, and 4-4 in this handbook). The SRB chair provides a draft of the snapshot report to the program or project manager prior to the snapshot teleconference so they are informed and can be prepared to comment or respond. For a one-step review process, one snapshot report is required. For a two-step review process, a snapshot report is required after each step.

After the snapshot report, the SRB finalizes its findings and recommendations. The SRB's fundamental product is its assessment of whether the program or project meets the six assessment criteria. With this comes the recommendation to advance the program or project into the next life-cycle phase or to hold the program or project in the current phase. If the SRB recommends advancing the program or project with qualifications, the SRB will explain the qualifications and why these areas need not delay advancing the program or project to the next life-cycle phase. If the SRB does not recommend advancing the program or project, the SRB provides the rationale. The SRB provides its final findings and recommendations to the program or project manager, and the program or project manager prepares his or her final responses to the SRB's findings and recommendations. The program or project manager's response includes concurrence or nonconcurrence with the SRBs findings, associated rationale, and plans for addressing SRB findings.

Prior to presentation to the program or project's governing PMC in support of the KDP, the SRB and the program or project present the SRB findings and recommendations and the program or project responses to the responsible Center CMC. For programs and for projects whose governing PMC is the APMC, the SRB and program or project also present to the Mission Directorate DPMC.

The SRB findings and recommendations and the program or project response are provided to the Convening Authorities and Decision Authority prior to the KDP. If the KDP scheduled date is significantly more than 30 days after the LCR concludes, a checkpoint may be required (see Figures 3-4, 4-3, and 4-4 in this handbook). At a checkpoint, the program or project manager describes to the Decision Authority the detailed program or project plans for significant decisions, activities, and commitments. The Decision Authority provides the program or project with interim authorization, guidance, and direction. For a one-step review, the Decision Authority may require a checkpoint when the KDP is estimated to be more than 30 days after the conclusion of the LCR. For a two-step review, the Decision Authority may require a checkpoint when the KDP is estimated to be significantly more than 30 days after the second step, or when the second step is estimated to occur more than 6 months after the first step. During the period between the LCR and the KDP, the program continues its planned activities unless otherwise directed by the Decision Authority.

The SRB findings and recommendations and the program or project response are presented to the program or project's governing PMC in support of the KDP. The Decision Authority reviews all the materials and briefings at hand, including briefings from the program or project team and the SRB, to make the KDP decision about the program or project's maturity and readiness to progress through the life cycle and authorizes the content, cost, and schedule parameters for the ensuing phase(s). (See Sections 3.2.3 and 4.2.3 for a more detailed description of a KDP.)

A life-cycle review that occurs at the end of a life-cycle phase is complete when the governing PMC and Decision Authority complete their assessment and sign the Decision Memorandum.

5.11 Other Reviews

Special reviews may be convened by the Office of the Administrator, Mission Directorate Associate Administrator (MDAA), the Technical Authorities (TAs), or other Convening Authority. (See Section 5.2 for more information on Technical Authorities.)

Special reviews, which include a Rebaseline Review and Termination Review, may be warranted for projects not meeting expectations for achieving technical, cost, or schedule requirements; not being able to develop an enabling technology; or experiencing some unanticipated change to the project baseline. In these cases, the authorizing official(s) forms a special review team composed of relevant members of the Standing Review Board (SRB) and/or additional outside expert members, as needed. The chair for these reviews is determined by the Convening Authority, who provides either Terms of Reference (ToR) or a Memorandum of Understanding (MOU) to the chair to govern the review. The process followed for these reviews is the same as for other reviews unless modified in the ToR or MOU. The special review team is dissolved following resolution of the issue(s) that triggered its formation. (For more detail on Rebaseline Reviews, see Section 5.5.5.1.)

Other reviews are part of the regular management process. For example, Safety and Mission Assurance (SMA) Compliance Verification reviews are spot reviews that occur on a regular basis to ensure projects are complying with NASA safety principles and requirements (see Section 5.11.2.). Program Implementation Reviews (PIRs) are intermittent SRB reviews requested by the NASA AA or the MDAA to assess program progress and the program's continuing relevance to the Agency's Strategic Plan. (See Section 5.11.3.)

Programs and projects may be subject to other reviews by organizations internal and external to NASA, for example, procurement, the NASA Office of the Inspector General (OIG), and the U.S. Government Accountability Office (GAO).

5.11.1 Termination Review

A program or project can come to an end in different ways. One way is through a special Termination Review when it is recommended by a Decision Authority, MDAA, or program executive who believes the Government's best interest is not served by continuing to fund the program or project. A recommendation is presented to the governing PMC. Circumstances that could trigger a Termination Review include the anticipated inability of the program or project to meet its commitments, an unanticipated change in Agency strategic planning, or an unanticipated change in the NASA budget.

A Termination Review usually concerns a program or project in operations. For a program or project in Formulation, it may be called a Confirmation or Continuation Review; for a program or project in development, a Cancellation Review. The Program and Project Plan needs to have defined the program- or project-specific top-level requirements and criteria that, if not met, could trigger a Termination Review.

The Decision Authority notifies NASA's Associate Administrator (AA), the Associate Administrator for Legislative and Intergovernmental Affairs, and the Chief Financial Officer prior to conducting the review. Initiating a termination decision process generally includes an internal independent evaluation of the program or project by the SRB or a specially appointed independent team of experts. In addition, the Decision Authority may also request an outside assessment by an independent organization.

The Decision Authority convenes the Termination Review, at which the SRB or specially appointed independent team and the program and/or project team(s) present status, including any material the Decision Authority requests. If a separate, external independent assessment is commissioned, the results of that assessment are also reported. In addition, a Center Technical Authority (TA) presents an assessment. For tightly coupled programs with multiple Centers implementing the projects, an Office of the Chief Engineer (OCE) assessment is presented by the TA. Appropriate support organizations are represented (e.g., procurement, external affairs, legislative affairs, Office of the Chief Financial Officer (OCFO), and public affairs) as needed. The SRB or the appointed independent assessment team that performs the Termination Review and program/project report at a Governing Program Management Council (i.e., APMC or DPMC) meeting during which the DA decision is made whether to terminate and/or any follow-up actions resulting from the review.

In the event a Termination Review takes place in the lifecycle prior to the nominal end of the mission, in preparation for the Governing Program Management Council meeting the Program/Project prepares to inform the council and DA on key aspects of potential termination and closeout impacts to the Agency, Center, Mission Directorate, and Program/Project that need to be considered before the final decision to terminate is made. Including:

1. Identify potential impacts and cancellation notifications related to external stakeholders before the decision to terminate the program/project is made, e.g., a congressional mandate to perform the program/project, which would require NASA to pursue external coordination to cancel the program/project.
2. Closeout of contracts, partnerships and significant financial obligations.
3. Identify additional impacts outside of the project because of termination. For example, contract fee or wrap factor impacts for any remaining contract tasks not indirectly related to the project termination.
4. Workforce transitions following termination, including Civil Servant and contractor workforce, including support contractors.
5. Closeout and transition of flight hardware plan and, if applicable, associated significant facility and equipment.
6. Initial Cost Estimate and schedule to complete the closeout of the program/project

If the decision is made to terminate the program/project, the details of the key aspects noted above will be included as part of the closeout plan. Aspects to consider for the full closeout plan are included at the end of this section.

Termination Reviews are not undertaken lightly. The Decision Authority may give the program or project time to address deficiencies. He or she may allow a program or project to proceed to its Implementation Key Decision Point (KDP) (I or C) and allow the decision to be part of the KDP decision, which always includes termination or cancellation as an option. Termination after Implementation has greater implications than before Implementation.

A decision to terminate a program or project is recorded in a termination Decision Memorandum. (If projects are terminated, this would also be reflected in the Program Commitment Agreement (PCA).) Whether the termination decision occurs as part of a KDP or part of a special review, the memorandum documenting the decision to terminate needs to include a signature page indicating that all signatories acknowledge the decision, without necessarily agreeing to it. The decision and the basis for the decision are fully documented and generally reviewed with the NASA Administrator prior to final resolution.

Programs or projects might not go forward for different reasons. In the case of the Spectroscopy and Photometry of the Intergalactic Medium's Diffuse Radiation (SPIDR) Small Explorer project, the principal investigator determined during Phase B that the project would not be able to meet the Level 1 requirement for resolution on their proposed data collection. For Gravity and Extreme Magnetism Small Explorer (GEMS), cost overruns and schedule slips plagued the project. Efforts to resolve technical issues were unsuccessful through Phase B, and the project was not approved to go to Implementation.

When a decision to terminate is made, several steps need to be followed. The decision is communicated to mission stakeholders. Generally, the NASA Administrator and Associate Administrator (AA), who is the Decision Authority for programs, are already involved in the process. Where decision authority resides at the MDAA level and the NASA

Administrator or AA has not yet been involved in the process, he or she needs to be informed. For all program and project missions in operations, across directorates, termination is handled in accordance with *NPD 8010.3, Notification of Intent to Decommission or Terminate Operating Space Systems and Terminate Missions*. For an operating mission, NPD 8010.3 requires that the NASA Administrator is notified of the intent to terminate at least 90 days in advance of the termination. (For additional details, see NPD 8010.3.)

The Chief Financial Officer and Associate Administrator for Legislative and Intergovernmental Affairs may also have participated in the process. If not, they need to be informed of the intent to terminate. The Office of Legislative and Intergovernmental Affairs (OLIA) is responsible for meeting the Agency's obligations to Congress in this situation.

The reprogramming requirements specified in Section 505 of the General Provisions of annual Commerce, Justice, Science, and Related Agencies' appropriations acts require that NASA notify the House and Senate Committees on Appropriations of a decision to terminate a program or project 15 days in advance of the termination.

OLIA is responsible for notifying the Committees on Appropriations pursuant to this reprogramming requirement. Protocol dictates, and it is in the Agency's interest, that such notification to the Committees on Appropriations and expiration of the 15-day notification period take place before there is public release of information regarding any termination of a program or project.

Once these official communications have been handled, it is important to ensure that all other affected parties are informed, potentially including partners, members of international or interagency partnerships, parties to MOUs in effect, mission science team partners, and mission operations team partners. The program or project executive (or equivalent) needs to ensure that other program or project executives (or equivalents) are notified and can inform their projects, and that the appropriate lessons learned are captured in an archive such as the online Lessons Learned Information System.

The program or project needs to have in place a Decommissioning Plan for disposal of program or project assets. This plan will need to be reviewed and finalized in accordance with the directions accompanying the termination decision and with approval of the MDAA, program and project managers, and/or program or project executive (or equivalent). For programs or projects in operations, on-orbit elements of the plan are reviewed and concurred with by the Office of Safety and Mission Assurance (OSMA) for orbital debris and other risk components.

Key aspects to consider for the program/project closeout reviews, documentation and content for a closeout plan are listed below, applicable to both nominal end of mission and termination that occurs earlier in the life cycle. These may need to be tailored depending on what point in the life cycle the termination occurs and the state of the program/project at that point in time.

Reviews and Documentation:

1. NPR 7123, Appendix G, Decommissioning Review (DR)and Disposal Readiness (DRR)Review Entrance and Success Criteria
2. NPR 7120.5, Appendix C and Appendix I, Program and Project Products required for DR and DRR

Closeout Plan Content:

1) Mission Overview
   a) Cancellation/Closeout Decision
   b) Purpose and overview
      i) Ensure alignment with Congressional and NASA stakeholder direction regarding remaining budget, continued development, and disposition of all hardware, software, ground support equipment (GSE), and documentation.
      ii) Examine/Determine approach for disposition of hardware including potential alternative use of the project assets and/or transition to other organizations.
      iii) Identify any guiding parameters for the closeout
         (1) Leadership identification for closeout
            (a) Roles and responsibility identification
         (2) Examples including capping contract values, if applicable
         (3) Identify mission/project closeout end date milestone target.
2) Property, records, IT Transition
   a) Technical Priority Identification
   b) Packing and Shipping Plans
      i) Basis of Estimation for new packing, shipping, and storage content created by closeout.
      ii) Develop and implement a Packing, Handling, Storage, and Transportation (PHS&T) Plan and Procedures document.
         (1) The PHS&T Plan and Procedures shall describe the plan and all step-by-step procedures for the packaging, handling, storage, and transporting the contract deliverables, ground support equipment, and spares.
         (2) The PHS&T Plan and Procedures shall, at a minimum, incorporate the following:
         (3) Identification of environmental conditions to be adhered to, including vibration/shock, temperature, humidity, cleanliness, and the controls to be implemented to maintain those conditions.
         (4) Requirements for testing.
         (5) Requirements for personnel, tools, equipment, handling fixtures, and containers, including:
         (6) Specific procedures for use of system/subsystem protective covers.
         (7) Method of transportation and carrier, if applicable.
         (8) Cargo manifest including aircraft layout diagrams, if applicable.
         (9) Ground and/or air shipment cargo loading and unloading procedures.
         (10) Staging area plans and diagrams.
         (11) Trip planning schedule of events, required support, route, contingency plans, permits.
         (12) Procedures to comply with local, state, and federal safety requirements.
         (13) Procedures for maintaining contract with the transported item.
3) Contract Closeout

a) Conduct a "Closeout Review" following the technical completion related to contract closeout as part of an acceptance process.
   i) Collaborative process between NASA, and contracted parties to determine status, need for updates/tailoring, and final listing needed for closeout.
   ii) Examine DRL/DRDs associated with current contracts are required; content should be tailored based on final state of instrument effort.
   iii) All documentation must be archived, including DRL/DRDs and items such as drawings, models (structural, thermal, optical, mechanical), analyses, trade studies, engineering reports, test reports, etc.
   iv) Determine appropriate documentation depository.

4) Document Lessons Learned
5) Management and Oversight
   a) Management of closeout activities
   b) Workforce (FTE and WYE) transition plan
   c) Full Cost Reporting
      i) Formulation and develop up to closeout Decision.
      ii) Closeout Budget and Cost Plan
   d) Closeout Schedule
6) Copy of Closeout Decision Memorandum (DM)

5.11.2 SMA Compliance Verification Reviews

NASA Headquarters SMA has a process that provides independent compliance verification for the applicable NASA SMA process and technical requirements within the program or project Safety and Mission Assurance Plan, the program or project baseline requirements set, and appropriate contract documentation. (See *NPR 8705.6, Safety and Mission Assurance (SMA) Audits, Reviews, and Assessments* for more detail.) This process includes the following SMA audits and assessments:

Quality Audit, Assessment, and Review. This audit is conducted to provide independent verification of compliance with NASA SMA quality and software assurance requirements contained in and related to SMA NPDs, NPRs, and NASA standards. It provides independent verification that each NASA Center, program, and project complies with applicable requirements. See NPR 8705.6, Appendix D for a list of documents included in these audits.

Requirement Flow Down Review. This review provides independent verification of the flow down of NASA SMA requirements into NASA programs and project documentation, including requirements flow down to external developers and suppliers in acquisitions (e.g., contracts and purchase orders).

Safety and Mission Success Review (SMSR). This review prepares Agency safety, engineering, and health and medical management to participate in program or project final readiness reviews preceding flights or launches, including experimental and/or test launch vehicles or other reviews as determined by the Chief, Safety and Mission Assurance. The SMSR provides the knowledge, visibility, and understanding necessary for senior safety, engineering, and health and medical management to either concur or nonconcur with program or project decisions to proceed with a launch or significant flight activity.

5.11.3 Program Implementation Review (PIR) Guidance

As discussed in Chapters 2 and 3, programs follow a life cycle that requires various Life-Cycle Reviews (LCRs) and Key Decision Points (KDPs). Once a program is in Implementation, the NASA AA or MDAA may request that the program go through periodic Program Implementation Reviews (PIRs) followed by a KDP where the results of the review are considered, and the program is authorized to continue to the next phase in Implementation.

The need for a PIR to assess the program's performance, evaluate its continuing relevance to the Agency's Strategic Plan, and authorize its continuation is determined in one of two ways:

1. The NASA AA determines the need for a PIR based on the occurrence of a trigger and discussion with the Convening Authorities. The MDAA or an independent team member (Technical Authorities (TAs), OCFO) report to the NASA AA that a trigger for discussing the need for a PIR has occurred. This is reported at the Agency Program Management Council (APMC) during the annual review of Mission Directorate Independent Assessment Manifests; or
2. The NASA AA or MDAA, at his or her discretion, determines that a PIR is needed.

Considerations that trigger a discussion on the need for a PIR include significant changes to the program (internally or externally driven) and/or planned outcomes not being achieved that signal the need to assess program performance with respect to expectations and determine the program's ability to execute the implementation plan. Examples of significant changes to the program include:

- Significant changes to Agency policy and direction create the need to ensure continued alignment with Agency goals and objectives and evaluate potential adjustments to program objectives and plans to increase support for Agency needs.
- Significant changes to interagency and/or international agreements involving the ability of NASA and/or its partners to meet their commitments.
- Significant changes to the acquisition approach, including contractors and Center roles and responsibilities.
- Significant changes to the budget profile.
- Significant changes to the program's constituent project(s) that impact the program and other projects.
- Unplanned scope or direction changes such as major changes in operations (e.g., step-up in capability); changes in management approach (e.g., giving mission operations responsibility to a private entity); and transition to extended operations.
- High interest from an external stakeholder, advisory committee, and/or audit organization in the program due to significant changes.

Examples of indicators that planned outcomes are not being achieved include:

- Not meeting performance goals (e.g., Agency Priority Goals).
- Not meeting or at risk of not meeting external or internal commitments (e.g., Space Policy Directives, interagency and/or international agreements, cross-NASA-Center commitments) or negative customer and/or partner feedback.
- Exceeding or at risk of exceeding cost or schedule plans.
- Failing to make progress toward or failing to achieve Level 1 requirements.
- Carrying significant unmitigated risks.
- Recurring or unusual requests for additional funding.
- Systemic issues. (These could reflect systemic issues across projects within the program.)
- Significant external and/or congressional interest in the program (e.g., heightened external sensitivity, more inquiries than normal to the Agency, significant external stakeholder focus) or actions and/or recommendations from external advisory committees or audit organizations such as the NASA Aerospace Safety Advisory Panel (ASAP), the NASA Advisory Council (NAC), the U.S. Government Accountability

Office (GAO), or the NASA Office of the Inspector General (OIG) identifying areas that need further investigation.

The PIR is an independent LCR that is conducted by a Standing Review Board (SRB) following the standard independent review process protocols described in Section 5.10. The purpose of the PIR is to periodically evaluate the program's continuing relevance to the Agency's Strategic Plan, assess performance with respect to expectations, and determine the program's ability to execute the implementation plan with acceptable risk within cost and schedule constraints. The results of the review are reported to the APMC and the NASA AA to show whether the program still meets Agency needs and is continuing to meet Agency commitments as planned.

Programs within NASA vary significantly in scope, complexity, cost, and criticality and as a result, the scope of the PIR varies depending on the program type: uncoupled, loosely coupled, tightly coupled, and single-project programs. Each PIR is designed to best enhance the probability of success for the program undergoing review and to enable the SRB to gather the required information. The information and products to be reviewed and the review agenda result from a collaborative process that includes the program, the SRB, and the NASA AA and MDAA.

5.12 External Reporting

This special topic describes some of NASA's ongoing, high-level reporting to the White House and Congress of program and project decisions, technical performance, baselines, and cost and schedule estimates.

The quality and consistency of NASA's technical, cost, and schedule reporting is critical to the Agency's budget and its future. Federal agencies, including NASA, are part of the Executive Branch and report on their performance to the White House through the Office of Management and Budget (OMB). Federal agencies are also required to report on their performance directly to Congress in various ways, including through their budget submissions. The U.S. Government Accountability Office (GAO), as the audit, evaluation, and investigative arm of the Congress, assesses NASA technical, cost, and schedule performance along with that of other Federal agencies.

Because reporting requirements change over time and data can be requested by Congress, the OMB, GAO, or the NASA Office of the Inspector General (OIG) at any time, the reporting described in this section is not a complete description of all the reporting that might be required of programs and projects.[121]

Section 5.12.1 provides background information on the conditions that led to many of NASA's external reporting requirements. Section 5.12.2 outlines NASA's integrated data collection and reporting process and includes a description of the data that programs and projects provide in support of the external reporting requirements. Section 5.12.3 describes the major reports that NASA provides to Congress, GAO, and OMB. Section 5.12.4 discusses NASA's internal use of the data collected in support of external reporting requirements.

5.12.1 Conditions Leading to External Reporting Requirements

A 2004 GAO study[122] concluded that a lack of disciplined project cost estimating at NASA was resulting in project management problems, schedule slippage, and cost growth. In reaction, Congress created an external reporting requirement in the NASA Authorization Act of 2005, i.e., the Major Program Annual Report (MPAR). MPAR requires NASA to report on projects in development with an estimated Life-Cycle Cost (LCC) exceeding $250 million. Projects of this size in Formulation are also subject to this report if they have awarded contracts of $50 million or more with development content. Congressional

[121] The NASA Office of the Chief Financial Officer (OCFO) Strategic Investments Division (SID) maintains a Cost and Schedule community of practice page with updated information (including external reporting) at: https://max.omb.gov/community/x/TQePJg. Contact OCFO to request access.

[122] GAO-04-642, "NASA: Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management." https://www.gao.gov/assets/gao-04-642.pdf

appropriations language also requires NASA and some other agencies to report if the LCC of projects with an LCC greater than $75 million grows by 10 percent or more.[123]

As a result of the congressional action, in part, the *National Security Presidential Directive (NSPD) 49, U.S. National Space Policy*[124] establishes OMB responsibility for assessing technical, cost, and schedule performance for major space projects. In addition, all appropriations since FY 2008 have included direction for GAO to "identify and gauge the progress and potential risks associated with selected NASA acquisitions."[125] This has resulted in GAO's annual "Assessment of Large-Scale NASA Programs and Projects," the audit known internally as the *Quick Look Book*.[126]

Some reporting requirements, such as the Annual Performance Plan (APP), are Government-wide to meet guidance in *OMB Circular A-11, Preparation, Submission and Execution of the Budget*.[127]

5.12.2 Integrated Technical, Cost, and Schedule Data Collection and Reporting Process

NASA's Chief Financial Officer (CFO) is responsible for ensuring that the Agency meets its congressional and White House program and project performance reporting requirements. The Office of the Chief Financial Officer (OCFO) works with Congress, GAO, and the Office of Management and Budget (OMB) to align those organizations' technical, cost, and schedule reporting requirements with NASA's existing processes to facilitate streamlined reporting. For example, NASA has established a standard basis for the congressional MPAR and OMB NSPD-49 reports. NASA also uses the KDP Decision Memorandum and a single quarterly data call to the Mission Directorates to collect the information needed to generate the various required reports. A number of reports are incorporated directly into NASA's budget submission to Congress to minimize the workload.

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[123] Section 530 of the appropriations language requires managers of projects with an LCC over $75 million that are in the Departments of Commerce or Justice, the National Aeronautics and Space Administration, or the National Science Foundation to report the increase. NASA must notify the House and Senate Committees on Appropriations within 30 days, including the date on which such determination was made; a statement of the reasons for such increases; the action taken and proposed to be taken to control future cost growth of the project; changes made in the performance or schedule milestones and the degree to which such changes have contributed to the increase in total program costs or procurement costs; and new estimates of the total project or procurement costs.

[124] National Security Presidential Directive 49: U.S. National Space Policy, 31 August 2006. https://irp.fas.org/offdocs/nspd/space.html

[125] FY 2008 House Appropriations Report H.R. 2764 (P.L. 110-161)) https://www.congress.gov/bill/110th-congress/house-bill/2764

[126] GAO-20-405, NASA: Assessments of Major Projects. April 2020. https://www.gao.gov/assets/gao-20-405.pdf

[127] https://www.whitehouse.gov/omb/information-for-agencies/circulars/

Figure 5-29 depicts NASA's integrated process for collecting project technical, cost, and schedule data and developing reports:

- KDP Decision Memoranda and accompanying documents (datasheet and KDP report) are provided to OCFO's Strategic Investments Division (OCFO/SID) and serve as the starting point for reporting.
- OCFO/SID issues a quarterly data call to collect updates to the datasheet information as required for one or more of the required reports. This data call provides guidance to the Mission Directorates, which collect and verify project submissions and forward the submissions to OCFO.
- OCFO/SID extracts the specific rolled-up information required for each report. If a more detailed report is required for an individual project because it entered Implementation or exceeded a key threshold during the previous quarter, SID supports the Mission Directorate in preparing the more detailed report.
- OCFO transmits reports that go to OMB and GAO.
- For threshold reports and any other reports that go to Congress, OCFO/SID provides the final report to the NASA Office of Legislative and Intergovernmental Affairs (OLIA), which transmits the signed report to Congress. OLIA also transmits breach notifications to Congress.

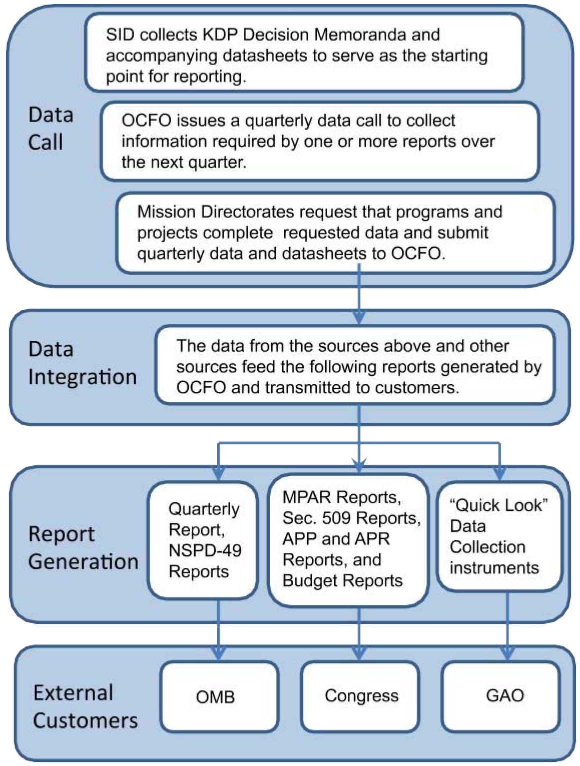

Figure 5-29 Integrated Technical, Cost, and Schedule Data Collection and Reporting Process

OCFO/SID maintains a record of data and reports provided to Congress, GAO, and OMB on its Cost and Schedule community of practice page.

5.12.2.1 Quarterly Data Call

The quarterly data call uses a datasheet to collect core data common to many reports and to collect data necessary for explaining any differences between a project's cost estimate and its budget request. OCFO/SID modifies the datasheet, if necessary, when there are changes to external reporting or Agency policy. The core data elements collected through the quarterly data call are as follows:

- **Current Estimate.** The project's Life-Cycle Cost (LCC), which includes Phase A through Phase F costs. For projects with an LCC greater than $250 million, the LCC is initially reported as an estimated range at KDP B. At KDP C, the LCC is the Agency Baseline Commitment (ABC). Costs are broken out by year and by whether they are Formulation (Phases A and B), development (Phases C and D), or operations (Phases E and F) costs.
- **Baseline.** LCC/ABC at KDP C.

- **Development Cost.** The project's costs while the project is in Phase C or D. Costs are by Work Breakdown Structure (WBS) element as well as by year during development.
- **Schedule.** Key milestones, including KDPs and Life-Cycle Reviews (LCRs).
- **Contract Value.** Total award value and current value for awarded contracts with development content within exercised options. The value of contract options is included separately.

5.12.2.2 Additional Data Collected from Projects

Specific projects may be required to provide additional information for the GAO *Quick Look Book* and for other external reporting purposes such as baseline and threshold reports.

The GAO uses its Data Collection Instrument (DCI) to gather data for its *Quick Look Book*. There are five separate GAO DCIs for each project in the Quick Look audit; Cost, Schedule, Project, Contract, and Software. SID completes the Cost and Schedule DCIs. Projects complete the Project DCI and, in conjunction with OCE, the Software DCI. The Office of Procurement completes the Contract DCI. (See Table 5-8.) Agency coordination of audit activities is provided by the Mission Directorate Audit Liaison Representative (ALR) and the NASA audit lead in the NASA Office of Internal Controls and Management Systems (OICMS).

When additional information is required, the rules of engagement are negotiated with GAO at the beginning of each audit. OCFO/SID works with GAO to ensure that the Cost and Schedule DCI reporting and additional GAO reporting are closely coordinated. Requests for technical data are issued directly to the projects with notification to the program executive, the Mission Directorate ALR, and the NASA audit lead. Requests for baseline and threshold reports are issued to the NASA audit lead.

Cost information reported to Congress and OMB includes all UFE, whether it is held and managed at the project level or above. While UFE and schedule margin are not broken out in the DCIs, GAO does receive this information separately.

5.12.3 Major Cost and Schedule Reports Provided to Congress and OMB

Table 5-6 identifies major reports provided to Congress (MPAR, 10 Percent Cost Growth Report, Threshold Report, KDP B Cost Range Report, and OMB Circular A-11) and OMB (NSPD-49). Table 5-7, External Reporting Requirements for GAO, identifies major reports provided to GAO (*Quick Look Book*). The tables include details on report contents, when the reports are required, and applicable projects. The MPAR and NSPD-49 Reports include common components: Current Estimate and Baseline.

Table 5-6 External Reporting Requirements for Congress and OMB

Report Name	Report Component	Cost and Schedule Content	Technical Content	Sources of Data	Congress	OMB
Major Program Annual Report (MPAR) (Applicable to projects in development with LCC > $250 million)	Current Estimate (Annually with budget submission)	Current estimated cost and schedule after KDP C, phased by WBS down to Level 2, with changes to baselines for LCC, development costs, key life cycle milestones and risks	Project purpose, major systems, contributions from participating partners, Center project management roles, acquisition strategy, risk management, with changes to risks and technical parameters	Datasheet, Quarterly Data Call	Annually (included in NASA's annual budget to Congress)	Reviewed by OMB
	Baseline (KDP C)	(1) ABC at KDP C	Project purpose, major systems, contributions from participating partners, Center project management roles, acquisition strategy, risk management	(1) KDP C Decision Memorandum, (2) Datasheet, Quarterly Data Call for Contract Baseline	Annually (included in NASA's annual budget; if a project rebaselines, report may be required before next budget)	Reviewed by OMB as part of NSPD-49 submission (see below)
NSPD-49 Report (Applicable to (1) projects in development with LCC > $250 million; (2) projects in Formulation with LCC > $250 million and awarded contract of >$50 million with development content.)	Current Estimate	(1) Same as MPAR (2) Contract values	None	Quarterly data call		Quarterly
	Baseline (1) KDP C (2) Contract award date.	(1) Same as MPAR (2) Contract value.	(1) Same as MPAR (2) None	(1) KDP C DM & supporting documentation (2) Quarterly data call		(1) Quarter following KDP C (2) Quarter following award of contract.
Threshold Report (Applicable to projects in development with LCC >$250 million and satisfies NSPD-49 and MPAR requirements)	Notification (When development cost growth > 15 percent of development cost in the ABC, or schedule slip > 6 months based on the ABC schedule)	Changes in cost and schedule, detailed explanation or reasons for cost or schedule growth, mitigation actions planned and/or taken, expected outcomes of actions planned,	Detailed project overview and scope, including management and acquisition strategies, technical performance requirements, data products, mission success criteria, and description and analysis of alternatives	Mission Directorate works with project to develop report	When needed (Congressional notification followed by detailed report; and a detailed reporting timetable)	Reviewed by OMB as part of NSPD-49 submission (see above)

Report Name	Report Component	Cost and Schedule Content	Technical Content	Sources of Data	Congress	OMB
		and impacts on other programs				
	Breach (When development cost growth > 30 percent of development cost in the ABC)	Changes in cost and schedule, detailed explanation or reasons for cost or schedule growth, mitigation actions planned and/or taken, expected outcomes of actions planned, and impacts on other programs	Detailed project overview and scope, including management and acquisition strategies, technical performance requirements, data products, mission success criteria, and description and analysis of alternatives	Mission Directorate works with project to develop report	When needed	When needed
KDP B Cost Range (Applicable to projects in Phase B with LCC estimates > $250 million)	KDP B Cost Estimate	KDP B date and estimated LCC range, estimated launch readiness date or other key milestone	Same as for annual budget submission to Congress	KDP B DM and supporting documentatio n	Included in project pages in the annual budget to Congress	Reviews before submission .
10 Percent Cost Growth Report (Applicable to projects with LCC ≥ $75M)	Threshold (LCC growth > 10 percent)	Cost growth	Explanation of cost growth	Mission Directorate works with project and OCFO/SID to develop report	When needed	When required
OMB Circular A-11 Performance Reporting	Management & Performance (M&P) section of the Congressional Justification, Annual Performance Plan, Annual Performance Reports	Varies by program area	Varies by program area	Developed by MDs as part of annual budget process	Provided in annual budget to Congress	

Table 5-7 External Reporting Requirements for GAO

Report Name	Report Component	Cost and Schedule Content	Technical Content	Sources of Data	GAO
Quick Look Book (Usually applicable to projects required to file MPAR and NSPD-49 reports)	Cost, schedule, project, contract and software DCIs (GAO's datasheets)	Current & baseline estimated cost and schedule, breakout by project phase, UFE.	Technical scope, progress, and risk, including critical and heritage technologies, drawing releases, parts quality issues, software TLOC, and technical leading indicators	Cost, schedule, & contract data from Integrated Quarterly Data Call; technical completed by project.	See Table 5-8
	Project documents	As required by NASA policy for project documents	As required by NASA policy for project documents	Project documents	See Table 5-8
	Site visits	May include specific GAO questions.	May include specific GAO questions.	Prepared responses to GAO questions	Annually

5.12.3.1 External Reports

Major Program Annual Report (MPAR). Report components include Current Estimate and Baseline. Congress requires these reports for projects in development (all projects, not just space flight projects) with an estimated Life-Cycle Cost Estimate (LCCE) exceeding $250 million.[128] The KDP C Decision Memorandum and supporting documentation serve as the basis for data included in the next annual MPAR report published in the congressional justification (annual budget request). The Department of Defense (DoD) and the National Oceanographic and Atmospheric Administration (NOAA) file similar reports.

NSPD-49 Report. Report components include Current Estimate and Baseline. NASA worked with OMB to make NSPD-49 apply to the same projects already included in the MPAR report. For projects in Formulation, reporting is limited to projects with an estimated LCC greater than $250 million and with awarded contracts of $50 million or more that include development content. NASA's OMB examiners receive quarterly updates on project technical, cost, and schedule performance during the year for those projects covered by NSPD-49. All agencies involved in space flight file these reports. Cost and schedule reporting to OMB is common across the Federal Government.

Threshold Report. Report components include Notification and Breach. Commensurate with both NSPD-49 and MPAR requirements for projects with an LCC greater than $250 million, notifications are required for exceeding 15 percent of development costs in the ABC or 6 months schedule slippage based on the ABC schedule. If a breach occurs by

[128] Pursuant to Section 103 of the NASA Authorization Act of 2005 (P.L. 109-155).

exceeding development costs in the ABC by 30 percent, then congressional reauthorization and a new baseline (ABC) are required for continuation.

KDP B Cost Range. The 2012 Appropriations Act[129] requires NASA to provide a cost range for projects with an LCC greater than $250 million in Phase B included in the Agency's annual budget to Congress. This is provided as a simple table within the budget pages for these projects.

10 Percent Cost Growth Report. NASA's annual congressional appropriations bills require NASA to report on projects with an LCC greater than $75 million that encounter a 10 percent LCC growth.[130]

OMB Circular A-11 Performance Reporting. The reporting components include the Management and Performance (M&P) section of the congressional justification, the Annual Performance Plan (APP), and the Annual Performance Report (APR). It includes performance goals and Annual Performance Indicators (APIs) that align to NASA's strategic framework as outlined in the NASA Strategic Plan and the M&P section. Developing and reporting of these measures is coordinated between OCFO and the Mission Directorates.

Quick Look Book. The components include DCIs, project documents, and site visits. GAO has generally chosen to review projects already required to file MPAR or NSPD-49 reports and publishes its results annually.[131] GAO conducts site visits and receives project documents along with standardized cost, schedule, contract, and technical information. The Quick Look Book focuses on changes in project cost and schedule and provides GAO's explanations for these changes. Beyond the cost, schedule, and contract data provided in conjunction with the integrated quarterly call described above, GAO requests additional data to help them assess design stability, critical technologies, and technical maturity. Data elements provided to GAO in support of GAO's 2012 Quick Look Book are listed in Table 5-8. In addition to understanding project performance, GAO seeks to verify that NASA follows its acquisition, program or project management, and related policies. GAO also produces Quick Look Books on DoD projects.[132]

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[129] Consolidated and Further Continuing Appropriations Act, 2012 [P.L. 112-55].
[130] Section 522 of Consolidated and Further Continuing Appropriations Act 2013 [P.L. 113-6].
[131] The explanatory statement of the House Committee on Appropriations accompanying the Omnibus Appropriations Act of 2009 included a provision for GAO to prepare project status reports on selected large-scale NASA programs, projects, and activities. 155 Cong. Rec. H1653, 1824-25 (daily ed., Feb. 23, 2009), on H.R. 1105, the Omnibus Appropriations Act of 2009, which became Pub. L. No. 111-8. In its report, GAO refers to these projects as major projects rather than large-scale projects as this is the term used by NASA. GAO-21-306, NASA: Assessments of Major Projects (Washington, D.C.: May, 20, 2021). GAO-21-306, NASA: Assessments of Major Projects or https://www.gao.gov/assets/gao-21-306.pdf is the 13th annual report responding to that mandate.
[132] Portfolio-level rollups of project-specific technical and cost and schedule performance are also provided to GAO as part of NASA's Corrective Action Plan responding to GAO's 'High Risk' audit. This reporting is not described here because it does not report on individual projects or require additional data from individual projects.

Table 5-8 provides a sample of data elements provided to GAO. As these data elements may change, contact the NASA lead for the GAO Quick Look audit for the latest list.[133]

Table 5-8 DCI 2012 Data Elements Provided to GAO

Data Category	Element	Frequency
Technical (collected in the project-level data collection instrument (DCI))	Design Stability	Annual + Updates
	Critical Technologies	Annual + Updates
	Heritage Technologies	Annual + Updates
	Software Complexity	Annual
	Quality Parts Issues	Annual
Cost (collected in the cost DCI)	MPAR Baseline	As occurs
	KDP B Estimated LCC Range	Semi-annual
	KDP C Baseline	As occurs
	JCLs completion date	As occurs (see KDP C docs)
	Project-held UFE	Monthly in Monthly Status Reviews (MSR)
Schedule (collected in the schedule DCI)	Key Milestones	Semi-annual
Contracts (collected in the contracts DCI)	Basic Information	Semi-annual
	Award Fee Structure	Semi-annual
Documentation	FAD/PCA	As occurs
	Project Plan	As occurs
	Control Plans	As occurs
	PDR/CDR Packages	As occurs
	SRB Final Briefing Package	As occurs
	KDP C, D, Replan, and Rebaseline Decision Memos	As occurs
	KDP C, D, Replan, and Rebaseline Datasheets and briefing charts	As occurs, includes all supporting documents
	MSR Presentations	Monthly

[133] NASA works with GAO to ensure that sensitive but unclassified (SBU) data, although shared with GAO, is not published.

5.12.4 NASA Management and Use of Data

All working files and final products for external reports, including submissions from Mission Directorates, technical performance, cost and schedule documents, and transmission emails are archived by SID by project, quarter, and report type. These files are available to NASA employees with approved access through the OCFO Cost and Schedule community of practice site (https://max.omb.gov/community/pages/viewpage.action?pageId=646907686). In addition, guidance materials and other resources are available on this site.

Program analysts use this information to better understand performance on an Agency-wide or portfolio basis using tools such as cost and schedule trend analyses. These analyses help the Agency understand how changes in policies and practices affect performance. Beginning in 2007, NASA put a series of cost-management policy changes in place. NASA's record since 2007 indicates significant improvement in cost and schedule performance.

5.13 NASA Required and Recommended Leading Indicators

The NASA Office of the Chief Engineer (OCE) has identified three leading indicators (common to almost every program or project) required to be reported by all programs and projects. These are mass margin, power margin, and Requests for Action (RFAs) (or other means used by the program or project to track review comments). These three leading indicators are required in NPR 7123.1 and NPR 7120.5. Trending of these leading indicators shows the use of margin (estimated to actual) for mass and power and the timely closeout of RFAs. This trending helps the program or project manager understand how stable a design is as well as whether the design is maturing at the expected rate. The intent of codifying these leading indicators as a requirement is to ensure consistent application of this "best practice" across all programs and projects. Details on these three required indicators can be found in the *NASA Common Leading Indicator Detailed Reference Guide* which can be found in NODIS on the OCE tab under the "Other NASA-Level Documents" menu at https://nodis3.gsfc.nasa.gov/OCE_rep/OCE_list.cfm.

Margins are the allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, memory) to account for uncertainties and risks. Margins are allocated in the Formulation process, based on assessments of risks, and are typically consumed as the program or project proceeds through the life cycle.

NASA has also identified a recommended set of programmatic and technical leading indicators to support trending analysis throughout the life cycle as shown in Table 5-9. (For more details on these indicators including their calculation and the minimum graph characteristics as well as other indicators to consider, refer to the *NASA Common Leading Indicator Detailed Reference Guide*.)

Table 5-9 Table of Highly Recommended Common Indicators

Type	Indicator
Requirements Trend	Requirement Growth
	TBD/TBR Burndown
	Pending Requirement Changes
Interface Trend	Interface Documentation Approved/Pending
	TBD/TBR
	Pending Requirement Changes
Verification Trend	Verification Burndown
	Number of Deviations/Waivers
Review Trend	Open RFAs/RIDs/Action Items per Review (Required)
Software-unique Trend	Number of Requirements per Build/Release vs. Plan
Problem Report/Discrepancy Report Trend	Open PR/DRs
Type	**Indicator**

Technical Performance Measures	Mass Margin (Required)
	Power Margin (Required)
	Project-unique
Cost Margin Trend	Expenditure of UFE
Schedule Margin Trend	Total Slack Time
Cost Trend	Management Agreement NOA
	Cost
	EVM
Staffing Trend	FTE
	WYE

Through the process of considering, developing, measuring, assessing, and reporting these leading indicators, program and project teams gain additional insight or understanding into their programmatic and technical progress, and management is in a better position to make informed decisions.

5.14 Earned Value Management and Integrated Baseline Reviews

This special topic provides a synthesis of guidance for NASA's Earned Value Management (EVM) requirements for NASA programs, projects, major contracts, and subcontracts. EVM is a disciplined project management process that integrates a project's scope of work with schedule and cost elements. EVM goes beyond simply comparing budgeted costs to actual costs. Its methodology effectively integrates a project's work scope, schedule, and resources with risk in a single Performance Measurement Baseline (PMB) for optimum planning and control. Progress against the baseline plan can be objectively measured and assessed to determine if the project did what it planned to do for the allocated cost and schedule throughout the duration of the project. This enables management to ask appropriate questions to determine causes and identify corrective actions, along with providing an objective Estimate at Completion (EAC). When properly used, EVM provides an assessment of project progress, early warning of schedule delays and cost growth, and unbiased, objective estimates of anticipated costs at completion.

In accordance with Section 2.2.8 of NPR 7120.5F, projects and single-project programs (and other programs at the discretion of the MDAA) with a Life-Cycle Cost (LCC) or initial capability cost[134] estimated to be greater than $250 million are required to perform EVM and comply with the standard *EIA-748, Earned Value Management Systems*[135] for all portions of work including in-house and contracted portions of the project. To ensure that projects meet KDP C requirements, Earned Value Management System (EVMS) setup and implementation efforts begin as soon as a project begins to develop the WBS, Organizational Breakdown Structure (OBS), and Integrated Master Schedule (IMS). EVM reporting to the PMB begins during Phase B and continues during the remaining phases for as long as EVM applies.

For in-house work, programs and projects subject to EVM also use the NASA EVM Capability Process, which is accessible to NASA employees on the Program and Project Management community of practice at https://nen.nasa.gov/web/evm by selecting "Document Repository." EVM is optional on the in-house portion of the work for programs and projects with an LCC or initial capability cost less than $250 million; however, EVM may be implemented at the discretion of the project manager. An EVMS is not required on non-developmental work, steady state operations, or basic and applied research.

In-house work includes work conducted solely by NASA HQ and/or Center personnel or other NASA resources (i.e., facilities, equipment) and work conducted by support contractors that augment NASA resources to achieve the objectives of the project. In-house work does not involve any prime contractor, university, laboratory, institution, or foreign

[134] Section 5.5.1 explains initial capability cost.
[135] The National Defense Industrial Association (NDIA) Integrated Program Management Division (IPMD) is the author and responsible for the EIA-748. It is approved by the Society of Automotive Engineers (SAE) and published as SAE Electronic Industries Alliance (EIA) 748. The current version is SAE EIA-748 D:2019-01-08, Earned Value Management Systems.

partner. EVM applies to in-house work only if the value of the project LCC or initial capability cost exceeds the threshold and the scope of the work is developmental in nature.

If the in-house work meets the criteria for EVM, but the project does not want to implement EVM, the project must complete the checklist in Appendix E of the *NASA/SP-20210024466, NASA Earned Value Management (EVM) Implementation Handbook*[136] and obtain approval for tailoring (i.e., obtaining a waiver from) the applicable NPR 7120.5 requirement. (See Section 5.4 in this handbook and NPR 7120.5 Section 3.5 and Appendix C for information on tailoring). The tailoring process is designed to ensure that the decision makers have the necessary information to make a knowledgeable decision on the waiver. This information is also used to support audits by entities within and external to the Agency.

In accordance with Section 2.2.8.4 of NPR 7120.5F, EVMS surveillance is conducted on contracts, programs, and projects with in-house work to ensure continued compliance with the standard *EIA-748, Earned Value Management Systems*. For guidance in performing EVMS surveillance, NASA employees can access the NASA Agency-level EVMS Surveillance Plan at https://nen.nasa.gov/web/pm/evm under the EVMS Surveillance and Acceptance folder.

EVM system requirements for contracted work are applied to suppliers in accordance with the NASA FAR Supplement (NFS) Subpart 1834.2, Earned Value Management System, independent of phase and the $250 million threshold. For contracts that require EVM, an Integrated Program Management Report (IPMR) and WBS are the Data Requirements Descriptions (DRDs) included in the contract or agreement. For guidance on tailoring the IPMR, see *NASA Integrated Program Management Report (IPMR) Data Requirements Description (DRD) Guide.*[137] (For guidance on developing the WBS and Contract Work Breakdown Structure (CWBS), refer to *NASA/SP-20210023927, NASA Work Breakdown Structure (WBS) Handbook.*[138])

OMB Circular A-11 requires EVM for acquisitions with developmental effort and for both in-house government and contractor work using the guidelines in EIA-748, which is regarded as the national standard and an industry best practice for EVMS. For certification, an EVMS needs to comply with EIA-748's 32 guidelines in the areas of organization; planning, scheduling, and budgeting; accounting; analysis and management reports; and revisions and data maintenance. NASA FAR Supplement (NFS) Subpart 1834.2, Earned Value Management System requires use of an EVMS on procurement for development or production work, including flight and ground support systems and components, prototypes, and institutional investments (facilities, IT infrastructure, etc.) when the

136 https://www.nasa.gov/evm/handbooks. See also NASA/SP-2018-599, NASA Earned Value Management (EVM) Implementation Handbook 20180001499.pdf (nasa.gov) or https://ntrs.nasa.gov/api/citations/20180001499/downloads/20180001499.pdf
137 https://www.nasa.gov/evm/guidance
138 https://www.nasa.gov/evm/handbooks

contract value is $20 million or more. If the program manager applies EVM at the program level, he or she will follow the same process that is used for projects.

For contracts and subcontracts valued from $20 million to $50 million, the EVMS must comply with the guidelines in EIA-748 but does not require validation. For contracts and subcontracts valued at $50 million or more, the contractor's EVMS (or plan to develop an EVMS) must be formally validated and accepted by the Government. Validation means the Government tests the contractor's EVMS for compliance through a series of reviews. Compliance means that the contractor's EVMS meets the guidelines listed in EIA-748; however, no reviews by the Government are required to formally accept the EVMS.

The *NASA/SP-20210024466, NASA Earned Value Management (EVM) Implementation Handbook* provides detailed guidance on EVM implementation and is maintained electronically.

During early Formulation, projects need to coordinate with the respective Center EVM Focal Point[139] (EVMFP) to establish the organization and key structures to facilitate effective EVM implementation and usage (e.g., Project WBS, Organizational Breakdown Structure (OBS), Responsibility Assignment Matrix, control accounts, etc.) and document project-specific tailoring when developing their EVM implementation plans. (See Appendix A for definitions for Organizational Breakdown Structure, Responsibility Assignment Matrix, and control accounts.)

The project's Performance Measurement Baseline (PMB) (Section 5.14.3) is established in Phase B in preparation for KDP C and is assessed during the Integrated Baseline Review (IBR) process (Section 5.14.1). A project-level IBR is completed prior to KDP C. The PMB is baselined at PDR and project-level EVM reporting to the PMB begins during Phase B. Contract EVM reporting requirements are defined in the IPMR DRD regardless of the system acquisition phase.

The PMB is a time-phased budget plan for accomplishing all authorized work scope in a project's life cycle, which includes both NASA internal costs and supplier costs. The project's performance against the PMB is measured using EVM if EVM is required or other performance measurement techniques if EVM is not required. The PMB does not include UFE.

An IBR is a point on the path of a continuous analytical process. It is not a pass/fail event, an independent review, a time to resolve technical issues, nor a demonstration of EVMS compliance.

The Program Plan will include the approach for integrating and managing program cost, schedule, and technical performance, including the flow down of EVM requirements to projects. The Project Plan documents the project's approach for meeting the EVM requirements in the Program Plan. Each project flows down EVM requirements to its

[139] https://nasa.gov/evm/evmwg

applicable suppliers (intra-Agency organizations and contractors), ensuring that EVM requirements are included in each Request for Proposal (RFP) and the responses are evaluated for compliance with these requirements. The primary considerations for EVM applicability are the nature of the work and associated risks and the value of the effort. In the EVM context, there are two basic classifications of the nature of work: discrete and Level of Effort (LOE). Discrete work is related to the completion of specific end products or services and can be directly planned, scheduled, and measured. LOE is effort of a general or supportive nature that does not produce definite end products. The application of EVM on projects and/or contracts that are exclusively LOE in nature may be impractical and inefficient and is therefore discouraged. Additionally, EVM is not required or recommended for firm fixed-price contracts. For these contracts, the project manager may implement an alternative method of management control to provide advance warning of potential performance problems.

5.14.1 Integrated Baseline Review (IBR)

In accordance with Section 2.2.8.3 of NPR 7120.5F, an IBR is required whenever EVM is required. Mission Directorates conduct an IBR in preparation for KDP C and for major changes that significantly impact the cost and schedule baseline, including the PMB. The IBR is used to verify technical content and the realism of related performance budgets, resources, and schedules. It is a risk-based review of a supplier's PMB conducted by the customer (e.g., the Mission Directorate, the program, the project, or even the contractor over its subcontractors). While an IBR has traditionally been conducted on contracts, it can be effective when conducted on in-house work as well. The same principles, objectives, and processes apply for in-house and contract IBRs; however, minor changes may be necessary to the steps in conducting an IBR. See *NASA/SP-20210026420, Integrated Baseline Review (IBR) Handbook*[140] for step-by-step instructions on how to conduct an IBR. Center EVM Focal Points (EVMFPs) may also be contacted for more information.

The IBR ensures that the PMB is realistic for accomplishing all the authorized work within the authorized schedule and budget and provides a mutual understanding of the supplier's underlying management control systems.

The IBR is an initialization of the continuous process of analyzing the PMB and will take place periodically any time there are significant changes to the PMB throughout the program or project life cycle.

NASA has many reviews during the program and project life cycles, and some of these reviews share common goals and objectives with the IBR. Therefore, when possible, the IBR can be combined with these other reviews. It is important, however, to ensure that the intent of the IBR is still met and supported by key personnel when reviews are consolidated.

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[140] https://nasa.gov/evm/handbooks

5.14.2 EVM Performance Reporting

The project manager needs to understand and emphasize the importance of the integrated technical, schedule, cost, and risk analyses provided by EVM in conjunction with other project information to formulate an overall project status. NASA projects with EVM requirements will need to integrate and report EVM performance measurement data to various customers. EVM data are obtained from the project team and/or the applicable suppliers by specifying the IPMR as a deliverable and including specific instructions for reporting. The IPMR comprises seven formats: cost and schedule performance by WBS and OBS, changes to the PMB, staffing forecasts, data analyses, IMS, and cost forecast. IPMRs are management reports that provide timely, reliable data used to assess the project or supplier's current and projected performance, to quantify and track known or emerging problems, to determine the project or supplier's ability to achieve the PMB, and to assist in decision making. It is important that the IPMR is as accurate and timely as possible so it can be used for its intended purpose, which is to facilitate informed, timely decisions.

EVM reporting requirements normally include explanations of cost, schedule, and (at completion) variances that breach established thresholds. These thresholds can be applied at various levels of the WBS, on a cumulative and/or current basis, and be represented by dollars, percentages, or other customer-specified criteria. For the project, specific reporting requirements and thresholds are defined in a Program or Project Plan or directive. Project EVM reporting to the PMB begins during Phase B.

It is NASA policy that a program or project write a contract requirement for an IPMR and WBS when EVM is required on contracts. Contract reporting requirements are defined in specific DRDs included in the solicitation and contract. For contracts, the IPMR is due no later than 90 days after contract award. When EVM is required on a project but not a contract, selected cost and schedule performance data will be required on those contracts to enable project-level planning, analysis and EVM reporting. See *NASA/SP-20210024466, Earned Value Management (EVM) Implementation Handbook*, *NASA/SP-2010-3403, NASA Schedule Management Handbook*, and *NASA/SP-20210023927, NASA Work Breakdown Structure (WBS) Handbook* at https://nasa.gov/evm/handbooks for more information on preparing the appropriate DRDs. EVM flow-down for contracts can be improved by following the guidance in the NASA Earned Value Management (EVM) Contract Requirements Checklist (CRC) located at https://nasa.gov/evm/regulations.

EVM data and analysis needs to be included in all management reviews and life-cycle reviews. Project status based on EVM data needs to be reported at the level appropriate for all levels of management and used for insight and management actions. Analysis comprises two major steps: analyzing past performance and then projecting future performance. NASA's EVM website contains a sample standard analysis package that can be used as a guide at https://nasa.gov/evm/guidance.

EVM reporting is also required at the Baseline Performance Review (BPR). Minimum metrics required in the report can be found in the June 4, 2019 OCFO memorandum entitled *Agency Policy Guidance to EVM and Create a Schedule Repository* available at https://nasa.gov/evm/regulations.

While not required, Empower ™[141] meets Agency requirements for analysis and reporting of EVM data. Empower is intended to integrate the scope, schedule, and budget EVM data of NASA's in-house-managed projects as well as contractor data. It graphically displays trends at all levels of the WBS and produces analyses and reports that can be used to support management reviews. For instructions on how to access Empower, see the document entitled *Requesting Access to EVM Tools* (NASA Instructions for Access to Earned Value Management (EVM) Tools: Empower, Cobra, Windchill & Acumen Fuse) at https://nasa.gov/evm/guidance.

All projects with EVM requirements submit EVM reports, such as IPMR and Empower reports, to the EVM Central Repository. See the NASA EVM Central Repository posting instructions at https://nasa.gov/evm/guidance.

5.14.3 Performance Measurement Baseline

The time-phased budget plan for accomplishing all authorized work scope is called the Performance Measurement Baseline (PMB). The PMB is different from the Management Agreement or ABC in that the PMB does not include UFE, nor is the PMB restricted by the formal establishment of external commitments. The PMB is different from the PPBE or phasing plan process in that the PMB is time-phased by month by work, planning, or summary level planning package for the program or project's entire LCC or initial capability cost. The PMB and EAC support and inform the NASA budgeting process. Figure 5-30 illustrates the PMB.

[141] Encore Analytics Empower ™ is a Commercial Off-The-Shelf (COTS) tool that facilitates effective analysis and reporting of EVM data for management insight and control. Empower ™ is available for use by all NASA programs and projects. Center EVMFPs provide access and training.

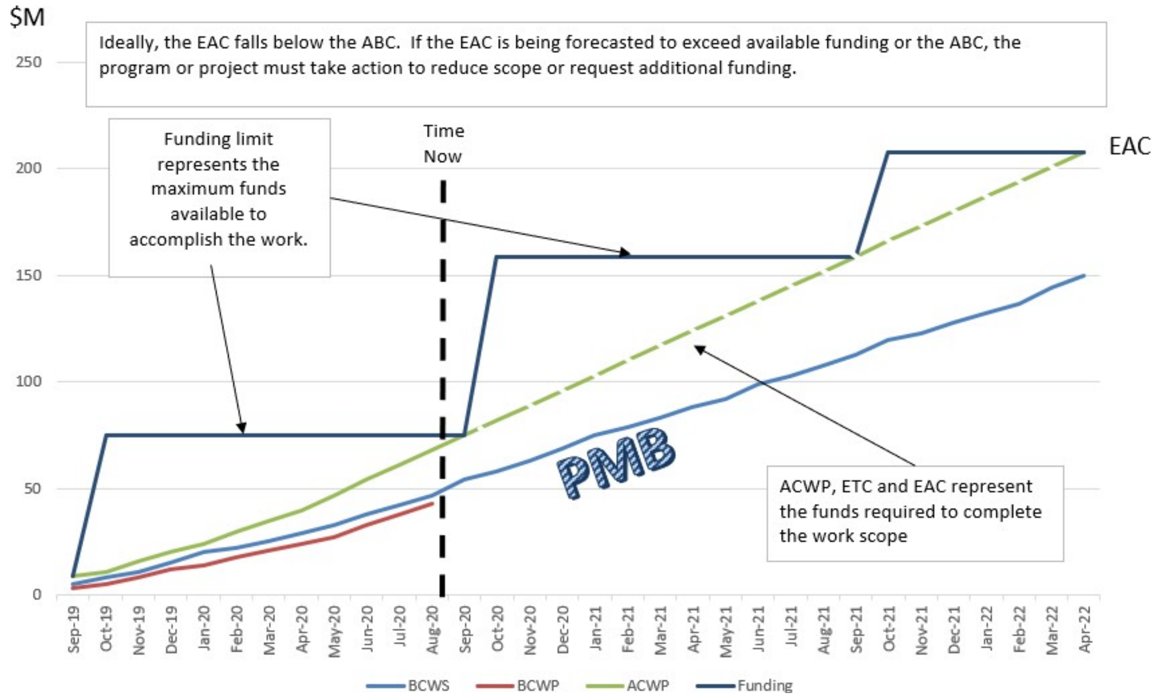

Figure 5-30 Performance Measurement Baseline

The PMB is maintained throughout the program or project life cycle and can be updated month by month. The PMB is reviewed at each Life-Cycle Review (LCR). Programs and projects update the PMB and conduct IBRs when major changes significantly impact the cost and schedule baseline, including the PMB, to ensure that the work is properly linked with its cost, schedule, and risk and that the systems are in place to conduct EVM.

5.15 Selecting and Certifying NASA Program and Project Managers

5.15.1 Selecting Program and Project Managers

Among their many duties, Center Directors (or their designees) are responsible for training, certifying, and providing qualified managers for the programs and projects assigned to their Center:

- For Category 3 projects, the Center Director or designee assigns a project manager with concurrence from the program manager and Mission Directorate Associate Administrator (MDAA).
- For Category 2 projects, the Center Director or designee either assigns a project manager with concurrence from the program manager and the MDAA or, for selected projects, recommends a project manager candidate to the MDAA or designee.
- For Category 1 projects, the Center Director or designee recommends a project manager candidate to the MDAA or designee.
- For programs assigned to the Center, the Center Director or designee recommends a program manager candidate to the MDAA or designee.

The MDAA approves the selection of all program managers, all Category 1 project managers, and selected Category 2 project managers.

For very high visibility programs and Category 1 projects, the NASA Administrator and the NASA Associate Administrator (AA) may concur in these assignments.

5.15.2 Certifying Program and Project Managers

In a letter dated April 25, 2007, the White House Office of Management and Budget (OMB) announced a new set of requirements for program and project management certification that applies to all civilian agencies. OMB's Federal Acquisition Certification for Program and Project Managers (FAC-P/PM) outlines the baseline competencies. This document and additional certification information may be obtained from the APPEL PM certification website at https://appel.nasa.gov/career-resources/fac-ppm-certification/.

To meet these requirements, NASA has established a process to:

- Certify existing experienced program and project managers who manage major acquisitions with LCCs or initial capability costs greater than $250 million.
- Ensure certification of future program and project managers assigned to manage major acquisitions with LCCs or initial capability costs greater than $250 million.
- Provide an Agency-wide career development framework to support the development of individuals pursuing program or project management career paths.

- Monitor and record the continuous learning achievements of certified program and project managers.
- Manage the process and maintain supporting documentation.

5.15.3 Agency Roles and Responsibilities

- **NASA Centers** establish Center review panels to inventory and validate the capabilities of Center program and project managers in accordance with the certification requirements.
- The **NASA Office of the Chief Engineer** (OCE) endorses the certification of NASA employees based on Center-validated career experience and Center reviews and recommendations.
- **NASA Mission Directorates** maintain an awareness of certified program and project managers within their directorates.
- The **Academy of Program/Project and Engineering Leadership Knowledge Services** (APPEL KS) provides a structured approach to program and project management development through life-long learning at the individual, team, and community level, including on-the-job work experiences, attendance at core and in-depth courses, and participation in knowledge-sharing activities. APPEL also develops the tools and resources for Center implementation.
- The **NASA Acquisition Career Manager** (appointed by the NASA Chief Acquisition Officer) oversees the Agency process for certifying program and project managers.
- **Program and project management practitioners** take the lead in participating in the experiences and training necessary to acquire the competency proficiencies to better perform their job responsibilities and to obtain certification.

5.15.4 Program or Project Manager Certification

The designated Point of Contact at each Center establishes a Center review panel to inventory and validate the capabilities of designated program and project managers (existing or future program and project managers managing major acquisitions) at the FAC-P/PM Senior/Expert certification level. The Center review panel:

- Validates and approves that Center program and project management candidates have satisfied certification requirements and met established criteria.
- Forwards names of recommended candidates to Center Directors for signature and then to the NASA Chief Engineer for final endorsement.
- Ensures candidate records are accumulated and maintained to satisfy OMB tracking requirements.
- Monitors and tracks workforce members as necessary to ensure training, developmental activities, and experiences are being made available. The System for

Administration, Training, and Educational Resources for NASA (SATERN) is used as a resource for tracking workforce development.

- Monitors and tracks the continuous learning activities of certified program and project managers.

5.15.4.1 Certification Process

OMB requires certification at the senior/expert level for NASA program or project managers who are currently managing major acquisitions with a LCC or initial capability cost of more than $250 million. OMB also requires that future program or project managers assigned to projects designated as major acquisitions be certified. Program or project managers assigned to these projects in the future will have one year to become certified if they do not possess the required NASA-awarded FAC-P/PM certification at the time they assume the role.

The Center Point of Contact verifies the list of existing program and project managers and designates any additional candidates the Center deems eligible for senior/expert level certification. Each prospective program or project manager then creates a Personal Development Portfolio (PDP), which documents their experience and development accomplishments. This PDP provides as much information as needed to assess the program or project manager's capabilities relative to OMB's certification requirements. The PDP needs to contain, at a minimum, a current resume, a completed NASA Program/Project Manager (P/PM) Competency Assessment, a supervisory endorsement, a SATERN training record if applicable, and any other supporting documentation the program or project manager deems necessary.

5.15.4.2 The Resume

The resume is a key component that needs to reflect the program or project manager's job history, documenting responsibilities in leading projects and/or programs. To meet OMB requirements for FAC-P/PM Senior/Expert Level certification, the program or project manager needs to have completed at least four years of program and project management experience on projects and/or programs. This includes responsibilities such as managing and evaluating Agency acquisition investment performance, developing and managing a program or project budget, building and presenting a successful business case, reporting program or project results, strategic planning, and high-level communication with internal and external stakeholders.

The resume needs to be comprehensive enough that the review panel members and any other reviewers can assess the length and types of the program or project manager's experiences.

5.15.4.3 The Competency Assessment

The FAC-P/PM requires essential competencies and levels of proficiency for certification. The FAC competency areas are encompassed within the existing NASA P/PM Competency Model, which comprises 31 competencies, including 12 common FAC competencies.

Table 5-10 shows an example of competencies, which are regularly updated, and their definitions. (NASA common competencies are in blue.) For each competency, the program or project manager selects the highest level of proficiency he or she can demonstrate. (More detailed current information on the competencies, including definitions and levels of proficiency, is available on the APPEL website http://appel.nasa.gov/pm-se/project-management-and-systems-engineering-competency-model/.)

Table 5-10 NASA Program and Project Management Competencies and Common Competencies

Project Proposal	Conceptualizing, analyzing, and defining program/project plans and requirements and using technical expertise to write, manage, and submit winning proposals. Also involves developing functional, physical, and operational architectures including life-cycle costing.
Requirements Development	Developing project requirements using functional analysis, decomposition, and allocation; finalizing requirements into the baseline; and managing requirements so that changes are minimal. Defining, developing, verifying, reviewing and managing changes to program/project requirements.
Acquisition Management	Developing, implementing, and monitoring acquisition strategies, procurement processes, contract activities, and approval requirements to support flight hardware/software or other project requirements.
Project Planning	Developing effective project management plans and technical integration of project elements for small, moderate, and complex projects including scope definition, schedule and resource estimation and allocation for all project phase activities from concept to launch and tracking.
Cost-Estimating	Developing credible cost estimates to support a variety of systems engineering trade studies, affordability analyses, strategic planning, capital investment decision-making, and budget preparation during project planning. Also, providing information for independent assessments as required.
Risk Management	Risk-Informed Decision Making (RIDM) for selection of program/project alternatives; Continuous Risk Management (CRM) for identifying, analyzing, planning, tracking, controlling, and communicating and documenting individual and aggregate risks for the purpose of meeting program/project objectives within stated risk tolerance levels.
Budget and Full Cost Management	Executing NASA and Center budgeting processes for annual (PPBE) and life-cycle budget projections ensuring consistency between resource availability and project resource needs, including staffing, facilities, equipment, and budget.
Capital Management	Allocating, tracking, and managing funding and other capital resources within a project element, project or program.
Systems Engineering	Integrating technical processes to define, develop, produce, and operate the project's systems in the most technically robust and cost-effective way possible. (See Systems Engineering Competency Model for specific competencies.)

Design and Development	Developing subsystems to meet implementation requirements and producing, integrating, verifying, and testing the subsystem/ system to achieve product quality requirements and optimal technical performance.
Contract Management	Performing acquisition management and monitoring contractor activities to ensure hardware/software components are delivered on time, at projected costs, and meet all performance requirements. Also involves performing variance reporting and change control functions.
Stakeholder Management	Identifying, soliciting, and executing of planning interrelationships with those individuals and organizations that are actively involved in the project, exert influence over the project and its results, or whose interests may be positively or negatively affected as a result of project execution or project completion.
Technology Transfer and Communication	Evaluating the feasibility, development, progression, readiness, cost, risk, and benefits of new technologies so they can be developed and transferred efficiently and effectively to project stakeholders or for possible commercialization.
Tracking/Trending of Project Performance	Monitoring and evaluating performance metrics, project risks, and earned value data to analyze, assess and report program/project status and technical performance.
Project Control	Performing technical and programmatic activities to control cost, schedule, and technical content and configuration to assure the project's performance is within approved baseline and to address performance variances.
Project Review and Evaluation	Planning, conducting and managing internal and external project programmatic and technical reviews that include using metrics to monitor and track the status of the project.
Agency Structure, Mission and Internal Goals	Understanding and successfully adapting work approach and style to NASA's functional, social, cultural, and political structure and interrelationships to achieve Agency, Mission, Directorate, Center, program and project goals. Includes aligning activities with Agency vision, mission, objectives, goals and plans.
NASA PM/SE Procedure & Guidelines	Structuring activities to comply with relevant Agency and Center processes and guidelines, including NPR 7120.5 and NPR 7123.1.
External Relationships	Maintaining cognizance of the policies and procedures of other organizations by participating in professional societies/ organizations, contributing to professional development activities, researching best practices from external sources such as industry standards, procedures, and regulations and Universities, and developing international partnerships and agreements, where applicable, complying with ITAR and as well as international agreements and standards.
Staffing and Performance	All elements of personnel management including, identifying, recruiting, selecting, managing, and evaluating the team members to achieve a coherent, efficient, and effective team. Includes vigorous open communications, decision-making processes, and working relationships.
Team Dynamics and Management	Managing the team aspects of the workforce. This requires working cooperatively with diverse team members; designing, facilitating, and managing team processes; developing and implementing strategies to promote team morale and productivity; motivating and rewarding team members' performance; managing relationships among team members, customers, stakeholders, and partners; and facilitating brainstorming sessions, conflict resolution, negotiation and problem solving, communication, collaboration, integration and team meetings.
Security	Assuring that all proprietary, classified and privileged information is protected from unauthorized use and dissemination. Also requires identification of information

	technology (IT) security requirements and developing and implementing an effective IT security plan.
Workplace Safety	Ensuring that workplace safety is an integral part of developing products by applying systems safety analysis techniques throughout the project life cycle and integrating critical hazard elimination/mitigation measures into risk management and safety plans.
Safety and Mission Assurance	Activities associated with assuring the safety of personnel and property and success of the project. These activities include: Environmental Impact Statements; hazards analyses, elimination, and mitigation; mishap investigations; failure review boards; the flight safety review process; and safety, mission assurance, and risk management plans.
Mentoring and Coaching	Activities designed to help less-experienced members of the team to advance their knowledge and careers by: acting as an advisor, sponsor, or confidant who shares knowledge about NASA's functional, social, cultural, and political aspects or provides counseling to cultivate skills in order to enhance individual, team, and organizational performance and growth.
Communication	Implementing effective strategies for clear and constructive communication both internally within the team and externally to stakeholders, other experts, contractors and others. Also involves communicating decisions in a timely manner.
Leadership	Influencing, inspiring, and motivating individuals and teams to accomplish goals; creating conditions for individuals and teams to be effective; and recognizing and rewarding individual and team achievements.
Ethics	Demonstrating integrity, ethical conduct, and acceptable behavior in all project activities in line with Federal Government principles.
Knowledge Capture and Transfer	Capturing and transferring knowledge in an organized fashion to improve performance and reduce risk associated with future programs and projects.
Knowledge Sharing	Sharing organizational practices and approaches related to generating, capturing, disseminating know-how and other content relevant to NASA's business and processes.

For senior/expert certification, the program or project manager needs to be able to demonstrate Level 4 proficiency for the 12 common competencies. He or she needs to be able to demonstrate Level 3 proficiency for at least 80 percent of the remaining 19 NASA competencies.

The program or project manager identifies how the capability to perform at the specified proficiency level was achieved. Examples include courses, on–the-job training, knowledge-sharing activities, rotational assignments, government or professional organization certification, or other individual assignments. There needs to be some traceability, either on the resume, the training record, or other materials that supports the development experience noted on the competency assessment. For example, if a program or project manager identifies a rotational assignment as a development activity, some information about the rotational assignment (i.e., when, what office, etc.) needs to be referenced on the individual's resume.

Additionally, OMB requires that through acquiring the underlying competencies, senior/expert-level program and project managers possess the capabilities below. Review panels use these as additional guidelines for assessing program and project managers:

- Knowledge and skills to manage and evaluate moderate to high-risk programs or projects that require significant acquisition investment and Agency knowledge and experience.
- Ability to manage and evaluate a program or project and create an environment for program or project success.
- Ability to manage and evaluate the requirements development process, overseeing junior-level team members in creation, development, and implementation.
- Expert ability to use, manage, and evaluate management processes, including performance-based management techniques.
- Expert ability to manage and evaluate the use of Earned Value Management (EVM) as it relates to acquisition investments.

5.15.4.4 The Supervisory Endorsement

The portfolio also needs to include a signed endorsement from the supervisor. This endorsement indicates the supervisor's concurrence that the individual's experience, competency proficiency level, and capabilities meet OMB's requirements for senior/expert-level certification.

For new supervisors who may not be aware of the candidate's capabilities, the Center review panel can use its own discretion in allowing the program or project manager to identify other individuals who can provide validation.

Based on the candidate's PDP, the Center Director recommends the candidate for certification and the NASA Chief Engineer provides the final endorsement. The NASA Chief Engineer signs and sends a letter of endorsement to the acquisition career manager who forwards copies to the program or project manager, a Center review panel representative, and the appropriate Mission Directorate, and ensures the program or project manager's SATERN record is updated to reflect certification level, date, etc.

5.15.4.5 Meeting Certification Requirements

In the event a program or project manager does not satisfy the requirements for senior/expert-level certification, the Center review panel, along with the program or project manager and the supervisor, identify development activities and a timeframe to complete the activities. The program or project manager completes the identified activities, updates his or her portfolio, and resubmits it to the panel for review. This process can be repeated if necessary. The program or project manager has a maximum of one year to satisfy the requirements.

5.15.4.6 Maintaining Certification

Certified program and project managers maintain their certification by earning 80 Continuous Learning Points (CLPs) of skills currency every two years. They can earn CLPs for continuous learning activities such as:

- Serving on NASA boards.
- Serving as an instructor or student for APPEL and a Center.
- Obtaining other formal education.
- Publishing technical papers or other documents.
- Rotating jobs.
- Attending the PM Challenge, Master's Forum, or Principal Investigator (PI) Forum.
- Participating on a Center or Agency team to define policy or improve processes.
- Participating in critical activities of the NASA Program and Project Management Board (PPMB).
- Participating in critical NASA or other technical Agency reviews.
- Serving on a Standing Review Board (SRB), failure review board, or other special-purpose team or committee.
- Mentoring or coaching.

5.15.4.7 Meeting the Continuous Learning Requirements

If a program or project manager does not meet the continuous learning requirements within the two-year period, the certification becomes conditional. In this situation, the program or project manager meets with his or her supervisor and a representative from the Center review panel to discuss how to satisfy the requirements.

5.15.4.8 Meeting Tracking and Reporting Requirements

Centers maintain all documentation for every reviewed and certified program and project manager. The Center review panel designates a Point of Contact for records management to maintain copies of PDPs, the recommendation letter, and any documentation or rationale for requiring that the program and project manager complete additional development activities.

A. Definitions

Acquisition. The process for obtaining the systems, research, services, construction, and supplies that NASA needs to fulfill its missions. Acquisition, which may include procurement (contracting for products and services), begins with an idea or proposal that aligns with the NASA Strategic Plan and fulfills an identified need and ends with the completion of the program or project or the final disposition of the product or service.

Acquisition Strategy. The integrated acquisition strategy that enables a program or project to meet its mission objectives and provides the best value to NASA. (See a description in NPR 7120.5, Appendices G and H, Section 3.4 of the Program Plan and Project Plan templates.)

Acquisition Strategy Council. The Acquisition Strategy Council (ASC) serves as the Agency's senior decision-making body for matters of long-term, annual, and tactical acquisition strategy planning and for matters of policy and performance assessment pertaining to the Agency's acquisition approaches. The scope and authority of the ASC includes the strategic acquisition process as defined in *NPD 1000.5, Policy for NASA Acquisition*. The ASC conducts Pre-ASMs and ASMs for large, high-profile programs and projects following thresholds and requirements specified in NPD 1000.5.

Acquisition Strategy Meeting. A decision-making forum where senior Agency Management reviews and approves program and project acquisition strategies. The ASM focuses on considerations such as impacting the Agency workforce, maintaining core capabilities, make-or-buy decisions, supporting Center assignments, potential partnerships, and risk. (See NPD 1000.5 for more information on ASMs.)

Agency Baseline Commitment. Establishes and documents an integrated set of project requirements, cost, schedule, technical content, and an agreed-to JCL that forms the basis for NASA's commitment to the external entities of OMB and Congress. Only one official baseline exists for a NASA program or project, and it is the ABC.

Agency Program Management Council. The senior management group, chaired by the NASA Associate Administrator(AA) or designee that is responsible for reviewing Formulation performance, recommending approval, and overseeing implementation of programs and Category 1 projects according to Agency commitments, priorities, and policies.

Agreement. The statement (oral or written) of an exchange of promises. Parties to a binding agreement can be held accountable for its proper execution, and a change to the agreement requires a mutual modification or amendment to the agreement or a new agreement.

Allocated Requirements. Requirements that are established by dividing or otherwise allocating a high-level requirement into lower-level requirements.

Analysis of Alternatives. A formal analysis method that compares alternative approaches by estimating their ability to satisfy mission requirements through an effectiveness analysis and by estimating their Life-Cycle Costs (LCCs) through cost analysis. The results of these two analyses are used together to produce a cost-effectiveness comparison that allows decision makers to assess the relative value or potential programmatic returns of the alternatives. An analysis of alternatives broadly examines multiple elements of program and project alternatives (including technical performance, risk, LCC or initial capability cost, and programmatic aspects).

Announcement of Opportunity. An Announcement of Opportunity (AO) is one form of a NASA Broad Agency Announcement (BAA), which is a form of public/private competition. NASA solicits, accepts, and evaluates proposals submitted by all categories of proposers in response to an AO, including academia, industry, not-for-profits, Government laboratories, Federally Funded Research and Development Centers (FFRDCs), NASA Centers, and the Jet Propulsion Laboratory (JPL). Regulatory coverage of AOs appears in NASA Federal Acquisition Regulation (FAR) Supplement (NFS) Part 1872. NASA typically uses a one-step or a two-step AO process. In a one-step AO process, proposals for new projects are evaluated competitively and selected for Formulation in a single step. In two-step competitions, several proposals for new projects may be selected in Step 1 and given time to mature their concepts in a funded concept study before the Step 2 down-selection.

Annual Performance Plan. The Annual Performance Plan (APP) shows the supporting strategic objectives and annual performance goals that are being implemented by one or more program activities for each strategic goal. The plan covers each program activity in the budget and is comprehensive of the strategic objectives. Additionally, the plan addresses the Agency's contributions to Cross-Agency Priority Goals.

Annual Performance Report. NASA's Annual Performance Report (APR) provides the public with key information on whether the performance commitments aligned to the annual budget request were met, and if unmet, plans to address any challenges that were barriers to success. The APR also includes progress toward NASA's priority goals.

Approval. Authorization by a required management official to proceed with a proposed course of action. Approvals are documented.

Baseline (document context). Implies the expectation of a finished product, though updates may be needed as circumstances warrant. All approvals required by Center policies and procedures have been obtained.

Baseline (general context). An agreed-to set of requirements, cost, schedule, designs, documents, etc., that will have changes controlled through a formal approval and monitoring process.

Baseline Performance Review. A monthly Agency-level independent assessment to inform senior leadership of performance and progress toward the Agency's mission and program and project performance. The monthly meeting encompasses a review of crosscutting mission support issues and all NASA mission areas.

Baseline Science Requirements. The mission performance requirements necessary to achieve the full science objectives of the mission. (Also see Threshold Science Requirements.)

Basis of Estimate. The Basis of Estimate (BoE) documents the ground rules and assumptions and the drivers used in developing the cost and schedule estimates, including applicable model inputs, rationale or justification for analogies, and details supporting cost and schedule estimates. The BoE is contained in material available to the Standing Review Board (SRB) and management as part of the Life-Cycle Review (LCR) and Key Decision Point (KDP) process.

Budget. A financial plan that provides a formal estimate of future revenues and obligations for a definite period of time for approved programs, projects, and activities. (See *NPR 9420.1, Budget Formulation* and *NPR 9470.1, Budget Execution* for other related financial management terms and definitions.)

Business Case (Infrastructure). An analysis of options for construction of new facilities or infrastructure or significant modification of existing infrastructure. (See *NPR 8800.15, Real Estate Management Program* and the *NASA Business Case Guide for Real Property and Facilities Project Investments* at https://www.hq.nasa.gov/office/codej/codejx/Assets/Docs/NASA_Business_Case_Guide_11_29_10.pdf.)

Capability Component. An individual capability within a capability portfolio or the larger capability domain. It is a system comprising workforce (i.e., FTE/WYE), equipment, facilities, processes, resources, competencies, and technologies that delivers products and services; for example, a wind tunnel and the workforce that manages, operates, and maintains it; or a complex dedicated to an end-to-end process.

Capability Portfolio. A specific collection of functionally similar site-specific capability components and enabling infrastructure strategically and centrally managed together to meet NASA's strategic goals and objectives. For example, the Space Environments Testing Management Office (SETMO) capability portfolio includes testing in high enthalpy arc jets, flight simulators, thermal vacuum chambers, and radiation laboratories. The program or project manager coordinates with capability portfolio managers on any planned investments, divestments, acquisition strategies, procurements, agreements, and changes to capability portfolio capability components in accordance with requirements and strategic guidance included in *NPR 8600.1, NASA Capability Portfolio Management Requirements*. NPR 8600.1 provides a link to the list of Capability Portfolios.

Center Management Council. The council at a Center that performs oversight of programs and projects by evaluating all program and project work executed at that Center.

Change Request. A change to a prescribed requirement set forth in an Agency or Center document intended for all programs and projects for all time.

Compliance Matrix. The Compliance Matrix (Appendix C of NPR 7120.5) documents whether and how the program or project complies with the requirements of NPR 7120.5. It provides rationale and approvals for tailoring (waivers and deviations) requirements and is part of retrievable program and project records.

Component Facilities. Complexes that are geographically separated from the NASA Center or institution to which they are assigned but are still part of the Agency.

Concept Documentation. Documentation that captures and communicates a feasible concept that meets the goals and objectives of the mission, including results of analyses of alternative concepts, the concept of operations, preliminary risks, and potential descopes. It may include images, tabular data, graphs, and other descriptive material. The Concept Documentation is approved at Mission Concept Review (MCR).

Concept of Operations (ConOps): Developed early in Pre-Phase A, describes the overall high-level concept of how the system will be used to meet stakeholder expectations, usually in a time sequenced manner. It describes the system from an operational perspective and helps facilitate an understanding of the system goals. It stimulates the development of the requirements and architecture related to the user elements of the system. It serves as the basis for subsequent definition documents and provides the foundation for the long-range operational planning activities (for nominal and contingency operations). It provides the criteria for the validation of the system. In cases where an Operations Concept (OpsCon) is developed, the ConOps feeds into the OpsCon and they evolve together. The ConOps becomes part of the Concept Documentation.

Concurrence. A documented agreement by a management official that a proposed course of action is acceptable.

Confidence Level. A probabilistic assessment of the level of confidence of achieving a specific goal.

Configuration Management. A technical and management process applying appropriate processes, resources, and controls to establish and maintain consistency between product configuration information and the product throughout the product life cycle.

Conflict of Interest. A conflict of interest involves the abuse (actual, apparent, or potential) of the trust that NASA has in its personnel. A conflict of interest is a situation in which financial or other personal considerations have the potential to compromise or bias professional judgment and objectivity. An apparent conflict of interest is one in which a reasonable person would think that the individual's judgment is likely to be compromised. A potential conflict of interest involves a situation that may develop into an actual conflict of interest. A conflict of interest exists whether or not decisions are affected by a personal interest; a conflict of interest implies only the potential for bias, not likelihood.

Continuous Risk Management. A systematic and iterative process that efficiently identifies, analyzes, plans, tracks, controls, communicates, and documents risks associated with implementation of designs, plans, and processes.

Contract. A mutually binding legal relationship obligating the seller to furnish the supplies or services (including construction) and the buyer to pay for them. It includes all types of commitments that obligate the Government to an expenditure of appropriated funds and that, except as otherwise authorized, are in writing. In addition to bilateral instruments, contracts include (but are not limited to) awards and notices of awards; job orders or task letters issued under basic ordering agreements; letter contracts; orders, such as purchase orders, under which the contract becomes effective by written acceptance or performance; and bilateral contract modifications. Contracts do not include grants and cooperative agreements.

Control Account. An identified intersection of the Work Breakdown Structure (WBS) and Organizational Breakdown Structure (OBS) at which responsibility for work is assigned to one organizational unit, and actual direct labor, material, and Other Direct Costs (ODC) are compared with the planned budget and the earned value for management control.

Control Account Manager. A Control Account Manager (CAM) is a NASA manager responsible for task performance of a Control Account within the Performance Measurement Baseline (PMB) and for planning and managing the resources authorized to accomplish such task.

Convening Authority. The management official(s) responsible for convening a program or project review; establishing the Terms of Reference (ToR), including review objectives and success criteria; appointing the Standing Review Board (SRB) chair; and concurring in SRB membership. These officials receive the documented results of the review.

Cost Analysis Data Requirement. A three-part document required for tightly coupled programs, loosely coupled programs, single-project programs, and projects (regardless of Category or Class) that provides critical data to assist NASA in developing high fidelity cost and schedule estimates for new NASA projects. CADRe comprises Part A "Narrative" and Part B "Technical Data" in tabular form, provided by the program or project using existing program or project material. The program or project team produces the project Life-Cycle Cost Estimate (LCCE), schedule, and risk identification which is appended as Part C. For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the initial capability cost plus the current Phase E cost estimate is used instead of the Life-Cycle Cost (LCC).

Cost-Loaded Schedule. In the context of the Joint Cost and Schedule Confidence Level (JCL) requirement, a schedule that has costs and/or resources assigned to its individual activities or summary tasks.

Decision Authority (program and project context). The individual authorized by the Agency to make important decisions on programs and projects under his or her authority.

Decision Memorandum. The document that summarizes the decisions made at Key Decision Points (KDPs) or as necessary in between KDPs. The Decision Memorandum includes the Agency Baseline Commitment (ABC), if applicable, Management Agreement cost and schedule, Unallocated Future Expenses (UFE), and schedule margin managed above the project, as well as life-cycle cost and schedule estimates, as required. For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the initial capability cost and the current Phase E cost estimate are documented in the Decision Memorandum. (Documentation of the Phase E cost estimate begins at KDP E.)

Decommissioning. The process of ending an operating mission and the attendant project as a result of a planned end of the mission or project termination. Decommissioning includes final delivery of any remaining project deliverables, disposal of the spacecraft and all its various supporting systems, closeout of contracts and financial obligations, and archiving of project or mission operational and scientific data and artifacts. Decommissioning does not mean that scientific data analysis ceases, only that the project will no longer provide the resources for continued research and analysis.

Derived Requirements. Requirements arising from constraints, consideration of issues implied but not explicitly stated in the high-level direction provided by NASA Headquarters and Center institutional requirements, and factors introduced by the selected architecture and the design. These requirements are finalized through requirements analysis as part of the overall systems engineering process and become part of the program or project requirements baseline. Derived non-technical requirements are established by, and are the responsibility of, the Programmatic Authority. Derived technical requirements are the responsibility of the Institutional Authority.

Design Documentation. A document or series of documents that captures and communicates to others the specific technical aspects of a design. It may include images, tabular data, graphs, and other descriptive material. Design documentation is different from the Cost Analysis Data Requirement (CADRe), though parts of the design documentation may be repeated in the latter.

Development Costs. The total of all costs from the period beginning with the approval to proceed to Implementation at the beginning of Phase C through operational readiness at the end of Phase D.

Deviation. A documented authorization releasing a program or project from meeting a requirement before the requirement is put under configuration control at the level the requirement will be implemented.

Directorate Program Management Council. The forum that evaluates all programs and projects executed within that Mission Directorate and provides input to the Mission Directorate Associate Administrator (MDAA). For programs and Category 1 projects, the MDAA carries forward the DPMC findings and recommendations to the Agency Program Management Council (APMC).

Disposal. The process of eliminating a project's assets, including the spacecraft and ground systems. Disposal includes the reorbiting, deorbiting, and/or passivation (i.e., the process of removing stored energy from a space structure at the end of the mission that could result in an explosion or deflagration of the space structure) of a spacecraft.

Earned Value Management. A project management approach for measuring and assessing project performance through the integration of technical scope with schedule and cost objectives during the execution of the project. EVM provides quantification of technical progress with objective performance measurement techniques, enabling management to gain insight into project status and project completion costs and schedules. Two essential characteristics of successful EVM are EVM system data integrity and carefully targeted monthly EVM data analyses (e.g., identification of risky Work Breakdown Structure (WBS) elements).

Earned Value Management System. The integrated set of policies, processes, systems, and practices that meet an organization's implementation of EIA-748. This integrated management system and its related subsystems allow for planning all work scope to completion; assignment of authority and responsibility at the work performance level; integration of the cost, schedule, and technical aspects of the work into a detailed baseline plan; objective measurement of progress (earned value) at the work performance level; accumulation and assignment of actual costs; analysis of variances from plans; summarization and reporting of performance data to higher levels of management for action; forecast of achievement of milestones and completion of events; forecast of final costs; and disciplined baseline maintenance and incorporation of baseline revisions in a timely manner.

Engineering Requirements. Requirements defined to achieve programmatic requirements and relating to the application of engineering principles, applied science, or industrial techniques.

Ensure. To do or have what is necessary for success. (An example is: Connectivity will be ensured by testing that a signal to noise ratio of ten is maintained in environmental testing.)

Environmental Management. The activity of ensuring that program and project actions and decisions that may potentially affect or damage the environment are assessed during the Formulation Phase and reevaluated throughout Implementation. This activity is performed according to all NASA policy and Federal, State, Tribal Government, and local environmental laws and regulations.

Environmental Impact. The direct, indirect, or cumulative beneficial or adverse effect of an action on the environment.

Evaluation. The continual self- and independent assessment of the performance of a program or project and incorporation of the evaluation findings to ensure adequacy of planning and execution according to plans.

Extended Operations. Extended operations are operations conducted after the planned prime mission operations are complete. Extended operations require approval, as determined by the Mission Directorate. Once the extension of operations is approved, program or project documentation must be updated.

Final (document context). Implies the expectation of a finished product. All approvals required by Center policies and procedures have been obtained.

Final Mission Report. The Final Mission Report is a summary of what the mission accomplished and is prepared at the end of a mission. It has also been called an End of Mission report, but this is not to be confused with the End of Mission Plan (EOMP) required by *NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments*. The Final Mission Report generally includes a summary of the mission accomplishments, science data and/or samples collected, and a summary of the results achieved. This report is prepared in conjunction with documenting the mission's lessons learned as described in *NPD 7120.6, Knowledge Policy for Programs and Projects* and the project's Knowledge Management Plan. Projects need to ensure that resources are allocated to develop the Final Mission Report and lessons learned. These provide a valuable historical record of NASA's accomplishments and the issues that were encountered and overcome as part of the mission.

Formal Dissent. A disagreement with a decision or action that is based on a sound rationale (not on unyielding opposition) that an individual judges is of sufficient importance that it warrants a specific review and decision by higher-level management, and the individual specifically requests that the dissent be recorded and resolved by the Formal Dissent process.

Formulation. The identification of how the program or project supports the Agency's strategic needs, goals, and objectives; the assessment of feasibility, technology, and concepts; risk assessment, team building, development of operations concepts, and acquisition strategies; establishment of high-level requirements and success criteria; the preparation of plans, budgets, and schedules essential to the success of a program or project; and the establishment of control systems to ensure performance to those plans and alignment with current Agency strategies.

Formulation Agreement. The Formulation Agreement is prepared by the project 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.

Formulation Authorization Document. The document issued by the Mission Directorate Associate Administrator (MDAA) to authorize the formulation of a program whose goals will fulfill part of the Agency's Strategic Plan and Mission Directorate strategies and establish the expectations and constraints for activity in the Formulation Phase. In addition, a FAD or equivalent is used to authorize the formulation of a project. (See Appendix E of NPR 7120.5F.)

Formulation Phase. The first part of a program or project life cycle where Formulation activities are completed. The Formulation Phase begins at Approval for Formulation and ends at Approval for Implementation as depicted in life-cycle figures 2-2 through 2-5 of NPR 7120.5F.

Functional Requirements. Requirements that specify what a system needs to do. Requirements that specify a function that a system or component needs to be able to perform.

Funding (budget authority). The authority provided by law to incur financial obligations that will result in expenditures. There are four basic forms of budget authority, but only two are applicable to NASA: appropriations and spending authority from offsetting collections (reimbursables and working capital funds). Budget authority is provided or delegated to programs and projects through the Agency's funds distribution process.

Health and Medical Requirements. Requirements defined by the Office of the Chief Health and Medical Officer (OCHMO).

Human Systems Integration. A required interdisciplinary integration of the human as an element of the system to ensure that the human and software and hardware components cooperate, coordinate, and communicate effectively to perform a specific function or mission successfully.

Implementation. The execution of approved plans for the development and operation of a program or project and the use of control systems to ensure performance to approved plans and continued alignment with the Agency's needs, goals, and objectives.

Implementation Phase. The second part of a program or project life cycle where Implementation activities are completed. The Implementation Phase begins at Approval for Implementation and continues through the end of the program or project as depicted in life-cycle figures 2-2 through 2-5 of NPR 7120.5F.

In-House (EVM). Project work scope conducted solely using NASA Headquarters and/or Center personnel or other NASA resources (i.e., facilities, equipment), including support contractors that augment NASA resources to achieve the objectives of the project. There is no prime contractor, university, laboratory, institution, or foreign partner involvement in in-house work.

Independent Assessment(s) (includes reviews, evaluations, audits, analysis oversight, investigations). Assessments are independent to the extent the involved personnel apply their expertise impartially and without any conflict of interest or inappropriate interference or influence, particularly from the organization(s) being assessed.

Independent Funding (context of Technical Authority). The funding of Technical Authorities (TAs) is considered independent if funding originating from the Mission Directorate or other Programmatic Authorities is provided to the Center in a manner that cannot be used to influence the technical independence or security of TAs.

Industrial Base. The capabilities residing in either the commercial or government sector required to design, develop, manufacture, launch, and service the program or project. This encompasses related manufacturing facilities, supply chain operations and management, a skilled workforce, launch infrastructure, research and development, and support services.

Information Technology. Any equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by an executive Agency. Information technology also includes computers; ancillary equipment (including imaging peripherals, input, output, and storage devices necessary for security and surveillance); peripheral equipment designed to be controlled by the central processing unit of a computer; software; firmware; and similar procedures, services (including support services), and related resources. It does not include any equipment acquired by a Federal contractor incidental to a Federal contract.

Infrastructure Requirements. The facilities real property (buildings and/or other structures) and environmental, aircraft, personal property, collateral equipment, and associated system resources that are needed to support programs and projects. Use of the capability afforded by the infrastructure includes consideration of the Life-Cycle Cost (LCC), (design, construction, commissioning, outfitting, special test equipment, utilities, operations and maintenance, and future disposal cost) and other liabilities it presents. The construction of real property infrastructure or the modification of existing infrastructure above a defined dollar amount must go through the Agency's Construction of Facilities account, i.e., Construction and Environmental Compliance Restoration (CECR). (See *NPR 9250.1, Property, Plant, and Equipment and Operating Materials and Supplies*, *NPD 8800.14, Policy for Real Estate Management*, and *NPR 8820.2, Facility Project Requirements (FPR).)*

Initial Capability. For single-project programs and projects that have an indefinite Phase E end point and plan for on-going production and operations during Phase E, the initial capability is the first operational mission flight or as defined as part of the KDP B Review Plan. The scope of the initial capability is documented in the KDP B Decision Memorandum.

Institutional Authority. Institutional Authority encompasses all those organizations and authorities not in the Programmatic Authority. This includes engineering, safety and mission assurance, and health and medical organizations; mission support organizations; and Center Directors.

Institutional Requirements. Requirements that focus on how NASA does business that are independent of a particular program or project. There are five types: engineering, program and project management, safety and mission assurance, health and medical, and mission support requirements.

Integrated Baseline Review. The Integrated Baseline Review (IBR) is a risk-based review conducted by program or project management to ensure a mutual understanding between the customer and supplier of the risks inherent in the supplier's Performance Measurement Baseline (PMB) and to ensure that the PMB is realistic for accomplishing all authorized work within the authorized schedule and budget.

Integrated Center Management Council. The forum used by projects and programs that are being implemented by more than one Center and includes representatives from all participating Centers. The ICMC will be chaired by the director of the Center (or representative) responsible for program or project management.

Integrated Logistics Support. The management, engineering activities, analysis, and information management associated with design requirements definition, material procurement and distribution, maintenance, supply replacement, transportation, and disposal that are identified by space flight and ground systems supportability objectives.

Integrated Master Schedule. A logic network-based schedule that reflects the total project scope of work, traceable to the Work Breakdown Structure (WBS), as discrete and measurable tasks/milestones and supporting elements that are time phased through the use of valid durations based on available or projected resources and well-defined interdependencies.

Integrated Program Management Report. The standard report format to communicate program/project monthly cost/schedule performance and status between a contractor and the Government. The IPMR comprises seven report formats that provide program/project managers information to: integrate cost and schedule performance data with technical performance measures; identify the magnitude and impact of actual and potential problem areas causing significant cost and schedule variances; forecast schedule completions; and provide valid, timely program/project status information to higher management for effective decision making. This is a contract data requirement when EVM is required.

Integration Plan. The integration and verification strategies for a project interface with the system design and decomposition into the lower-level elements. The plan is structured to bring the elements together to assemble each subsystem and to bring all of the subsystems together to assemble the system or product. The primary purposes of the plan are: (1) to describe the coordinated integration effort that supports the implementation strategy, (2) to describe for the participants what needs to be done in each integration step, and (3) to identify the required resources and when and where they will be needed.

Interface Control Document. An agreement between two or more parties on how interrelated systems will interface with each other. It documents interfaces between things like electrical connectors (e.g., what type, how many pins, what signals will be on each of the pins, etc.); fluid connectors (type of connector or of fluid being passed, flow rates of the fluid, etc.); mechanical (types of fasteners, bolt patterns, etc.); and any other interfaces that might be involved.

Joint Cost and Schedule Confidence Level. The probability that cost will be equal to or less than the targeted cost and schedule will be equal to or less than the targeted schedule date. The JCL calculation includes consideration of the risk associated with all elements, whether they are funded from appropriations or managed outside of the project (e.g., risk impacts of a foreign contribution behind schedule, risk impacts of the launch vehicle). JCL calculations include content from the milestone at which the JCL is calculated through the completion of Phase D activities. (See the *NASA Cost Estimating Handbook* at https://www.nasa.gov/content/cost-estimating-handbook for more information on JCL.)

Key Decision Point. The event at which the Decision Authority determines the readiness of a program or project to progress to the next phase of the life cycle (or to the next KDP).

Knowledge Management. A collection of policies, processes, and practices relating to the use of intellectual and knowledge-based assets in an organization.

Leading Indicator. A measure for evaluating the effectiveness of how a specific activity is applied on a program in a manner that provides information about impacts likely to affect the system performance objectives. A leading indicator may be an individual measure, or collection of measures, predictive of future system and project performance before the performance is realized. The goal of the indicators is to provide insight into potential future states to allow management to act before problems are realized.

Lessons Learned. Captured knowledge or understanding gained through experience which, if shared, would benefit the work of others. Unlike a best practice, a lesson learned describes a specific event that occurred and provides recommendations for obtaining a repeat of success or for avoiding reoccurrence of an adverse work practice or experience.

Life-Cycle Cost. The total of the direct, indirect, recurring, nonrecurring, and other related expenses both incurred and estimated to be incurred in the design, development, verification, production, deployment, prime mission operation, maintenance, support, and disposal of a project, including closeout, but not extended operations. The LCC of a project or system can also be defined as the total cost of ownership over the project or system's planned life cycle from Formulation (excluding Pre-Phase A) through Implementation (excluding extended operations). The LCC includes the cost of the launch vehicle.

Life-Cycle Review. A review of a program or project designed to provide a periodic assessment of the technical and programmatic status and health of a program or project at a key point in the life cycle, (e.g., Preliminary Design Review (PDR) or Critical Design Review (CDR)). Certain LCRs provide the basis for the Decision Authority to approve or disapprove the transition of a program or project at a Key Decision Point (KDP) to the next life-cycle phase.

Loosely Coupled Programs. These programs address specific objectives through multiple space flight projects of varied scope. While each individual project has an assigned set of mission objectives, architectural and technological synergies and strategies that benefit the program as a whole are explored during the Formulation process. For instance, Mars orbiters designed for more than one Mars year in orbit are required to carry a communication system to support present and future landers.

Management Agreement. Within the Decision Memorandum, the parameters and authorities over which the program or project manager has management control constitute the program or project Management Agreement. A program or project manager has the authority to manage within the Management Agreement and is accountable for compliance with the terms of the agreement.

Margin. The allowances carried in budget (see Unallocated Future Expenses), projected schedules, and technical performance parameters (e.g., weight, power, memory) to account for uncertainties and risks. Margins are allocated in the Formulation process based on assessments of risks and are typically consumed as the program or project proceeds through the life cycle.

Metric. A measurement taken over a period that communicates vital information about the status or performance of a system, process, or activity.

Mission. A major activity required to accomplish an Agency goal or to effectively pursue a scientific, technological, or engineering opportunity directly related to an Agency goal. Mission needs are independent of any particular system or technological solution.

Mission Directorate Program Management Council. (See Directorate Program Management Council (DPMC).) The forum that evaluates all programs and projects executed within that Mission Directorate and provides input to the MDAA. For programs and Category 1 projects, the MDAA carries forward the DPMC findings and recommendations to the APMC.

Mission Resilience. The ability of a mission system to withstand or recover from adverse conditions such as intrusion, subversion, disruption, degradation, or destruction from environmental or hostile causes.

Mission Support Office Requirements. Requirements defined by mission support offices (e.g., procurement and infrastructure).

Non-Applicable Requirement. Any requirement that is not relevant or not capable of being applied. The non-applicable requirement provision is intended to provide an efficient means to grant and document relief from a requirement not relevant or not capable of being applied to the specific mission. The need for relief from the requirement is obvious and the judgment of non-applicable is likely to be the same regardless of who makes the determination. For example, the requirement to produce a Human-Rating Certification Package is non-applicable for a robotic project.

Operations Concept (OpsCon): Developed later in the life cycle and baselined at PDR, a more detailed description of how the flight system and the ground system are used together to ensure that the concept of operation is reasonable. This might include how mission data of interest, such as engineering data, scientific data, and data standards/metadata are captured, returned to Earth, processed, made searchable, accessible, and available to users, and archived for future reference. The OpsCon should describe how the flight system and ground system work together across mission phases for planning, training, launch, cruise, critical activities, science observations, and end of mission to achieve the mission. This product should be informed by the ConOps and they should evolve together. They may exist as a single product or separate products.

Operations Concept Documentation. A description of how the flight system and the ground system are used together to ensure that the concept of operation is reasonable. This might include how mission data of interest, such as engineering or scientific data, are captured, returned to Earth, processed, made available to users, and archived for future reference. The Operations Concept Documentation should describe how the flight system and ground system work together across mission phases for launch, cruise, critical activities, science observations, and the end of the mission to achieve the mission. The Operations Concept is baselined at the Preliminary Design Review (PDR) with the initial preliminary operations concept required at the Mission Concept Review (MCR) according to the product tables in NPR 7120.5F.

Operations Handbook. The Operations Handbook provides information essential to the operation of a spacecraft and other components of a mission. It generally includes a description of the spacecraft and other mission components and the operational support infrastructure; operational procedures, including step-by-step operational procedures for activation and deactivation; malfunction detection procedures; and emergency procedures. The handbook identifies the commands for the spacecraft and other mission components, defines the functions of these commands, and provides supplemental reference material for use by the operations personnel. The main emphasis is placed on command types, command definitions, command sequences, and operational constraints. Additional document sections may describe uploadable operating parameters, the telemetry stream data contents (for both the science and the engineering data), the Mission Operations System displays, and the spacecraft and other mission component health monitors.

Orbital Debris. Any object placed in space by humans that remains in orbit and no longer serves any useful function. Objects range from spacecraft to spent launch vehicle stages to components and include materials, trash, refuse, fragments, and other objects that are overtly or inadvertently cast off or generated.

Organizational Breakdown Structure. The project hierarchy of line and functional organizations as applied to the specific project. The OBS describes the organizations responsible for performing the authorized work.

Passback. In the spring of each year, the U.S. Office of Management and Budget (OMB) issues planning guidance to executive agencies for the budget beginning October 1 of the following year. In September, Agencies submit their initial budget requests to OMB. During October and November, OMB staff review the agency budget requests against the President's priorities, program performance, and budget constraints. In November and December, the President makes decisions on agency requests based on recommendations from the OMB director. OMB informs agencies of the President's decisions in what is commonly referred to as the OMB "passback." Agencies may appeal these decisions to the OMB director and in some cases directly to the President, but the timeframe for appeals is small.

Performance Measurement Baseline. The time-phased budget plan for accomplishing all authorized work scope in a project's life cycle, which includes both NASA internal costs and supplier costs. The PMB is used to measure project performance using Earned Value Management (EVM), if required, or other performance measurement techniques if EVM is not required. It is formed by the budgets assigned to scheduled control accounts and the applicable indirect budgets. For future effort not planned to the control account level, the PMB also includes budgets assigned to higher-level WBS elements and undistributed budgets. The PMB does not include UFE or management reserve for contractors.

Performance Requirement. A performance requirement describes in measurable terms how well a function is to be executed or accomplished. A performance requirement is generally couched in terms of degree, rate, quantity, quality, timeliness, coverage, timeliness or readiness and so on. A performance requirement can also describe the conditions under which the function is to be performed.

Pre-Acquisition Strategy Meeting. A precursor meeting to the ASM, where a small group of senior Agency management discusses preliminary acquisition strategies in preparation for the ASM to enable insight for the Associate Administrator (AA) and to allow information exchange about strategic options prior to presenting the fully developed acquisition strategy at the ASM. Pre-ASMs are not always required as determined by the Convening Authority. (See *NPD 1000.5, Policy for NASA Acquisition* for more information on Pre-ASMs.)

Pre-Customized Compliance Matrix. An NPR 7120.5F Compliance Matrix template that eliminates non-applicable requirements for a specific type of program or project.

Preliminary (document context). Implies that the product has received initial review in accordance with Center best practices. The content is considered correct, though some "to be determined" (TBDs) may remain. All approvals required by Center policies and procedures have been obtained. Major changes are expected.

Prescribed Requirement. A requirement levied on a lower organizational level by a higher organizational level.

Principal Investigator. A person who conceives an investigation and is responsible for carrying it out and reporting its results. In some cases, Principal Investigators (PIs) from industry and academia act as project managers for smaller development efforts with NASA personnel providing oversight.

Procurement Strategy Meeting. A forum where management reviews and approves the approach for the Agency's major and other selected procurements. Chaired by the Assistant Administrator for Procurement (or designee), the PSM addresses and documents information, activities, and decisions required by the Federal Acquisition Regulation (FAR) and the NASA FAR Supplement (NFS) and incorporates NASA strategic guidance and decisions from the Acquisition Strategy Meeting (ASM) to ensure the alignment of the individual procurement action with NASA's portfolio and mission.

Program. A strategic investment by a Mission Directorates or mission support offices that has a defined architecture and/or technical approach, requirements, funding level, and management structure that initiates and directs one or more projects. A program implements a strategic direction that the Agency has identified as needed to accomplish Agency goals and objectives. (See Section 2.4.)

Program Commitment Agreement. The contract between the NASA Associate Administrator (AA) and the responsible Mission Directorate Associate Administrator (MDAA) that authorizes the transition of a program from Formulation to Implementation. (See Appendix D in NPR 7120.5F.)

Program Plan. The document that establishes the program's baseline for Implementation, signed by the Mission Directorate Associate Administrator (MDAA), Center Director(s), and program manager.

Program (Project) Team. All participants in program (project) Formulation and Implementation. This includes all direct reports and others that support meeting program (project) responsibilities.

Programmatic Authority. Programmatic Authority includes the Mission Directorates and their respective program and project managers. Individuals in these organizations are the official voices for their respective areas. Programmatic Authority sets, oversees, and ensures conformance to applicable programmatic requirements.

Programmatic Requirements. Requirements set by the Mission Directorate, program, project, and Principal Investigator (PI), if applicable. These include strategic scientific and exploration requirements, system performance requirements, safety requirements, and schedule, cost, and similar nontechnical constraints.

Project. A space flight project is a specific investment identified in a Program Plan having defined requirements, a Life-Cycle Cost (LCC), a beginning, and an end. A project also has a management structure and may have interfaces to other projects, agencies, and international partners. A project yields new or revised products that directly address NASA's strategic goals.

Project Plan. The document that establishes the project's baseline for Implementation, signed by the responsible program manager, Center Director, project manager, and the Mission Directorate Associate Administrator (MDAA), if required. (See Appendix H in NPR 7120.5F.)

Rebaselining. The process that results in a change to a project's Agency Baseline Commitment (ABC).

Reimbursable Program/Project. A project (including work, commodities, or services) for customers other than NASA for which reimbursable agreements have been signed by both the customer and NASA. The customer provides funding for the work performed on its behalf.

Replanning. The process by which a program or project updates or modifies its plans.

Request for Action/Review Item Discrepancy. The most common names for the comment forms that reviewers submit during Life-Cycle Reviews (LCRs) that capture their comments, concerns, and/or issues about the product or documentation.

Residual Risk. The remaining risk that exists after all mitigation actions have been implemented or exhausted in accordance with the risk management process. (See *NPD 8700.1, NASA Policy for Safety and Mission Success.*)

Resource Management Officer. The person responsible for integrating project inputs for budget planning and execution across many projects or control accounts.

Responsibility Assignment Matrix. A matrix showing the relationship between the WBS elements and the organizations assigned responsibility for ensuring their accomplishment. The RAM normally depicts the assignment of each control account to a single manager, along with the assigned budget. When resource values are applied to these relationships, it may be referred to as a dollarized RAM.

Risk. In the context of mission execution, risk is the potential for performance shortfalls, which may be realized in the future, with respect to achieving explicitly established and stated performance requirements. The performance shortfalls may be related to any one or more of the following mission execution domains: (1) safety, (2) technical, (3) cost, and (4) schedule. (See *NPR 8000.4, Agency Risk Management Procedural Requirements*.)

Risk Assessment. An evaluation of a risk item that determines: (1) what can go wrong, (2) how likely is it to occur, (3) what the consequences are, (4) what the uncertainties are that are associated with the likelihood and consequences, and (5) what the mitigation plans are.

Risk Management. Risk management includes Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM) in an integrated framework. RIDM informs systems engineering decisions through better use of risk and uncertainty information in selecting alternatives and establishing baseline requirements. CRM manages risks over the course of the development and the Implementation Phase of the life cycle to ensure that safety, technical, cost, and schedule requirements are met. This is done to foster proactive risk management, to better inform decision making through better use of risk information, and then to more effectively manage Implementation risks by focusing the CRM process on the baseline performance requirements emerging from the RIDM process. (See *NPR 8000.4, Agency Risk Management Procedural Requirements*.) These processes are applied at a level of rigor commensurate with the complexity, cost, and criticality of the program.

Risk-Informed Decision Making. A risk-informed decision-making process that uses a diverse set of performance measures (some of which are model-based risk metrics) along with other considerations within a deliberative process to inform decision making.

Risk-Informed Probabilistic Analysis. Analysis that is informed by all appropriate discrete risks and uncertainties including those that may not be discretely managed in the risk management system.

Safety. Freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Safety and Mission Assurance Requirements. Requirements defined by the Safety and Mission Assurance (SMA) organization related to safety and mission assurance.

Security. Protection of people, property, and information assets owned by NASA that covers physical assets, personnel, Information Technology (IT), communications, and operations.

Signature. A distinctive mark, characteristic, or thing that indicates identity; one's name as written by oneself.

Single-Project Programs. These programs tend to have long development and/or operational lifetimes, represent a large investment of Agency resources, and have contributions from multiple organizations/agencies. These programs frequently combine program and project management approaches, which they document through tailoring.

Space Act Agreements. The National Aeronautics and Space Act of 1958 (herein, the Space Act), as amended (51 U.S.C. § 20113(e)), authorizes NASA "to enter into and perform such. other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate, with any agency or instrumentality of the United States, or with any state, territory, or possession, or with any political subdivision thereof, or with any person, firm, association, corporation, or educational institution." Space Act Agreements information is available at http://www.nasa.gov/open/plan/space-act.html.

Stakeholder. An individual or organizational customer having an interest (or stake) in the outcome or deliverable of a program or project.

Standards. Formal documents that establish a norm, requirement, or basis for comparison; a reference point to measure or evaluate against. A technical standard, for example, establishes uniform engineering or technical criteria, methods, processes, and practices. (Refer to *NPR 7120.10, Technical Standards for NASA Programs and Projects*.)

Standing Review Board. The board responsible for conducting independent reviews (life cycle and special) of a program or project and providing objective, expert judgments to the Convening Authorities. The reviews are conducted in accordance with approved Terms of Reference (ToR) and life-cycle requirements per NPR 7120.5 and NPR 7123.1.

Success Criteria. That portion of the top-level requirements that defines what is to be achieved to successfully satisfy NASA Strategic Plan objectives addressed by the program or project.

Suppliers. Each project office is a customer having a unique, multi-tiered hierarchy of suppliers to provide it products and services. A supplier may be a contractor, grantee, another NASA Center, university, international partner, or other Government agency. Each project supplier is also a customer if it has authorized work to a supplier lower in the hierarchy.

Supply Chain. The specific group of suppliers and their interrelationships that is necessary to design, develop, manufacture, launch, and service the program or project. This encompasses all levels within a space system, including providers of raw materials, components, subsystems, systems, systems integrators, and services.

System. The combination of elements that function together to produce the capability required to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose.

Systems Engineering. Per NPR 7123.1, NASA systems engineering is a logical systems approach performed by multidisciplinary teams to engineer and integrate NASA's systems to ensure NASA products meet the customer's needs. Implementation of this systems approach enhances NASA's core engineering capabilities while improving safety, mission success, and affordability. This systems approach is applied to all elements of a system (i.e., hardware, software, and human) and all hierarchical levels of a system over the complete program/project life cycle.

Tailoring. The process used to adjust or seek relief from a prescribed requirement to accommodate the needs of a specific task or activity (e.g., program or project). The tailoring process results in the generation of deviations and waivers depending on the timing of the request.

Technical Authority. Part of NASA's system of checks and balances that provides independent oversight of programs and projects in support of safety and mission success through the selection of individuals at delegated levels of authority. These individuals are the Technical Authorities. Technical Authority delegations are formal and traceable to the NASA Administrator. Individuals with Technical Authority are funded independently of a program or project.

Technical Authority Requirements. Requirements invoked by Office of the Chief Engineer (OCE), Office of Safety and Mission Assurance (OSMA), and Office of the Chief Health and Medical Officer (OCHMO) documents (e.g., NPRs or technical standards cited as program or project requirements) or contained in Center institutional documents. These requirements are the responsibility of the office or organization that established the requirement unless delegated elsewhere.

Technical Performance Measures. The set of critical or key performance parameters that are monitored by comparing the current actual achievement of the parameters with that anticipated at the current time and on future dates.

Technical Standard. Common and repeated use of rules, conditions, guidelines, or characteristics for products or related processes and production methods and related management systems practices; the definition of terms, classification of components; delineation of procedures; specification of dimensions, materials, performance, designs, or operations; measurement of quality and quantity in describing materials, processes, products, systems, services, or practices; test methods and sampling procedures; or descriptions of fit and measurements of size or strength. (Source: OMB Circular No. A-119, Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities.) (See *NPR 7120.10, Technical Standards for NASA Programs and Projects*.)

Technology Readiness Level. Provides a scale against which to measure the maturity of a technology. TRLs range from 1, Basic Technology Research, to 9, Systems Test, Launch, and Operations. Typically, a TRL of 6 (i.e., technology demonstrated in a relevant environment) is required for a technology to be integrated into a flight system. (See *NASA/SP-2016-6105, NASA Systems Engineering Handbook* for more information on TRL levels and technology assessment, and *SP-20205003605, Technology Readiness Assessment Best Practices Guide*.)

Termination Review. A special review convened to determine whether to continue or terminate a program or project. Circumstances that could trigger a Termination Review include the anticipated inability of the program or project to meet its commitments, an unanticipated change in Agency strategic planning, or an unanticipated change in the NASA budget. (See Section 5.11.1.)

Terms of Reference. A document specifying the nature, scope, schedule, and ground rules for an independent review or independent assessment.

Threshold Science Requirements. The mission performance requirements necessary to achieve the minimum science acceptable for the investment. In some Announcements of Opportunity (AOs) used for competed missions, threshold science requirements may be called the "science floor" for the mission. (See also Baseline Science Requirements.)

Tightly Coupled Programs. Programs with multiple projects that execute portions of a mission(s). No single project is capable of implementing a complete mission. Typically, multiple NASA Centers contribute to the program. Individual projects may be managed at different Centers. The program may also include other agency or international partner contributions.

Unallocated Future Expenses. The portion of estimated cost required to meet the specified confidence level that has not been allocated to the specific project Work Breakdown Structure (WBS) subelements because the probabilistic estimate includes risks and uncertainties.

Uncoupled Programs. Programs implemented under a broad theme and/or a common program implementation concept, such as providing frequent flight opportunities for cost-capped projects selected through Announcements of Opportunity (AO) or NASA Research Announcements (NRAs). Each such project is independent of the other projects within the program.

Validation. The process of showing proof that the product accomplishes the intended purpose based on stakeholder expectations. May be determined by a combination of test, analysis, demonstration, and inspection. (Answers the question, "Am I building the right product?")

Verification. Proof of compliance with requirements. Verification may be determined by a combination of test, analysis, demonstration, and inspection. (Answers the question, "Did I build the product right?")

Waiver. A documented authorization releasing a program or project from meeting a requirement after the requirement is put under configuration control at the level the requirement will be implemented.

Work Breakdown Structure. A product-oriented hierarchical division of the hardware, software, services, and data required to produce a program or project's end product(s), structured according to the way the work will be performed and reflecting the way in which program or project costs and schedule, technical, and risk data are to be accumulated, summarized, and reported.

Work Package. A work package is a natural subdivision of control accounts. A work package is simply a task/activity or grouping of work. A work package is the point at which work is planned, progress is measured, and earned value is computed.

B. Acronyms

AA	Associate Administrator
ABC	Agency Baseline Commitment
AI&T	Assembly, Integration, and Test
ALR	Audit Liaison Representative
AMPL	Agency Master Program/Project List
AO	Announcement of Opportunity
AOP	Agency Operating Plan
API	Annual Performance Indicator
APMC	Agency Program Management Council
APP	Annual Performance Plan
APPEL	Academy of Program/Project and Engineering Leadership
APPEL KS	APPEL Knowledge Services
APR	Annual Performance Report
ASAP	NASA Aerospace Safety Advisory Panel
ASC	Acquisition Strategy Council
ASM	Acquisition Strategy Meeting
BAA	Broad Agency Announcement
BoE	Basis of Estimate
BPR	Baseline Performance Review
BY	Budget Year
CADRe	Cost Analysis Data Requirement
CAIB	Columbia Accident Investigation Board
CAM	Control Account Manager
CDR	Critical Design Review
CECR	Construction and Environmental Compliance Restoration
CERR	Critical Events Readiness Review
CHMO	Chief Health and Medical Officer
CLP	Continuous Learning Point
CMC	Center Management Council
CoF	Construction of Facilities
COFR	Certification of Flight Readiness
ConOps	Concept of Operations
COOP	Continuity of Operations
COP	Congressional Operating Plan
COPV	Composite Overwrapped Pressure Vessel
COSTAR	Corrective Optics Space Telescope Axial Replacement
COTS	Commercial Off The Shelf
CPD	Center Policy Directive
CPR	Center Procedural Requirements
CR	Continuing Resolution

CRA	Cost Risk Analysis
CRC	Contract Requirements Checklist
CRM	Continuous Risk Management
CSO	Chief Safety and Mission Assurance Officer
CWBS	Contract Work Breakdown Structure
DA	Decision Authority
DCE	Deputy Chief Engineer
DCI	Data Collection Instrument
DM	Decision Memorandum
DoD	U.S. Department of Defense
DPMC	Directorate PMC
DR	Decommissioning Review
DRD	Data Requirements Description
DRM	Design Reference Mission
DRR	Disposal Readiness Review
EA	Environmental Assessment
EAC	Estimate at Completion
EEE	Electrical, Electronic, and Electromechanical
EIA	Electronic Industries Alliance
ELV	Expendable Launch Vehicle
EMS	Environmental Management System
EOM	End of Mission
EOMP	End of Mission Plan
EPR	Engineering Peer Review
ETA	Engineering Technical Authority
EVM	Earned Value Management
EVMFP	Earned Value Management Focal Point
EVMS	Earned Value Management System
FAC-P/PM	Federal Acquisition Certification for Program/Project Managers
FAD	Formulation Authorization Document
FAR	Federal Acquisition Regulation
FFRDC	Federal Funded Research and Development Center
FRR	Flight Readiness Review
FRR (LV)	Flight Readiness Review (Launch Vehicle)
FTE	Full-Time Equivalent
FY	Fiscal Year
GAO	U.S. Government Accountability Office
GDS	Ground Data System
GEMS	Gravity and Extreme Magnetism Small Explorer
GFY	Government Fiscal Year
GOES-R	Geostationary Operational Environmental Satellite—R Series
GOS	Ground Operations System
GSE	Government Standard Equipment

HATS	Headquarters Action Tracking System
HMTA	Health and Medical Technical Authority
HQ	Headquarters
HRCP	Human-Rating Certification Package
HSF	Human Space Flight
HSI	Human Systems Integration
HST	Hubble Space Telescope
IAEA	International Atomic Energy Agency
IBR	Integrated Baseline Review
ICA	Independent Cost Assessment
ICD	Interface Control Document
ICE	Independent Cost Estimate
ICMC	Integrated Center Management Council
IG	NASA Inspector General
ILS	Integrated Logistics Support
IMS	Integrated Master Schedule
INCOSE	International Council on System Engineering
IPMR	Integrated Program Management Report
IRD	Interface Requirements Document
ISE	Independent Schedule Estimate
ISS	International Space Station
IT	Information Technology
IV&V	Independent Verification and Validation
JCL	Joint (Cost and Schedule) Confidence Level
JPL	Jet Propulsion Laboratory
JWST	James Webb Space Telescope
KDP	Key Decision Point
LAS	Launch Abort System
LCC	Life-Cycle Cost
LCCE	Life-Cycle Cost Estimate
LDE	Lead Discipline Engineer
LoE	Level of Effort (also LOE)
LRD	Launch Readiness Date
LRR	Launch Readiness Review
LV	Launch Vehicle
M&P	Management and Performance
MCP	Mishap Contingency Plan
MCR	Mission Concept Review
MD	Mission Directorate
MDAA	Mission Directorate Associate Administrator
MDCE	Mission Directorate Chief Engineer
MdM	Metadata Manager (database)
MDR	Mission Definition Review

MEL	Master Equipment List
MMT	Mission Management Team
MOA	Memorandum of Agreement
MOS	Mission Operations System
MOU	Memorandum of Understanding
MPAR	Major Program Annual Report
MRB	Mission Readiness Briefing
MRR	Mission Readiness Review
MSD	Mission Support Directorate
MSO	Mission Support Organization
MSR	Monthly Status Report
N2	Agency budget database
NA	Non-Applicable
NAC	NASA Advisory Council
NAII	NASA Advisory Implementing Instruction
NAMS	NASA Account Management System
NASA	National Aeronautics and Space Administration
NEN	NASA Engineering Network
NEPA	National Environmental Policy Act
NESC	NASA Engineering and Safety Center
NFS	NASA FAR Supplement
NFSAM	NASA Nuclear Flight Safety Assurance Manager
NID	NASA Interim Directive
NOA	New Obligation Authority
NOAA	National Oceanographic and Atmospheric Administration
NODIS	NASA Online Directives Information System
NPD	NASA Policy Directive
NPI	NASA Policy Instruction
NPR	NASA Procedural Requirements
NRA	NASA Research Announcement
NSM	NASA Structure Management
NSPD	National Security Presidential Directive
NSPM	National Security Presidential Memorandum
OBS	Organizational Breakdown Structure
OCAP	Orbital Collision Avoidance Plan
OCE	Office of the Chief Engineer
OCFO	Office of the Chief Financial Officer
OCHMO	Office of the Chief Health and Medical Officer
OCIO	Office of the Chief Information Officer
ODAR	Orbital Debris Assessment Report
ODC	Other Direct Costs
OICMS	Office of Internal Controls and Management Systems
OIG	Office of the Inspector General

OIIR	Office of International and Interagency Relations
OLIA	Office of Legislative and Intergovernmental Affairs
OMB	U.S. Office of Management and Budget
ONCE	One NASA Cost Engineering database
OpsCon	Operations Concept
ORR	Operational Readiness Review
OSMA	Office of Safety and Mission Assurance
PAA	Program Analyses and Alignment
PBR	President's Budget Request
PCA	Program Commitment Agreement
PCE	Project Chief Engineer
PCLS	Probabilistic Cost-Loaded Schedule
PDP	Personal Development Portfolio
PDR	Preliminary Design Review
PE	Program or Project Executive
PFAR	Post-Flight Assessment Review
PI	Principal Investigator
PIR	Program Implementation Review
PLAR	Post-Launch Assessment Review
PM	Program or Project Management
PMB	Performance Measurement Baseline
PMC	Program Management Council
PPBE	Planning, Programming, Budgeting, and Execution
P/PM	Program or Project Manager
PPMB	Program and Project Management Board
PPP	Project Protection Plan
Pre-ASM	Pre-Acquisition Strategy Meeting
PRG	Programming and Resource Guidance
PRR	Production Readiness Review
PSM	Procurement Strategy Meeting
RFA	Request For Action
RFP	Request For Proposal
RID	Review Item Discrepancy
RIDM	Risk-Informed Decision Making
R&M	Reliability and Maintainability
RMO	Resource Management Officer
SAA	Space Act Agreement
SAP	Systems, Applications, and Products (in Data Processing)
SAR	System Acceptance Review or Safety Analysis Report
SAS	Safety Analysis Summary
SATERN	System for Administration, Training, and Educational Resources for NASA
SCaN	Space Communications and Navigation
SCRM	Supply Chain Risk Management

SDR	System Definition Review
SEMP	Systems Engineering Management Plan
SER	Safety Evaluation Report
SETMO	Space Environments Testing Management Office
SI	Système Internationale (International System of Units)
SID	NASA OCFO Strategic Investments Division
SIP	Strategy Implementation Planning
SIR	System Integration Review
SLS	Space Launch System
S(&)MA	Safety (and) Mission Assurance
SMA TA	Safety and Mission Assurance Technical Authority
SMC	Strategic Management Council
SMD	Science Mission Directorate
SME	Subject Matter Expert
SMSR	Safety and Mission Success Review
SOMA	Science Office for Mission Assessments
SOMD	Space Operations Mission Directorate
SPG	Strategic Programming Guide
SPIDR	Spectroscopy and Photometry of Intergalactic Medium's Diffuse Radiation
SPP	Single-Project Program
SRA	Schedule Risk Analysis
SRB	Standing Review Board
SRM	Solid Rocket Motor
SRR	Systems Requirement Review
STEM	Science, Technology, Engineering, and Math
TA	Technical Authority
TBD	To Be Determined
TBR	To Be Resolved
TD	Time Dependent (costs)
TI	Time Independent (costs)
TLI	Technical Leading Indicator
ToR	Terms of Reference
TRL	Technology Readiness Level
TRR	Test Readiness Review
UFE	Unallocated Future Expenses
V&V	Verification and Validation
WBS	Work Breakdown Structure
WYE	Work-Year Equivalent

C. NPR 7120.5F Requirements Rationale

Para #	Requirement Statement	Rationale for Requirement
2.1.1.2	Regardless of the structure of a program or project meeting the criteria of Section P.2, this NPR shall apply to the full scope of the program or project and all the activities under it.	Large projects tend to divide their work into smaller "activities," elements, etc. and these must be managed according to NPR 7120.5 even though they are not listed in a Program or Project Plan.
2.1.3.1	Projects are Category 1, 2, or 3 and shall be assigned to a category based initially on: (1) the project life-cycle cost (LCC) estimate, the inclusion of significant radioactive material, and whether or not the system being developed is for human space flight; and (2) the priority level, which is related to the importance of the activity to NASA, the extent of international participation (or joint effort with other government agencies), the degree of uncertainty surrounding the application of new or untested technologies, and spacecraft/payload development risk classification.	Projects vary in scope and complexity and thus require varying levels of management requirements and Agency attention and oversight. Project categorization defines Agency expectations of project managers by determining both the oversight council and the specific approval requirements. Guidelines for determining project categorization are shown in Table 2-1 of NPR 7120.5, but categorization may be changed based on recommendations by the Mission Directorate Associate Administrator (MDAA) that consider additional risk factors facing the project. The NASA Associate Administrator (AA) approves the final project categorization.
2.1.3.2	For Category 1 projects, the assignment of a project to a Center or implementing organization shall be with the concurrence of the NASA AA.	Due to the external visibility and dollar amount of Category 1 projects, it is important that the NASA AA concur that the assignment of the project by the Mission Directorate is consistent with the direction and guidance from the strategic acquisition planning process.
2.1.4.1	Programs and projects with a LCC or initial capability cost (see Section 2.4.1.3.b) greater than $250M shall be managed by program and project managers who have been certified in compliance with Office of Management and Budget (OMB)'s promulgated Federal acquisition	The Office of Management and Budget (OMB) has established a set of requirements for program and project management certification that applies to all civilian agencies. OMB's Federal Acquisition Certification for Program and Project Managers (FAC-P/PM) outlines the baseline competencies, training, and experience required for program and project managers in the Federal government. This document and additional certification information may be obtained from the APPEL PM certification website at https://appel.nasa.gov/career-resources/fac-ppm-certification/.

Para #	Requirement Statement	Rationale for Requirement
	program/project management certification requirements.	
2.2.1	Program and project managers shall follow their appropriate life cycle, which includes life-cycle phases; life-cycle gates and major events, including KDPs; major life-cycle reviews (LCRs); principal documents that govern the conduct of each phase; and the process of recycling through Formulation when program changes warrant such action.	NASA programs and projects are managed to life cycles, the division of the program's and project's activities over the full lifetime of the program or project, based on the expected maturity of program and project information and products as they move through defined phases in the life cycle. At the top level, this work is divided into two phases, Formulation and Implementation, each of which is divided into subphases. As part of checks and balances, programs and projects must be given formal approval at specific points to progress through their life cycle. This approval is based on periodic evaluation.
2.2.2	Program and project managers shall organize the work required for each phase using a product-based WBS developed in accordance with the Program and Project Plan templates (appendices G and H).	NASA requires the use of a standard WBS and Dictionary template to ensure that space flight projects define work to be performed and accumulate corresponding costs in a standard manner. This provides uniformity across projects and allows for the accumulation of historical cost data for analysis and comparison.
2.2.3	The documents shown on the life-cycle figures and described below shall be prepared in accordance with the templates in appendices D, E, F, G, and H.	The purpose of program formulation activities is to establish a cost-effective program that is demonstrably capable of meeting Agency and Mission Directorate goals and objectives. The program Formulation Authorization Document (FAD) authorizes a Program Manager to initiate the planning of a new program and to perform the analyses required to formulate a sound Program Plan. The Program Plan establishes the program's baseline for Implementation, signed by the MDAA, Center Director(s), and program manager. The Program Commitment Agreement (PCA) is the contract between the Associate Administrator and the responsible MDAA that authorizes transition from Formulation to Implementation of a program. The project FAD authorizes a Project Manager to initiate the planning of a new project and to perform the analyses required to formulate a sound Project Plan. The Formulation Agreement represents the project's response to the FAD. The Project Plan establishes the project's baseline for Implementation, signed by the responsible program manager, Center Director, project manager, and the MDAA, if required. The templates are designed to ensure all content necessary is addressed.
2.2.4	Each program and project shall perform the LCRs and KDPs identified in its respective life-cycle figure in accordance with NPR 7123.1, applicable Center practices, and the requirements of this document.	LCRs provide a periodic assessment of the program's or project's technical and programmatic status and health at key points in the life cycle. An LCR that occurs at the end of a life-cycle phase is complete when the governing Program Management Council (PMC) and Decision Authority complete their assessment and sign the Decision Memorandum. The maturity tables identify the expected program/project maturity state for each major review specified by the following six assessment criteria: Agency Strategic Goals and Outcomes, Management Approach, Technical Approach, Budget Schedule, Resources other than Budget, and Risk Management.

Para #	Requirement Statement	Rationale for Requirement
2.2.5	Program or project managers and an independent Standing Review Board (SRB) shall conduct the System Requirements Review (SRR), System Definition Review (SDR)/ Mission Definition Review (MDR), Preliminary Design Review (PDR), Critical Design Review (CDR), System Integration Review (SIR), Operational Readiness Review (ORR), and PIR LCRs in figures 2-2, 2-3, 2-4, and 2-5.	The Governance model provides an organizational structure that emphasizes mission success by taking advantage of different perspectives that different organizational elements bring to issues. The organizational separation of the Mission Directorates and their respective programs and projects (Programmatic Authorities) and the Headquarters mission support offices, the Center organizations that are aligned with these offices, and the Center Directors (Institutional Authorities) is the cornerstone of this organizational structure and NASA's system of checks and balances. Independent assessments provide: 1. The program/project with a credible, objective assessment of how they are doing 2. NASA senior management with an understanding of whether a. The program/project is on the right track, b. Is performing according to plan, and c. Externally imposed impediments to the program's/projects' success are being removed 3. For a life-cycle review that immediately precedes a KDP, a credible basis for the Decision Authority to approve or disapprove the transition of the program at the KDP to the next life-cycle phase. The independent review also provides additional assurance to external stakeholders that NASA's basis for proceeding is sound.
2.2.5.1	The Conflict of Interest (COI) procedures detailed in the NASA Standing Review Board Handbook shall be strictly adhered to.	NASA accords special importance to the policies and procedures established to ensure the integrity of the SRB's independent review process and to comply with Federal law.
2.2.5.2	The portion of the LCRs conducted by the SRB shall be convened by the Convening Authorities in accordance with Table 2-2.	The Convening Authorities are the heads of the organizations principally responsible for authorizing, overseeing, supporting and evaluating the programs and projects. The SRB is convened by these individuals, as part of the Agency's checks and balances, to provide an independent assessment that addresses each organization's perspective. This approach minimizes the burden on programs and projects by using only one review team to meet the needs of multiple organizations.
2.2.5.3	The program or project manager, the SRB chair, and the Center Director (or designated Engineering Technical Authority (ETA) representative) shall mutually assess the program's or project's expected readiness for the LCR and report any disagreements to the Decision Authority for final decision.	Life-cycle reviews are important in determining program or project readiness to proceed to the next phase. Conducting a life-cycle review before a program or project is ready would waste the time of both the program/project and the SRB.
2.2.6	In preparation for these LCRs, the program or project manager shall generate the appropriate	The documents provide tangible evidence of the work performed by the program/project during the current life-cycle phase and a concrete way to demonstrate readiness to proceed to the next phase.

Para #	Requirement Statement	Rationale for Requirement
	documentation per the Appendix I tables of this document, NPR 7123.1, and Center practices, as necessary, to demonstrate that the program's or project's definition and associated plans are sufficiently mature to execute the follow-on phase(s) with acceptable technical, safety, and programmatic risk.	
2.2.8	Projects, single-project programs (and other programs at the discretion of the MDAA) with a life-cycle cost (LCC) or initial capability cost (see Section 2.4.1.3.b) estimated to be greater than $250M shall perform earned value management (EVM) and comply with EIA-748, Standard for Earned Value Management Systems for all portions of work including in-house and contracted portions of the project.	The Office of Management and Budget (OMB) Circular A-11 (Part 7 Planning, Budgeting, Acquisition, and Management of Capital Assets and the Capital Programming Guide) sets forth the policy, budget justification, and reporting requirements that apply to all agencies of the Executive Branch of the government that are subject to Executive Branch review for major capital acquisitions. It requires that Earned Value Management (EVM) be consistent with the guidelines in the Electronic Industries Alliance 748 (EIA-748), Earned Value Management Systems, for developmental efforts for both government and contractor work, and that in-house work be managed with the same rigor as contract work. While a Project Plan or Intra-Agency Work Agreement replaces the contract for NASA in-house work, the other requirements for good project management, including the use of EVM in accordance with the EIA-748 standard, are applicable for developmental and production efforts.
2.2.8.1	Program and project managers with programs and projects subject to EVM shall utilize the NASA EVM Capability Process for in-house work.	The EVM Capability Process provides projects with in-house work an integrated set of processes, tools, guidance, training, and technical support to demonstrate EVM capability. It was approved by the APMC and committed to GAO, with the goal to apply EIA-748 guidelines to enhance EVM capabilities on NASA projects.
2.2.8.2	EVM system requirements for contracted work shall be applied to suppliers in accordance with the NASA Federal Acquisition Regulation (FAR) Supplement, independent of phase and the $250M threshold (https://www.hq.nasa.gov/office/procurement/regs/NFS.pdf.).	To comply with NASA FAR Supplement 1834.201, and thus, OMB requirements in Circular A-11 as described above.
2.2.8.3	Mission Directorates shall conduct an IBR in preparation for KDP C and for major changes that significantly impact the cost and schedule baseline.	A risk-based review conducted by Program/Project Management is necessary to ensure a mutual understanding between the customer and supplier of the risks inherent in the supplier's PMB and to ensure that the PMB is realistic for accomplishing all of the authorized work within the authorized schedule and budget.

Para #	Requirement Statement	Rationale for Requirement
2.2.8.4	EVMS surveillance shall be conducted on contracts and programs and projects with in-house work to ensure continued compliance with EIA-748, Standard for Earned Value Management Systems.	The purpose of EVMS surveillance is to ensure that the performance measurement data from the EVM system is credible, timely, and accurate and will enable informed decision making.
2.2.10	Program and project managers shall complete and maintain a Compliance Matrix (see Appendix C) for this NPR and attach it to the Formulation Agreement for projects in Formulation and/or the Program or Project Plan.	The Compliance Matrix documents the program's or project's compliance with the requirements of NPR 7120.5 or how the program or project is tailoring the requirements in accordance with Section 3.5. The Compliance Matrix may also be used to document approval for designating requirements as non-applicable. If the Compliance Matrix is completed in accordance with instructions, it meets the requirements for requesting tailoring and for designating requirements as non-applicable and serves as a group submittal for waivers to NPR 7120.5. Once the Formulation Agreement or Program or Project Plan is signed, tailoring and non-applicable designations are approved.
2.2.11	Single-project programs and projects shall develop a Project Protection Plan that addresses NASA-STD-1006, Space System Protection Standard in accordance with NPR 1058.1, Enterprise Protection Program.	The Project Protection Plan assesses applicable adversarial threats to the project or system, identifies system susceptibilities, potential vulnerabilities, countermeasures, resilience strategies, and risk mitigations. The results inform the project's or system's design and concept of operations, in context with the project's or system's requirements.
2.3.1	Each program and project shall have a Decision Authority the Agency's responsible individual who determines whether and how the program or project proceeds through the life cycle and the key program or project cost, schedule, and content parameters that govern the remaining life-cycle activities.	The Agency's Governance model requires that there be a single approving authority for all program/project phase transitions.
2.3.1.1	The MDAA shall inform the NASA AA and Administrator via email on all Agency Baseline Commitments (ABCs) per the following: inform the NASA AA on ABCs for single-project programs and projects with a LCC or initial capability cost (see Section 2.4.1.3.b) greater than $250M; and inform the NASA Administrator on ABCs for all single-project programs	The ABC for these programs and projects is required to be externally reported to OMB and the Congress. Thus they are inherently highly visible to our stakeholders. The NASA Associate Administrator is responsible for the technical and programmatic integration of these programs and projects at the Agency level and serves as the Decision Authority for them. The NASA Associate Administrator, as chair of the Agency PMC, ensures that projects are subjected to an appropriate level of Agency oversight.

Para #	Requirement Statement	Rationale for Requirement
	and projects with a LCC or initial capability cost greater than $1B and all Category 1 projects. (See Section 2.4.1.5 for more information on ABCs.)	
2.3.2	Each program and project shall have a governing PMC.	A KDP is an event where the Decision Authority determines the readiness of a program/project to progress to the next phase of the life cycle. As such, KDPs serve as gates through which programs and projects must pass. Within each phase, the KDP is preceded by one or more reviews, including the governing PMC review. These reviews enable a disciplined approach to assessing programs and projects. Per NPD 1000.3 charter, the Agency Program Management Council (APMC) serves as the Agency's senior decision-making body to baseline and assess program/project performance and ensure successful achievement of NASA strategic goals. This role is delegated to the DPMC for projects as specified in NPR 7120.5F or as delegated by the NASA AA.
2.3.4	The Center Director (or designee) shall oversee programs and projects usually through the CMC, which monitors and evaluates all program and project work (regardless of category) executed at that Center.	The Center Director has a unique role as the only person who can ensure proper planning and execution of activities requiring constructive integration across Programmatic, Technical, and Institutional Authorities. The Center Director is therefore responsible and accountable to the Administrator for the safe, effective, and efficient execution of all activities at his/her Center. As part of the Institutional Authority, Center Directors are responsible for establishing, developing, and maintaining the Center's institutional capabilities (such as processes, competency development and leadership, human capital, facilities, and independent review) required for the execution of programs, projects, and missions assigned to the Center. The Center Directors work closely with the AA for Mission Support in this role. Center Directors have specifically delegated Technical Authority (TA) responsibilities for work performed at the Center and are responsible for establishing and maintaining Center technical authority policies and practices, consistent with Agency policies and standards. The Center Directors work closely with the Chief Engineer, Chief Safety and Mission Assurance Officer, and Chief Medical Officer in this role. While the Center Directors do not exercise Programmatic Authority over programs and projects (i.e., do not make programmatic cost and schedule decisions), they work closely with the Mission Directorate (MD) AAs to balance the specific needs of individual programs and projects alongside thoughtful compliance with applicable priorities, policies, procedures, and practices. The summation of the "balanced" agreements between the Program/Project Manager and Center Directors of participating NASA Centers are documented in the Program/Project Plan, consistent with the Mission Directorate's requirements and with Agency policy and the Center's best practices and institutional policies. The Center Director is a Convening Authority for SRBs and uses their assessment along with lower level review teams and his/her Center leadership team such as the CMC or ICMC (Integrated Center Management Council) in forming his/her assessment and affecting the plans as necessary. When the Center Director sees an issue which, in his/her judgment, may require programmatic direction, he/she engages the MDs or Program Office as needed to cooperatively identify solutions, including cases where resolution of a Technical Authority issue might impact top level programmatic requirements.
2.3.5	Following each LCR, the independent SRB chair and the program or project	It is important for the Governing PMC and the Decision Authority to hear the assessments and feedback from the both the SRB and the program or project in order for them to make the best informed decision possible. In

Para #	Requirement Statement	Rationale for Requirement
	manager shall brief the applicable management councils on the results of the LCR to support the councils' assessments.	this way they will hear issues and plans to address disagreements and rationales for those disagreements so that decisions can be made.
2.4.1	The decisions by the Decision Authority on whether and how the program or project proceeds into the next phase shall be summarized and recorded in the Decision Memorandum signed at the conclusion of the governing PMC by all parties with supporting responsibilities, accepting their respective roles.	After reviewing the supporting material and completing discussions with concerned parties, the Decision Authority determines whether and how the program or project proceeds into the next phase and approves any additional actions, which are documented in the Decision Memorandum. It is important to document this information as part of the permanent record and to capture acknowledgement of resulting responsibilities by supporting parties.
2.4.1.1	The Decision Memorandum shall describe the constraints and parameters within which the Agency, the program manager, and the project manager will operate; the extent to which changes in plans may be made without additional approval; any additional actions that came out of the KDP; and the supporting data (i.e., the cost and schedule datasheet) that provide further details.	The Decision Memorandum describes the Decision Authority's decisions. Within the Decision Memorandum, the parameters and authorities over which the program or project manager has management control constitute the program or project Management Agreement. A program or project manager has the authority to manage within their Management Agreement and is accountable for compliance with the terms of the agreement. The Management Agreement is established at every KDP but may be changed between KDPs as the program or project matures and in response to internal and external events. The Program Plan or Project Plan is updated and approved during the life cycle, if warranted, by changes in the stated Management Agreement commitments.
2.4.1.2	A divergence from the Management Agreement that any party identifies as significant shall be accompanied by an amendment to the Decision Memorandum.	The purpose is to document rationale for changes as part of the permanent record and that all signatories in the original Decision Memorandum have an opportunity to review and agree or disagree.
2.4.1.3	During Formulation, the Decision Memorandum shall establish a target LCC or initial capability cost range (and schedule range, if applicable) as well as the Management Agreement addressing the schedule and resources required to complete	It is important for the project to assess and request the resources it needs during Formulation so that expectations by the project and resources provided by the Mission Directorate are aligned and agreed to in the Management Agreement.

Para #	Requirement Statement	Rationale for Requirement
	Formulation.	
2.4.1.3 a	For single-project programs and projects with a LCC or initial capability cost greater than or equal to $1B, the Decision Memorandum shall establish a high and low value for cost and schedule with the corresponding JCL value at KDP B.	Producing a JCL at KDP B for NASA's largest single-project programs and projects will better inform leadership of the range of potential cost and schedule impacts on the portfolio through Phase B and through the life cycle and may further reduce cost and schedule overruns. By focusing this new JCL requirement on the largest single-project programs and projects NASA is intelligently applying its programmatic resources to mitigate the largest potential impacts to its portfolios.
2.4.1.5	All single-project program managers and project managers shall document the Agency's LCC estimate or initial capability cost estimate and other parameters in the Decision Memorandum for Implementation (KDP C), and this becomes the ABC.	The ABC is the baseline against which the Agency's performance is measured during the Implementation Phase. The ABC for single-project programs (regardless of LCC or initial capability cost) and projects with a life-cycle cost or initial capability cost of $250 million or more forms the basis for the Agency's external commitment to the Office of Management and Budget (OMB) and Congress.
2.4.1.5 .a	For all single-project programs and projects with a definite Phase E end point, the Agency's LCC estimate and other parameters shall become the ABC.	When there is a definite Phase E end point, the ABC forms the basis for external reporting (e.g., Office of Management and Budget (OMB) and Congress) and is the scope of the ABC as defined by US Code 51, National and Commercial Space Programs, § 30104, Baselines and Cost Controls.
2.4.1.5 .b	For single-project programs and projects that plan continuing operations and production, including integration of capability upgrades, with an unspecified Phase E end point, the initial capability cost estimate and other parameters shall become the ABC.	Single-project programs and projects with an unspecified Phase E end point do not have a traditional lifecycle because the operations timeframe is undefined with a plan for continuing operations, production, and/or the integration of capability upgrades. The initial capability cost estimate provides a reasonable estimate of the costs for the content that is defined and becomes the ABC. The Phase E cost estimate for continuing operations and production is established separately as part of the ORR and KDP E for the 5 years after initial capability and subsequently updated and documented annually for the next 5-year period. Capability upgrades during Phase E that meet Agency criteria for a major project for external reporting (i.e., cost estimate of $250M or more) are treated as projects for the purposes of establishing their own development ABC outside the Phase E cost estimate. The Phase E cost estimate is updated to include production and operations costs associated with these upgrades. Development, production, and operations costs of other (i.e., non-major) upgrades are included in single-project program or project Phase E cost estimate.
2.4.1.7	Tightly coupled programs shall document their LCC estimate in accordance with the scope defined in the FAD or PCA, and other	Tightly coupled programs can be viewed as very large projects and KDP I is where the program ends formulation and begins implementation (KDP C for projects). Since tightly coupled programs generally have very long life cycles that exceed normal planning horizons, the life cycle to be used is documented in the FAD or PCA.

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	parameters in their Decision Memorandum at KDP I and update it at subsequent KDPs.	
2.4.1.8	Programs or projects shall be rebaselined when: (1) the estimated development cost exceeds the ABC development cost by 30 percent or more (for projects over $250M, also that Congress has reauthorized the project); (2) the NASA AA judges that events external to the Agency make a rebaseline appropriate; or (3) the NASA AA judges that the program or project scope defined in the ABC has been changed or the project has been interrupted.	For (1), per the NASA Appropriation Act and the 2005 NASA Authorization Act, NASA is required to notify Congress of significant cost growth. For (2) and (3), performance is not to be assessed against the original baseline when significant events outside the program/project control occur. Therefore, a new baseline is generated for the program/project to perform against.
2.4.2	The program or project shall document the basis of estimate (BOE) for cost estimates and planned schedules in retrievable program or project records.	The BoE is documentation of the ground rules, assumptions, and drivers used in developing the cost or schedule estimates including applicable model inputs, rationale or justification for analogies, and details supporting cost and schedule estimates. The basis of estimate is contained in material available to the SRB and management as part of the LCR and KDP process.
2.4.3.1 .a	Single-project programs with an estimated LCC under $1B and projects with an estimated LCC greater than $250M and under $1B shall provide a range of cost and a range for schedule, each range (with confidence levels identified for the low and high values of the range) established by a probabilistic analysis and based on identified resources and associated uncertainties by fiscal year.	Producing ranges for cost and schedule at KDP B will better inform leadership of the range of potential cost and schedule impacts on the portfolio through Phase B and through the life cycle and may further reduce cost and schedule overruns.
2.4.3.1 b.	Single-project programs and projects with an estimated LCC greater than or equal to $1B shall develop a JCL and provide a high and low value for cost and schedule with the corresponding	Producing a JCL and providing a high and low value for cost and schedule with the corresponding JCL value at KDP B for NASA's largest single-project programs and projects will better inform leadership of the range of potential cost and schedule impacts on the portfolio through Phase B and through the life cycle and may further reduce cost and schedule overruns. By focusing this new JCL requirement on the largest single-project

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	JCL value (e.g., 50 percent, 70 percent).	programs and projects NASA is intelligently applying its programmatic resources to mitigate the largest potential impacts to its portfolios.
2.4.3.2	At KDP C, single-project programs (regardless of LCC) and projects with an estimated LCC greater than $250M shall develop a cost-loaded schedule and perform a risk-informed probabilistic analysis that produces a JCL.	A cost/schedule estimate is required by Congress by KDP C. The JCL is required to enable the Agency to assert that the programs/projects have executable plans. This is required for all single-project programs regardless of LCC, and projects with an LCCE greater than $250 million.
2.4.3.3	At CDR, single-project programs and projects with an estimated LCC greater than or equal to $1B shall update their KDP C JCL and communicate the updated JCL values for the ABC and Management Agreement to the APMC for informational purposes.	Updating the JCL at CDR for NASA's largest single-project programs and projects will capture evolving and emergent risks and provide leadership with an enhanced awareness regarding projections of the cost and schedule through Implementation and may further reduce cost and schedule overruns. By focusing this new JCL requirement on the largest single-project programs and projects NASA is intelligently applying its programmatic resources to mitigate the largest potential impacts to its portfolios.
2.4.3.4	At KDP D, single-project programs and projects with an estimated LCC greater than or equal to $1B shall update their JCL if current reported development costs have exceeded the development ABC cost by 5 percent or more and document the updated JCL values for the ABC and Management Agreement in the KDP D Decision Memorandum.	Updating the JCL at KDP D, for NASA's largest single-project programs and projects that are off plan will better inform decision-makers at KDP D of the confidence of hitting cost and schedule targets given evolving risk postures. By focusing this new JCL requirement on the largest single-project programs and projects NASA is intelligently applying its programmatic resources to mitigate the largest potential impacts to its portfolios.
2.4.3.5	When a single-project program (regardless of LCC) or project with an estimated LCC greater than $250M is rebaselined, a JCL shall be calculated and evaluated as a part of the rebaselining approval process.	A rebaseline is a major activity that arises when the ABC is breached. In order to set a healthy new baseline, a JCL is required to be calculated and evaluated to ensure that the new ABC is appropriate. NASA uses the JCL to set the ABC and ensure a full analysis of cost, schedule, risk, and uncertainties.
2.4.4.1	At KDP B, Mission Directorates shall plan and budget single-project programs and projects with an	Single-project programs and projects with LCC >= $1B are of sufficient size that NASA needs more insight at the KDP B milestone to ensure a healthy baseline will be set at KDP C. Large-scale missions frequently have cost and schedule challenges. A 70 percent JCL will provide large projects with sufficient cost and schedule

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	estimated LCC greater than or equal to $1B based on a 70 percent JCL or as approved by the Decision Authority.	that can improve the likelihood of mission success. The Decision Authority can approve an alternate JCL percent with rationale to tailor the requirement as needed. A higher JCL percent will typically require a longer schedule with more UFE. A lower JCL percent, with a shortened schedule and less UFE, can lead to reduced likelihood of mission success since time and resources will potentially not be available to deal with risks and challenges as they occur during development.
2.4.4.2	At KDP C, Mission Directorates shall plan and budget single-project programs (regardless of LCC) and projects with an estimated LCC greater than $250M based on a 70 percent JCL or as approved by the Decision Authority.	Single-project programs and projects perform a JCL at KDP C for a full analysis of cost, schedule, risk, and uncertainties to ensure that the ABC is healthy and can accommodate challenges and risks as they occur during development. Any JCL under 70 percent is considered a management challenge.
2.4.4.3	At KDP B and KDP C, any JCL approved by the Decision Authority at less than 70 percent shall be justified and documented in a Decision Memorandum.	This is required to ensure the Agency has a record of and rationale for deviating from the 70 percent policy. Any JCL under 70 percent is considered a management challenge.
2.4.4.4	At KDP C, Mission Directorates shall ensure funding for single-project programs (regardless of LCC) and projects with an estimated LCC greater than $250M is consistent with the Management Agreement and in no case less than the equivalent of a 50 percent JCL or as approved by the Decision Authority.	Any funding less than the 50 percent JCL significantly diminishes a single-project program's and project's chances of being successful in meeting cost and schedule commitments.
2.4.4.5	At KDP C, any funding approved by the Decision Authority that is inconsistent with the Management Agreement or less than 50 percent JCL shall be justified and documented in a Decision Memorandum.	This is required to ensure the Agency has a record of and rationale for deviating from the 50 percent policy.
2.4.5	Tightly coupled, loosely coupled, and uncoupled-programs shall provide analysis of the program's risk posture	It is important for any program to provide an analysis of its risk posture to management so that management can assess for itself the likelihood the program can meet its commitments and to understand if any of the risks might impact other programs within the Mission Directorate or the Agency.

Para #	Requirement Statement	Rationale for Requirement
	to the governing PMC as each new project reaches KDP B and C or when a project's ABC is rebaselined.	
3.3.1	Programs and projects shall follow the Technical Authority (TA) process established in this Section 3.3.	NASA established the Technical Authority process as part of its system of checks and balances to provide independent oversight of programs and projects in support of safety and mission success through the selection of specific individuals with delegated levels of authority. These individuals are the Technical Authorities. The responsibilities of a program or project manager are not diminished by the implementation of Technical Authority. The program or project manager is ultimately responsible for the safe conduct and successful outcome of the program or project. This includes meeting programmatic, institutional, technical, safety, cost, and schedule commitments.
3.4.1	Programs and projects shall follow the Formal Dissent process in this Section 3.4.	NASA teams need to have full and open discussions, with all facts made available, to understand and assess issues. Diverse views are to be fostered and respected in an environment of integrity and trust with no suppression or retribution. In the team environment in which NASA operates, team members often have to determine where they stand on a decision. In assessing a decision or action, a member has three choices: agree, disagree but be willing to fully support the decision, or disagree and raise a Formal Dissent. Unresolved issues of any nature (e.g., programmatic, safety, engineering, health and medical, acquisition, accounting) within a team need to be quickly elevated to achieve resolution at the appropriate level.
3.5.1	Programs and projects shall follow the tailoring process in this Section 3.5.	It is NASA policy to comply with all prescribed directives, requirements, procedures, and processes unless relief is formally granted. Tailoring is the process used to adjust or seek relief from a prescribed requirement to accommodate the needs of a specific task or activity (e.g., program or project). Additional details regarding the tailoring process are in NPR 7120.5 Appendix C and the Agency Tailoring Website.
3.5.5	A request for a permanent change to a prescribed requirement in an Agency or Center document that is applicable to all programs and projects shall be submitted as a "change request" to the office responsible for the requirement policy document unless formally delegated elsewhere.	This requirement alleviates the need for programs and projects at a Center to continually request deviations or waivers to requirements that no longer apply to the programs and projects at that Center.
3.6.1	Center Directors negotiating reimbursable space flight work with another agency shall propose NPR 7120.5 as the basis by which it will perform the space flight work.	It is understood that outside agencies come to NASA for its expertise and approach to program/project management. Therefore, it is only natural that NASA propose the management policy that it uses itself.

Para #	Requirement Statement	Rationale for Requirement
3.7.1	Each program and project shall perform and document an assessment to determine an approach that maximizes the use of SI.	Federal policy requires agencies to use the International System of Units (SI) to the extent possible without incurring a substantial increase in cost or unacceptable delays in schedule. Documentation of the project's assessment and approach to its system of measurement demonstrates why the program or project is or is not fully using SI and is also needed to ensure that all members of the project team understand and use consistent units of measure.

D. Roles and Responsibilities

The following table provides a summary of the roles and responsibilities for key program and project management officials. The table is informational only.

Table D-1 Roles and Responsibilities Relationships Matrix

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Strategic Planning	Establish Agency strategic priorities and direction Approve Agency Strategic Plan and programmatic architecture, and top-level guidance Approve implementation plans developed by Mission Directorates	Lead development of Agency Strategic Plan Lead development of Annual Performance Plan	Support Agency strategic planning Develop directorate implementation plans and cross-directorate architecture plans consistent with Agency strategic plans, architecture, and top-level guidance	Support Agency and Mission Directorate strategic planning and supporting studies		Support Mission Directorate strategic implementation plan	

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Program Initiation (FAD/ASM)	Approves programs and assigns them to MDs and Centers and validates partnerships Approve strategy for acquisition	Approve Program Chief Engineers[1] (Technical Authority) (OCE) Approves procurement strategy (AA for Procurement)	Implement new programs via FAD Recommend assignment of programs to Centers Approve appointment of Program Managers Approve strategy for acquisition	Provide human and other resources to execute FAD Recommend Program Managers to MDAA Ensure strategy for acquisition and the program's plans are executable	Appoint Program Chief Engineers* and SMA TA (Technical Authority) in consultation with and after approval by OCE and OSMA, respectively Appoint Center Lead Discipline Engineers (LDEs) Lead HMTA Integration Center CMO appoints Program Chief Health and Performance Officer	Establish the program office and structure to direct/monitor projects within program Develop strategy for acquisition Develop Formulation Agreement (only combined SPP)	
Project Initiation (FAD/ASM)	Approves Category 1 projects and assigns them to MDs and Centers Approve strategy for acquisition	Approve Project Chief Engineers[1] (Technical Authority) appointment to Category 1 projects (OCE)	Implement new projects via FAD Recommend assignment of Category 1 projects to Centers Assign Category 2 and 3 projects to Centers.	Provide human and other resources to execute FAD Recommend Category 1 Project Managers to MDAA	Appoint Project Chief Engineers[1] (Technical Authority) on Category 1 projects in consultation with and after approval by OCE	Concur with appointment of Project Managers Define content with support of Project Approve Formulation Agreement	Establish the project office and structure to direct and monitor tasks/activities within project Develop Formulation Agreement

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
		Is notified of Project Chief Engineers[1] (Technical Authority) assigned to Category 2 and 3 projects (OCE) Approves procurement strategy (AA for Procurement)	Approve appointment of Category 1 and selected Category 2 Project Managers Approve strategy for acquisition Approve Formulation Agreement	Appoint Category 2 and 3 Project Managers Ensure strategy for acquisition and the project's plans are executable Approve Formulation Agreement	Appoint Project Chief Engineers[1] (Technical Authority) on Category 2 and 3 projects with notification of OCE Appoint project CSO with OSMA concurrence Lead HMTA Integration Center CMO appoints Project Chief Health and Performance Officer.		Develop strategy for acquisition

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Policy Development	Approve policies	Establish Agency Institutional policies and ensure support infrastructure is in place, This includes: Technical Authority (OCE), SMA functions (OSMA), Health and Medical functions (OCHMO) Develop and maintain Agency-wide engineering (OCE), health and medical (OCHMO), and safety and mission assurance (OSMA) standards applicable to programs and projects	Establish Directorate policies (e.g., guidance, risk posture, and priorities for acquisition) applicable to program, projects, and supporting elements	Ensure Center policies are consistent with Agency and Mission Directorate policies Establish policies and procedures to ensure program and projects are implemented consistent with sound technical and management practices	Establish institutional engineering design and verification/validation best practices for products and services provided by the Center Develop implementation plan for technical authority at the Center		

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Program/Project Concept Studies		Provide technical expertise for advanced concept studies, as required (OCE/NESC)	Develop direction and guidance specific to concept studies for formulation of programs and non-competed projects	Develop direction and guidance specific to concept studies for Formulation		Initiate, support, and conduct program-level concept studies consistent with direction and guidance from MDAA	Initiate, support, and conduct project-level concept studies consistent with direction and guidance from program (or Center for competed projects)
Development of Programmatic Requirements			Establish, coordinate, and approve high-level program requirements Establish, coordinate, and approve high-level project requirements, including success criteria	Provide support to program and project requirements development Provide assessments of resources with regard to facilities	Approve changes to and deviations and waivers from those requirements that are the responsibility of the TA and have been delegated to the CD for such action	Originate requirements for the program consistent with the PCA Approve program requirements levied on the project	Originate project requirements consistent with the Program Plan

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Development of Institutional Requirements	Approve Agency-level policies and requirements for programs and projects	Develop policies and procedural requirements for programs and projects and ensure adequate implementation (OCE, OCHMO, OSMA, MSOs) Approve/ disapprove waivers and deviations to requirements under their authority	Develop crosscutting Mission Directorate policies and requirements for programs and projects and ensure adequate implementation Approve/ disapprove waivers and deviations to requirements under their authority	Develop Center policies and requirements for programs and projects and ensure adequate implementation Approve/ disapprove waivers and deviations to requirements under their authority	Develop TA policies and requirements for programs and projects and ensure adequate implementation Approve/ disapprove waivers and deviations to requirements under their authority		
Budget and Resource Management	Determine relative priorities for use of Agency resources (e.g., facilities) Establish budget planning controls for Mission Directorates and mission support offices Approve Agency Budgets	Manage and coordinate Agency annual budget guidance, development, and submission (OCFO)	Develop workforce and facilities plans with implementing Centers Provide guidelines for program and project budget submissions consistent with approved plans	Confirm program and project workforce requirements Provide the personnel, facilities, resources, and training necessary for implementing assigned programs and projects	Provide resources for review, assessment, development, and maintenance of the core competencies required to ensure technical and program/project management excellence	Implement program consistent with budget Develop cost estimates for program components Develop workforce and facilities plans Manage program resources	Develop mission options, conduct trades, and develop cost estimates Maintain up-to-date estimated costs at completion Develop workforce and facilities plans Implement project budget

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
		Analyze Mission Directorate submissions for consistency with program and project plans and performance (OCFO) Develop Agency operating plans and execute Agency budget (OCFO).	Allocate budget resources to Centers for assigned projects Conduct annual program and project budget submission reviews	Support annual program and project budget submissions, and validate Center inputs	Ensure independence of resources to support the implementation of technical authority	Provide annual program budget submission input	Manage project resources Provide annual project budget submission input
PCA	Approve Program Commitment Agreement (NASA AA)	Concur with PCA (OCE)	Develop and approve Program Commitment Agreement			Support development of the Program Commitment Agreement	
Agency Baseline Commitment	Informed for programs and projects greater than $1 billion and all Category 1 projects (Administrator) Approve for all programs and Category 1 projects (NASA AA)	Concur with ABC (OCFO)	Approve ABC Inform AA for programs and projects greater than $250 million Inform Administrator for programs and projects greater than $1 billion and all Category 1 projects			Develop ABC	Develop ABC

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
	Informed for programs and projects greater than $250 million (NASA AA)						
Program Plans			Approve Program Plan	Approve Program Plan	Approve the implementation of Technical Authority	Develop and approve Program Plan Execute Program Plan	
Project Plans			Approve Project Plan	Approve Project Plan	Approve the implementation of Technical Authority	Approve Project Plan	Develop and approve Project Plan Execute Project Plan
Program/Project Performance Assessment	Assess program and Category 1 project technical, schedule, and cost performance through status reviews Conduct Agency PMC (NASA AA) Chair monthly BPR (NASA AA)	Provide independent performance assessments (OCE, OCFO, OCHMO, OSMA)	Provide independent performance assessments Assess program technical, schedule, and cost performance and take action, as appropriate, to mitigate risks Conduct Mission Directorate PMC	Assess program and project technical, schedule, and cost performance against approved plans as part of ongoing processes and forums and the Center Management Council		Assess program and project technical, schedule, and cost performance and take action, as appropriate, to mitigate risks Provide data to support the monthly BPR process and report on performance.	Assess project technical, schedule, and cost performance and take action, as appropriate, to mitigate risks Support monthly BPR reporting.

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
	Administer the BPR process (Office of Agency Council Staff)		Support the Agency BPR process.	Provide summary status to support the Agency BPR process and other suitable forums			
Program/Project Performance Issues	Review program and project performance issues, risks, and mitigation and recovery plans through Agency PMC and BPR	Maintain issues and risk performance information (OSMA) Track project cost and schedule performance (OCFO) Manage project performance reporting to external stakeholders (OCFO)	Communicate program and project performance issues and risks to Agency management and present plan for mitigation or recovery Provide support and guidance to programs and projects in resolving technical and programmatic issues and risks Proactively work with Centers, programs, and projects to find constructive solutions to problems	Monitor the technical and programmatic progress of programs and projects to help identify issues as they emerge Provide support and guidance to programs and projects in resolving technical and programmatic issues and risks Proactively work with the Mission Directorates, programs, projects, and other Institutional Authorities to find constructive solutions to problems		Communicate program and project performance issues and risks to Center and Mission Directorate management and present recovery plans	Communicate project performance, issues and risks to program, Center, and Mission Directorate management and present recovery plans

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
				Direct corrective actions to resolve performance issues, if within approved plans Communicate program and project technical performance issues and risks to Mission Directorate and Agency management and provide recommendations for recovery			

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Termination Reviews	As DA, determine and authorize termination of programs and Category 1 projects through Agency PMC	Provide status of program or project performance, including budgetary implications of termination or continuation (OCFO)	Ensure SRB support for Termination Reviews when needed As DA, determine and authorize termination of Category 2 and Category 3 projects through DPMC and coordinate final decision with Administrator Support Termination Reviews for programs and Category 1 projects	Support Termination Reviews Perform supporting analysis for Termination Reviews, if required		Conduct program and project analyses to support Termination Reviews	Support Termination Reviews
Life-Cycle Reviews	Authorize implementation of programs and Category 1 projects through APMC	Convene and support life-cycle reviews for programs and Category 1 and 2 projects (OCE, OCFO)	Convene and support life-cycle reviews	Ensure adequate checks and balances (e.g., technical authority) are in place	Convene and support life-cycle reviews	Prepare for and conduct/support LCRs Provide assessment of program and project readiness to enter next phase	Prepare for and conduct/support LCRs Provide assessment of project readiness to enter next phase

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
	Convene life-cycle reviews for programs and Category 1 projects (NASA AA)	Convene and support life-cycle reviews for Category 3 projects (OCFO) Support life-cycle reviews or technical assessments, as required (OCE/NESC, OSMA, and OCHMO) Provide project budget and performance status to SRB (OCFO)		Convene and support life-cycle reviews requiring an independent Center SRB Conduct independent life-cycle reviews that do not require an SRB		Provide program and project budget and performance status to SRB	Provide project budget and performance status to SRB
KDPs (all)	Authorize program and Category 1 projects to proceed past KDPs (NASA AA) (May delegate Category 1 projects to MDAA as documented in PCA, FAD, Program Plan, Project Plan)	Provide Executive Secretariat function for APMC KDPs, including preparation of final decision memorandum	Authorize Category 2 and 3 projects to proceed past KDPs (MDAA may delegate to Center Director as documented in PCA, FAD, Program Plan, Project Plan)	Perform supporting analysis to confirm readiness leading to KDPs for programs and Category 1, 2, and 3 projects	Present TA assessment of readiness to proceed past KDPs	Assess readiness for KDPs for program Assess readiness for KDPs for Category 1, 2, and 3 projects Present program and project readiness to proceed past KDPs	Assess readiness for KDPs for projects Present readiness to proceed past KDPs Provide proposed Management Agreement, cost and schedule commitments

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
			Provide recommendation to NASA AA for programs and Category 1 projects at KDPs, including proposing cost and schedule commitments	Assess readiness for KDPs for Category 1, 2, and selected Category 3 projects Present Center's assessment of readiness to proceed past KDPs, adequacy of planned resources, and ability of Center to meet commitments Engage in major replanning or rebaselining activities and processes, ensuring constructive communication and progress between the time it becomes clear that a replan is necessary and the time it is formally put into place		Provide proposed program Management Agreement, cost and schedule estimates for KDPs	

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
Decision Memorandum (DM)	As DA, approve program and Category 1 project DM, approving P/p plans and accepting technical and programmatic risks for the Agency (NASA AA)	Approve DM (OCE, OSMA, OCHMO), certifying policies and standards have been followed and risks are deemed to be acceptable Approve DM (OCFO), certifying policies and standards have been followed and funding; obligations; and commitments on budget, schedules, LCC, and JCL estimates are accurate and consistent with previous commitments	Approve DM (either as DA for Category 2 and 3 projects or as MDAA), certifying P/p can execute mission within resources and committing funding for mission at proposed levels, approving P/p plans and accepting technical and programmatic risks for the MD. Approve DM certifying policies and standards have been followed and independent analysis was used to inform Agency decision processes.	Approve DM, concurring with P/p plans as approved by GPMC and committing to oversee P/p; providing necessary institutional staffing and resources to make P/p successful; making sure that policies, requirements, procedures, and technical standards are in place and are being properly implemented, and accepting technical and programmatic risks for the Center		Approve DM to commit to execute P/p plan approved at GPMC	Approve DM to commit to execute project plan approved at GPMC

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
International, Intergovern-mental, and other external Agreements	Deciding authority to proceed with certain external partnerships based on established Agency thresholds (ASC)	Support the development of and negotiate international agreements (OIIR) Review intergovernmental agreements (OIIR)	Negotiate intergovernmental and other external agreements Coordinate international agreements with OIIR	Negotiate intergovernmental and other external agreements Coordinate international agreements with OIIR		Support development of content of agreements with international, intergovern-mental, and other external organizations	Support development of content of agreements with international, intergovern-mental, and other external organizations
Launch Readiness	Approve launch request	Validate, certify, and approve human rating and launch readiness to Administrator (OCE, OSMA, and OCHMO)	Validate, certify, and approve human rating	Certify that programs and/or projects assigned to the Center have been accomplished properly as part of the launch approval process		Develop program launch readiness criteria Sign the CoFR	Develop program/project launch readiness criteria Sign the CoFR
Program Operations	Ensure program performance through periodic reviews Determine the need for a Program Implementation Review (PIR)	Provide assessments of program performance at periodic reviews (OCE, OSMA, and OCHMO)	Ensure program performance through periodic reviews Report to NASA AA when a trigger for discussing the need for a PIR has occurred	Ensure program performance against approved plans through periodic reviews Provide recommendation on continued implementation when requested	Maintain continuous insight into program performance Report to NASA AA when a trigger for discussing the need for a PIR has occurred	Support PIRs, when requested Execute the Mission Operations Plan	

	Office of the Administrator	Administrator Staff and Mission Support Offices	Mission Directorate Associate Administrator	Center Director		Program Manager	Project Manager
				Institutional	Technical Authority		
	Approve continued program implementation, when desired	Report to NASA AA when a trigger for discussing the need for a PIR has occurred	Provide recommendation on continued implementation when requested Determine the need for a PIR, at their discretion Ensure SRB support for PIRs when needed				
Project Operations	Ensure project performance through periodic reviews	Provide assessments of project performance at periodic reviews (OCE, OSMA, and OCHMO)	Ensure project performance through periodic reviews	Ensure project performance against approved plans through periodic reviews	Maintain continuous insight into project performance	Ensure project performance through periodic reviews	Execute the Mission Operations Plan
Decommission-ing/Disposal	Approve program and project Decommissioning /Disposal Plans for programs and Cat 1 projects	Support development and assessment of program and project Decommissioning /Disposal Plans	Approve program and project Decommissioning /Disposal Plans	Approve program and project Decommissioning /Disposal Plans		Approve project Decommissioning /Disposal Plan Develop program Decommissioning /Disposal Plan Execute approved Decommissioning /Disposal Plan	Develop project Decommissioning /Disposal Plan Execute approved Decommissioning /Disposal Plan

1 Centers may use an equivalent term for these positions, such as program/project systems engineer.

E. Addressing the Six Assessment Criteria

For the following tables, note that the life-cycle review entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP requirements in NPR 7120.5 provide specifics for addressing the six assessment criteria required to demonstrate that the program or project has met the expected maturity state.

Table E-1 Expected Maturity State Through the Life Cycle of Uncoupled and Loosely Coupled Programs

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
KDP 0[1]	SRR—To evaluate whether the program functional and performance requirements are properly formulated and correlated with the Agency and Mission Directorate strategic objectives; to assess the credibility of the program's estimated budget and schedule.	The program has merit and is within the Agency scope; program requirements reflect Mission Directorate requirements and constraints, and are approved.	Program Formulation Authorization Document (FAD) has been approved and a preliminary Program Plan is appropriately mature; the management framework is in place with key interfaces and partnerships identified; and preliminary acquisition strategy is defined.	Functional and performance requirements have been defined, and the requirements satisfy the Mission Directorate needs; a feasible set of program implementation options has been identified that broadly addresses the functional and performance requirements.	Credible risk-informed program implementation options exist that fit within desired schedule and available funding profile.	Preliminary staffing and essential infrastructure requirements have been identified and documented; preliminary sources have been identified.	The driving risks associated with each identified program implementation option have been identified; approaches for managing these risks have been proposed and are adequate.	Overall KDP 0: Program addresses critical NASA needs and can likely be achieved as conceived.

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
KDP I	SDR—To evaluate the proposed program requirements/ architecture and allocation of requirements to initial projects, to assess the adequacy of project pre-Formulation efforts, and determine whether the maturity of the program's definition and associated plans are sufficient to begin implementation.	Program requirements, program approaches, and initial projects reflect Mission Directorate requirements and constraints, and fulfill the program needs and success criteria.	Program Plan and Program Commitment Agreement (PCA) are complete and management infrastructure, including interfaces and partnerships, are in place; initial project(s) have been identified and project pre-Formulation is ready to be (or already) started; technology development plans are adequate, and acquisition strategy is approved.	Driving program and project requirements have been defined, and program architectures, technology developments and operating concepts respond to them; initial project pre-Formulation responds to program needs and appears feasible.	Credible cost/schedule estimates are supported by a documented Basis of Estimate (BoE) and are consistent with driving assumptions, risks, system requirements, conceptual designs, and available funding and schedule profile.	Availability, competency and stability of staffing, essential infrastructure and additional resources other than budget are adequate for remaining life-cycle phases.	Significant program and project safety, development, cost, schedule, and safety risks are identified and assessed; mitigation plans have been defined; a process and resources exist to effectively manage or mitigate them.	Program is in place and stable, addresses critical NASA needs, has adequately completed Formulation activities, has an acceptable plan for Implementation that leads to mission success, has proposed projects that are feasible within available resources, and has risks that are commensurate with the Agency's expectations.

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	**Management Approach**	**Technical Approach**	**Budget and Schedule**	**Resources Other Than Budget**	**Risk Management**	
KDP II to KDP *n*	PIR—To evaluate the program's continuing relevance to the Agency's Strategic Plan, assess performance with respect to expectations, and determine the program's ability to execute the implementation plan with acceptable risk within cost and schedule constraints.	Program's goals, objectives, and requirements remain consistent with the Agency strategic goals; requirements are complete and properly flowed down to projects.	Program Plan and PCA are up-to-date and management infrastructure, including interfaces and partnerships, are working efficiently; program/project relationships are good; technology development plans remain adequate; and acquisition strategy is working properly.	Program's technical approach and processes are enabling project mission success; and technology development activities (if any) are enabling improved future mission performance; projects are proceeding as planned.	Credible cost/schedule estimates are supported by a documented BoE and are consistent with driving assumptions, risks, project implementation, and available funding and schedule profile.	Availability, competency and stability of staffing, essential infrastructure and additional resources other than budget are adequate for continuing program acquisitions and operations.	Significant program and project safety, development, cost, schedule and safety risks are identified and assessed; mitigation plans have been defined; a process and resources exist to effectively manage or mitigate them.	Program still meets Agency needs and is continuing to meet Agency commitments as planned.

[1] KDP 0 may be required by the Decision Authority to ensure major issues are understood and resolved prior to formal program approval at KDP I

NOTE: See also LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP requirements in NPR 7120.5.

Table E-2 Expected Maturity State Through the Life Cycle of Tightly Coupled Programs

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
KDP 0[1]	SRR—To evaluate whether the functional and performance requirements defined for the system are responsive to the Mission Directorate requirements on the program and its projects and represent achievable capabilities.	The program has merit and is within the Agency scope; program requirements reflect Mission Directorate requirements and constraints, and are approved.	Program Formulation Authorization Document (FAD) has been approved and a preliminary Program Plan is appropriately mature; the management framework is in place with key interfaces and partnerships identified; and preliminary acquisition strategy is defined.	Functional and performance requirements have been defined, and the requirements satisfy the Mission Directorate needs; a feasible set of program implementation options has been identified that broadly addresses the functional and performance requirements.	Credible risk-informed program implementation options exist that fit within desired schedule and available funding profile.	Preliminary staffing and essential infrastructure requirements have been identified and documented; preliminary sources have been identified.	The driving risks associated with each identified program implementation option have been identified; approaches for managing these risks have been proposed and are adequate.	Program addresses critical NASA needs, and projects are feasible within available resources.
	SDR—To evaluate the credibility and responsiveness of the proposed program requirements/architecture to the Mission Directorate requirements and constraints, including available resources, and allocation of requirements to projects. To determine whether the maturity of the program's mission/system definition and associated plans are	Program requirements, program approaches, and initial projects incorporate Mission Directorate requirements and constraints, and fulfill the program needs and success criteria; and allocation of program's requirements to projects is	Program Plan and draft PCA are appropriately mature and management infrastructure, including interfaces and partnerships, are in place; project Formulation may be underway; technology development plans are adequate, and acquisition strategy is	Driving program and project requirements have been defined, and program architectures, technology developments and operating concepts respond to them; initial project Formulation responds to program needs and appears	Credible cost and schedule range estimates are supported by a documented BoE and are consistent with driving assumptions, risks, system requirements, conceptual design, and available funding.	Availability, competency and stability of staffing, essential infrastructure and additional resources other than budget are adequate for remaining life-cycle phases.	Significant mission, development, cost, schedule, and safety risks are identified and assessed; mitigation plans have been defined; a process and resources exist to effectively manage or mitigate them.	

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	sufficient to begin preliminary design.	complete.	approved and initiated.	feasible.				
KDP I	PDR— To evaluate the completeness/ consistency of the program's preliminary design, including its projects, in meeting all requirements with appropriate margins, acceptable risk, and within cost and schedule constraints, and to determine the program's readiness to proceed with the detailed design phase of the program.	Program requirements and program/project preliminary designs satisfy Mission Directorate requirements and constraints, mission needs and success criteria.	Program Plan and PCA are complete; external agreements and infrastructure business case are in place; contractual instruments are in place; and execution plans for the remaining phases are appropriate; project PDRs are compliant with sequencing prescribed in the Program Review Plan.	Program and project preliminary designs satisfactorily meet requirements and constraints with acceptable risk; projects are properly integrated into the larger system.	The integrated cost/schedule baseline has a sound basis and is consistent with driving assumptions; reflects risks; is fully supported by a documented BoE; fits within the available funding and schedule profile; and cost/schedule management tools/ processes are in place.	Adequate agreements exist for staffing, essential infrastructure and additional resources, as appropriate, for remaining life-cycle phases.	Mission, development and safety risks are addressed in designs and operating concepts; a process and resources exist to effectively manage or mitigate them.	Program is in place and stable, addresses critical NASA needs, has adequately completed Formulation activities, and has an acceptable plan for Implementation that leads to mission success. Proposed projects are feasible with acceptable risk within Agency cost and schedule baselines.
KDP II	CDR— To evaluate the integrity of the program integrated design, including its projects and ground systems. To meet mission requirements with appropriate margins and acceptable risk within cost and schedule constraints. To	Changes in program scope affecting Mission Directorate requirements and constraints have been approved and documented and have been or will be implemented.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining life-cycle phases; project CDRs are compliant with sequencing prescribed in the	Detailed program and project design satisfactorily meets requirements and constraints with acceptable risk.	Driving ground rules and assumptions are realized; adequate technical and programmatic margins and resources exist to complete the remaining life-cycle phases of	Infrastructure and staffing for final design and fabrication are available/ready; adequate agreements exist for remaining life-cycle phases.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	Program is still on plan. The risk is commensurate with the projects' payload classifications. The program is ready for Assembly, Integration, and Test (AI&T) with acceptable risk

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	determine if the integrated design is appropriately mature to continue with the final design and fabrication phase.		Program Review Plan.		the program within budget, schedule, and risk constraints.			within Agency cost and schedule baselines.
	SIR—To evaluate the readiness of the program, including its projects and supporting infrastructure, to begin system Assembly, Integration, and Test (AI&T) with acceptable risk and within cost and schedule constraints.	Changes in program scope affecting Mission Directorate requirements and constraints have been approved and documented and implemented.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases; project SIRs are compliant with sequencing prescribed in the Program Review Plan.	The hardware/ software systems, processes, and procedures needed to begin system AI&T are available.	AI&T and remaining life-cycle phases can be completed within budget, schedule, and risk constraints.	Infrastructure and staffing for start of system AI&T are available and ready; adequate agreements exist for remaining life-cycle phases.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	
KDP III[2]	ORR—To evaluate the readiness of the program, including its projects, ground systems, personnel, procedures and user documentation, to operate the flight system and associated ground systems in compliance with program requirements and constraints during the operations phase.	Any residual shortfalls relative to the Mission Directorate requirements have been identified to the Mission Directorate and documented and plans are in place to resolve the matter.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases; project ORRs are compliant with sequencing prescribed in the Program Review Plan.	Certification for mission operations is complete, and all systems are operationally ready.	Mission operations and sustainment can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the mission relies for nominal and contingency operations are in an operationally ready condition.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	Program is ready for launch and early operations with acceptable risk within Agency cost and schedule baselines.
	FRR—To evaluate the	Any residual	Acquisitions,	Certification for	Launch and	Infrastructure	Accepted risks	

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	readiness of the program and its projects, ground systems, personnel, and procedures, for a safe and successful launch and flight/mission.	shortfall relative to the Mission Directorate requirements has been resolved with the Mission Directorate and documented.	partnerships, agreements, and plans are in place to complete the remaining phases; project FRRs are compliant with sequencing prescribed in the Program Review Plan.	flight is complete, and all systems are operationally ready.	subsequent operations can be conducted within budget, schedule, and risk constraints.	support and certified staff on which the launch and the mission rely are in an operationally ready condition.	are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any remaining open risks.	
Non-KDP Mission Operations Reviews	PLAR—To evaluate the in-flight performance of the program and its projects. To determine the program's readiness to begin the operations phase of the life cycle and transfer responsibility to the operations organization.	Any newly discovered shortfalls relative to the Mission Directorate requirements have been identified to the Mission Directorate and documented; plans to resolve such shortfalls are in place.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases; project PLARs are compliant with sequencing prescribed in the Program Review Plan.	All systems are operationally ready and accommodate actual flight performance; anomalies have been documented, assessed and rectified or plans to resolve them are in place.	Full routine operations and sustainment, including accommodation of actual flight performance, can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the mission relies, including accommodation of actual flight performance, are in an operationally ready condition.	Accepted risks are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any remaining open risks.	PLAR Expected State: Project is ready to conduct mission operations with acceptable risk within Agency cost and schedule baselines.
	CERR—To evaluate the readiness of the program and its projects to execute a critical event during the flight operations phase of the life cycle.	Critical event requirements are complete, understandable and have been flowed down to appropriate levels for implementation.	Program and project agreements needed to support the Critical Event are in place; project CERRs are compliant with sequencing	Critical event design complies with requirements and preparations are complete, including V&V.	Planned Critical Event can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the Critical Event relies, including accommodation of actual flight performance, are in an	Accepted risks are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any	Mission CERR Expected State: Project is ready to conduct critical mission activity with acceptable risk.

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
			prescribed in the Program Review Plan.			operationally ready condition.	remaining open risks applicable to the Critical Event.	
	PFAR—To evaluate how well mission objectives were met during a human space flight mission. To evaluate the status of the flight and ground systems, including the identification of any anomalies and their resolution.	Any newly discovered shortfalls relative to the Mission Directorate requirements have been identified to the Mission Directorate and documented; plans to resolve such shortfalls are in place.	Acquisitions, partnerships, agreements, and plans are in place to support future flights; project PFARs are compliant with sequencing prescribed in the Program Review Plan.	All anomalies that occurred in flight are identified; actions necessary to mitigate or resolve these anomalies are in place for future flights.	Future flights and mission operations can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which future flights and missions rely, including accommodation of actual flight performance, are in an operationally ready condition.	Risks to future flights and missions, identified as a result of actual flight performance, are documented, credibly assessed, and closed or acceptable closure plans, including needed resources, are in place.	PFAR Expected State: All anomalies that occurred in flight are identified, and actions necessary to mitigate or resolve these anomalies are in place.
KDP IV to KDP *n*-1	PIR—To evaluate the program's continuing relevance to the Agency's Strategic Plan, assess performance with respect to expectations, and determine the program's ability to execute the implementation plan with acceptable risk within cost and schedule constraints.	Program's goals, objectives and requirements remain consistent with the Agency's strategic goals; requirements are complete and properly flowed down to projects.	Program Plan and PCA are up-to-date and management infrastructure, including interfaces and partnerships, are working efficiently; program/project relationships are good; technology development plans remain adequate; and acquisition	Program's technical approach and processes are enabling project mission success; and technology development activities (if any) are enabling improved future mission performance; projects are proceeding as planned.	Credible cost/schedule estimates are supported by a documented BoE and are consistent with driving assumptions, risks, project implementation, and available funding and schedule profile.	Availability, competency and stability of staffing, essential infrastructure and additional resources other than budget are adequate for continuing program acquisitions and operations.	Significant program and project safety, cost, schedule, and safety risks are identified and assessed; mitigation plans have been defined; a process and resources exist to effectively manage or mitigate them.	Program still meets Agency needs and is continuing with acceptable risk within Agency cost and schedule baselines.

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
			strategy is working properly.					
KDP *n*	DR—To evaluate the readiness of the program and its projects to conduct closeout activities, including final delivery of all remaining program/project deliverables and safe decommissioning/disposal of space flight systems and other program/project assets.	Decommissioning is consistent with Agency and Mission Directorate objectives and requirements; decommissioning requirements are complete, understandable and have been flowed down to appropriate levels for implementation.	Acquisitions, partnerships, agreements, and plans are in place to support decommissioning, disposal, data analysis and archiving and contract closeout; project DRs are compliant with sequencing prescribed in the Program Review Plan.	The flight hardware, and software and all associated ground systems are ready for decommissioning, including deorbit (if appropriate), and disposal.	Planned decommissioning and disposal operations can be completed within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which decommissioning, deorbit and disposal rely are in an operationally ready condition.	Risks associated with decommissioning, deorbit or disposal are documented, credibly assessed and closed, or acceptable closure plans, including needed resources, are in place.	Program decommissioning is consistent with program objectives, and program is ready for final analysis and archival of mission and science data and safe disposal of its assets.

[1] KDP 0 may be required by the Decision Authority to ensure major issues are understood and resolved prior to formal program approval at KDP I.

[2] See Section 4.4.4 for a detailed description of the reviews associated with KDP III, the launch approval process, and the transition to operations for human and robotic space flight programs and projects.

NOTE: See also LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP requirements in NPR 7120.5.

Table E-3 Comprehensive Expected Maturity State Through the Life Cycle of Projects and Single-Project Programs

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
KDP A	MCR—To evaluate the feasibility of the proposed mission concept(s) and its fulfillment of the program's needs and objectives. To determine whether the maturity of the concept and associated planning are sufficient to begin Phase A.	The proposed project has merit, is within the Agency/Program scope, and initial objectives and requirements are appropriate.	The Project FAD and Formulation Agreement are ready for approval and the management framework is in place; key interfaces and partnerships have been identified; and appropriate plans for Phase A are in place.	One or more technical concepts and attendant architectures that respond to mission needs are identified and appear feasible. Driving technologies, engineering development, payload, heritage hardware and software needs and risks have been identified.	Credible risk-informed options exist that fit within desired schedule and available funding profile.	Infrastructure and unique resource needs, such as special skills or rare materials, have been identified and are likely available.	The driving risks associated with each identified technical concept have been identified; approaches for managing these risks have been proposed and are adequate.	Project addresses critical NASA need. Proposed mission concept(s) is feasible. Associated planning is sufficiently mature to begin Phase A, and the mission can likely be achieved as conceived.
KDP B	SRR—To evaluate whether the functional and performance requirements defined for the system are responsive to the program's requirements on the project and represent achievable capabilities.	Project requirements reflect program requirements and constraints, and are responsive to mission needs.	Project documentation is appropriately mature to support conceptual design phase and acquisition strategy is defined and ready for approval.	Conceptual design documented; spacecraft architecture baselined; functional and performance requirements have been defined, and the requirements satisfy the mission.	Credible preliminary cost and schedule range estimates and associated confidence levels (if applicable) are supported by a documented BoE and are consistent with driving assumptions, risks, system requirements, design options, and available funding.	Preliminary staffing and essential infrastructure requirements have been identified and documented; preliminary sources have been identified.	Significant mission safety, technical, cost, and schedule risks have been identified; viable mitigation strategies have been defined; a preliminary process and resources exist to effectively manage or mitigate them.	Proposed mission/system architecture is credible and responsive to program requirements and constraints including resources. The maturity of the project's mission/system definition and associated plans is sufficient to begin Phase B, and the mission

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	SDR/MDR— To evaluate the credibility and responsiveness of the proposed mission/system architecture to the program requirements and constraints, including available resources. To determine whether the maturity of the project's mission/system definition and associated plans are sufficient to begin Phase B.	Mission/System requirements, design approaches, and conceptual design incorporate program requirements and constraints, and fulfill the mission needs and mission success criteria.	Preliminary Project Plan is appropriately mature to support preliminary design phase, technology development plans are adequate, acquisition strategy is approved, and U.S. partnerships are baselined. Formulation Agreement for Phase B is ready for approval.	Driving requirements have been defined, and system architectures and operating concepts respond to them. Inheritance assumptions identified, verified, and assessed for risk; components and subassemblies with significant engineering development prototyped.	Credible cost/schedule estimates are supported by a documented BoE and are consistent with driving assumptions, risks, system requirements, conceptual design, and available funding and schedule profile.	Availability, competency and stability of staffing, essential infrastructure, and additional resources other than budget are adequate for remaining life-cycle phases.	Significant mission, development, cost, schedule and safety risks are identified and assessed; mitigation plans have been defined; a process and resources exist to effectively manage or mitigate them.	can likely be achieved within available resources with acceptable risk.
KDP C	PDR— To evaluate the completeness/consistency of the planning, technical, cost, and schedule baselines developed during Formulation. To assess compliance of the preliminary design with applicable requirements and to determine if the project is sufficiently mature	Project requirements and preliminary designs satisfy program requirements and constraints, mission needs and mission success criteria.	Project Plan is complete; external agreements and infrastructure business case are in place; contractual instruments are in place; and execution plans for the remaining phases are appropriate.	Performance, cost, and risk trades completed; preliminary design satisfactorily meets requirements and constraints with acceptable risk; subsystem interfaces defined and evaluated for complexity and risk; assemblies with moderate to significant engineering	The integrated cost/schedule baseline has a sound basis and is consistent with driving assumptions; reflects risks; is fully supported by a documented BoE; fits within the available funding and schedule profile; and cost/schedule management tools/processes	Adequate agreements exist for staffing, essential infrastructure and additional resources, as appropriate, for remaining life-cycle phases.	Mission, development, and safety risks are addressed in designs and operating concepts; a process and resources exist to effectively manage or mitigate them.	Project's planning, technical, cost and schedule baselines developed during Formulation are complete and consistent. The preliminary design complies with its requirements. The project is sufficiently mature to begin Phase C, and the cost and schedule are adequate to enable mission

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	to begin Phase C.			development prototyped.	are in place.			success with acceptable risk.
KDP D	CDR—To evaluate the integrity of the project design and its ability to meet mission requirements with appropriate margins and acceptable risk within defined project constraints, including available resources. To determine if the design is appropriately mature to continue with the final design and fabrication phase.	Changes in project scope affecting program requirements and constraints have been approved and documented and have been or will be implemented.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining life-cycle phases.	Detailed project design satisfactorily meets requirements and constraints with acceptable risk.	Driving ground rules and assumptions are realized; adequate technical and programmatic margins and resources exist to complete the remaining life-cycle phases of the project within budget, schedule, and risk constraints.	Infrastructure and staffing for final design and fabrication are available/ready; adequate agreements exist for remaining life-cycle phases.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	Project is still on plan. The risk is commensurate with the project's payload classification, and the project is ready for AI&T with acceptable risk within its ABC.
	PRR— To evaluate the readiness of system developer(s) to produce the required number of systems within defined project constraints, for projects developing multiple similar flight or ground support systems.	Changes in project scope affecting program requirements and constraints have been approved and documented and have been implemented in the design.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases.	Project design is sufficiently mature to proceed with full-scale production and is consistent with requirements and constraints.	Production and remaining life-cycle phases can be completed within budget, schedule, and risk constraints.	Infrastructure and staffing for conducting production are available and ready; adequate agreements exist for remaining life-cycle phases.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	To evaluate the degree to which the production plans meet the system's operational support requirements.							
	SIR— To evaluate the readiness of the project and associated supporting infrastructure to begin system AI&T, evaluate whether the remaining project development can be completed within available resources, and determine if the project is sufficiently mature to begin Phase D.	Changes in project scope affecting program requirements and constraints have been approved, documented and implemented.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases.	The hardware/ software systems, processes and procedures needed to begin system AI&T are available.	AI&T and remaining life-cycle phases can be completed within budget, schedule, and risk constraints.	Infrastructure and staffing for start of system AI&T are available and ready; adequate agreements exist for remaining life-cycle phases.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	
KDP E[1]	ORR—To evaluate the readiness of the project to operate the flight system and associated ground system(s) in compliance with defined project requirements and constraints during	Any residual shortfalls relative to the program requirements have been identified to the program and documented and plans are in place to resolve the matter.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases.	Certification for mission operations is complete, and all systems are operationally ready.	Mission operations and sustainment can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the mission relies, for nominal and contingency operations, are in an operationally ready condition.	Accepted risks are documented and credibly assessed; a process and resources exist to effectively manage or mitigate remaining open risks.	Project and all supporting systems are ready for safe, successful launch and early operations with acceptable risk within ABC.

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
	the operations/sustainment phase of the project life cycle.							
	MRR/FRR— To evaluate the readiness of the project and all project and supporting systems for a safe and successful launch and flight/mission.	Any residual shortfall relative to the program requirements has been resolved with the program and documented.	Acquisitions, partnerships, agreements, and plans are in place to complete the remaining phases.	Certification for flight is complete, and all systems are operationally ready.	Launch & subsequent operations can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the launch and the mission rely are in an operationally ready condition.	Accepted risks are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any remaining open risks.	
KDP E*n*[2]	PIR — To evaluate the program's continuing relevance to the Agency's Strategic Plan, assess performance with respect to expectations, and determine the program's ability to execute the implementation plan with acceptable risk within cost and schedule constraints.	Program's goals, objectives and requirements remain consistent with the Agency's strategic goals; requirements are complete and properly flowed down to the project if there is one.	Program Plan and PCA are up-to-date and management infrastructure, including interfaces and partnerships, are working efficiently; program/project relationships are good; technology development plans remain adequate; and acquisition strategy is working properly.	Program's technical approach and processes are enabling program/project mission success; and technology development activities (if any) are enabling improved future mission performance; program/projects are proceeding as planned.	Credible cost/schedule estimates are supported by a documented BoE and are consistent with driving assumptions, risks, program/project implementation, and available funding and schedule profile.	Availability, competency and stability of staffing, essential infrastructure and additional resources other than budget are adequate for continuing program acquisitions and operations.	Significant program and project technical, cost, schedule, and safety risks are identified and assessed; mitigation plans have been defined; a process and resources exist to effectively manage or mitigate them.	Program still meets Agency needs and is continuing to meet Agency commitments as planned.
Non-	PLAR—To	Any newly	Acquisitions,	All systems are	Full routine	Infrastructure	Accepted risks	PLAR Expected

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
KDP Reviews	evaluate in-flight performance of the flight system early in the mission and determine whether the project is sufficiently prepared to begin Phase E.	discovered shortfalls relative to the program requirements have been identified to the program and documented; plans to resolve such shortfalls are in place.	partnerships, agreements, and plans are in place to complete the remaining phases.	operationally ready and accommodate actual flight performance; anomalies have been documented, assessed and rectified or plans to resolve them are in place.	operations and sustainment, including accommodation of actual flight performance, can be conducted within budget, schedule, and risk constraints.	support and certified staff on which the mission relies, including accommodation of actual flight performance, are in an operationally ready condition.	are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any remaining open risks.	State: Project is ready to conduct mission operations with acceptable risk within ABC.
Non-KDP Reviews	CERR—To evaluate the readiness of the project and the flight system for execution of a critical event during the flight operations phase of the life cycle.	Critical event requirements are complete, understandable and have been flowed down to appropriate levels for Implementation.	Project agreements needed to support the Critical Event are in place.	Critical event design complies with requirements and preparations are complete, including Verification and Validation (V&V).	Planned Critical Event can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the Critical Event relies, including accommodation of actual flight performance, are in an operationally ready condition.	Accepted risks are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any remaining open risks applicable to the Critical Event.	Mission CERR Expected State: Project is ready to conduct critical mission activity with acceptable risk.
Non-KDP Reviews	PFAR—To evaluate how well mission objectives were met during a human space flight mission and to evaluate the status of the returned vehicle.	Any newly discovered shortfalls relative to the program requirements have been identified to the program and documented; plans to resolve such shortfalls are in place.	Acquisitions, partnerships, agreements, and plans are in place to support remaining flights.	All anomalies that occurred in flight are identified; actions necessary to mitigate or resolve these anomalies are in place.	Continuing flights and mission operations can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which continuing flights and missions rely, including accommodation of actual flight performance, are in an operationally	Risks to future flights and missions, identified as a result of actual flight performance, are documented, credibly assessed, and closed or acceptable	PFAR Expected State: All anomalies that occurred in flight are identified. Actions necessary to mitigate or resolve these anomalies are in place.

KDP Review	Associated LCR and LCR Objectives	Expected Maturity State by Assessment Criteria						Overall Expected Maturity State at KDP
		Agency Strategic Goals	Management Approach	Technical Approach	Budget and Schedule	Resources Other Than Budget	Risk Management	
						ready condition.	closure plans, including needed resources, are in place.	
KDP F	DR—To evaluate the readiness of the project to conduct closeout activities, including final delivery of all remaining project deliverables and safe decommissioning of space flight systems and other project assets. To determine if the project is appropriately prepared to begin Phase F.	Decommissioning is consistent with Agency and program objectives and requirements; decommissioning requirements are complete, understandable and have been flowed down to appropriate levels for Implementation.	Acquisitions, partnerships, agreements, and plans are in place to support decommissioning.	The flight hardware, software, and all associated ground systems are ready for decommissioning.	Planned decommissioning can be completed within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which decommissioning rely are in an operationally ready condition.	Risks associated with decommissioning are documented, credibly assessed and closed, or acceptable closure plans, including needed resources, are in place.	All anomalies that occurred in flight are identified. Actions necessary to mitigate or resolve these anomalies are in place.
Non-KDP Reviews	DRR—To evaluate the readiness of the project and the flight system for execution of the spacecraft Disposal Event.	Disposal event requirements are complete, understandable and have been flowed down to appropriate levels for implementation.	Project agreements needed to support the Disposal Event are in place.	Disposal event design complies with requirements and preparations are complete, including V&V.	Planned Disposal Event can be conducted within budget, schedule, and risk constraints.	Infrastructure support and certified staff on which the Disposal Event relies, including accommodation of actual flight performance, are in an operationally ready condition.	Accepted risks are documented, credibly assessed and communicated; acceptable closure plans, including needed resources, exist for any remaining open risks applicable to the Disposal Event.	Mission DRR Expected State: Project ready to conduct disposal activity with acceptable risk.

[1] See Section 4.4.4 for a detailed description of the reviews associated with KDP E, the launch approval process, and the transition to operations for human and robotic space flight programs and projects.

[2] Applies only to single-project programs
NOTE: See also LCR entrance and success criteria in Appendix G of NPR 7123.1 and the life-cycle phase and KDP requirements in NPR 7120.5.

Table E-4 Objectives for Other Reviews

Review Name	Review Objective
System Acceptance Review (SAR)	To evaluate whether a specific end item is sufficiently mature to be shipped from the supplier to its designated operational facility or launch site.
Safety and Mission Success Review (SMSR)	To prepare Agency safety, engineering, and health and medical management to participate in program final readiness reviews preceding flights or launches, including experimental/test launch vehicles or other reviews as determined by the Chief, Safety and Mission Assurance. The SMSR provides the knowledge, visibility, and understanding necessary for senior safety, engineering, and health and medical management to either concur or nonconcur in program decisions to proceed with a launch or significant flight activity.
Launch Readiness Review (LRR)	To evaluate a program/project and its ground, hardware, and software systems for readiness for launch.

F. Control Plan Description and Information Sources

Control Plan	Description	For Additional Information
Acquisition Strategy	Documents an integrated acquisition strategy that enables the program or project to meet its mission objectives.	• NPD 1000.5 • Sections 3.3.2.1, 3.3.3.5, 4.3.4.1, 4.3.4.2, 4.3.6.2, 4.4.1.2, 4.4.3.2, and 4.4.6.2 of this handbook
Communications Plan	Identifies key milestones of interest to general public, media, and other key stakeholders and plans to engage these audiences for each milestone including during mission operations. Summarizes how efforts will promote understanding of and engagement with program or project and NASA goals and identifies resources and requirements for implementation.	• NPR 7120.5 • Sections 3.3.3.5, 3.4.1.1, 3.4.1.2, 4.3.4.2, 4.3.6.2, 4.4.1.3, and 4.4.3.3 of this handbook
Configuration Management Plan	Describes approach for implementing CM. Describes organization, tools, methods, and procedures for configuration identification, configuration control, interface management, configuration change management, configuration verification and audit, and configuration status accounting and communications. Describes how CM will be audited and how contractor CM processes will be integrated.	• NPRs 7120.5 and 7123.1 • NASA/SP-2016-6105, Systems Engineering Handbook • SAE/EIA 649 • Sections 3.3.4, 4.3.4.3, and 4.3.6.3 of this handbook
Human-Rating Certification Package	Focuses on integration of the human into the system, preventing catastrophic events during the mission, and protecting the health and safety of humans involved in or exposed to space activities, specifically the public, crew, passengers, and ground personnel.	• NPR 8705.2 • NASA/SP-2016-6105, Systems Engineering Handbook • Sections 3.3.4, 3.4.1.1, 3.4.1.2, 4.3.4.3, 4.3.6.3, 4.4.1.3 and 4.4.3.3 of this handbook
Human Systems Integration Plan	Describes how human systems integration (HSI) and human-centered design will be integrated into the program or project design process and life cycle. Describes roles and responsibilities related to implementation of HSI.	• NPR 7123.1 • NASA/SP-20210010952 NASA HSI Handbook • Sections 3.4.1.1 and 4.4.1.3 of this handbook

Control Plan	Description	For Additional Information
Integrated Logistics Support Plan	Describes how the program or project will implement a maintenance and support concept; enhance supportability; supply support; maintenance planning; packaging, handling, and transportation; manpower; required facilities; and logistics information systems for the life of the program or project.	• NPD 7500.1 • Sections 3.3.4, 3,4.1.1, 4.3.4.3, and 4.3.6.3 of this handbook
Integration Plan	Defines integration and verification strategies and shows how elements are assembled to produce subsystems and how subsystems are assembled into the system/product. Describes participants and required resources and when and where they will be needed.	• NPR 7120.5 • NASA/SP-2016-6105, Systems Engineering Handbook • Sections 3.3.4, 3.4.1.1, 4.3.4.3, 4.3.6.3, and 4.4.1.3 of this handbook
Knowledge Management Plan	Describes approach to creating program or project knowledge management strategy and processes, including practices for examining lessons learned database; identifying, capturing, and transferring knowledge; and continuously capturing and documenting lessons learned throughout life cycle.	• NPDs 7120.4 and 7120.6 • Sections 3.3.3.5, 3,4.1.1, 3.4.1.4, 4.3.1.3, 4.3.4.3, 4.3.6.3, 4.4.1.3, 4.4.3.3, 4.4.6.3, and 4.4.8.2 of this handbook
Mission Operations Plan	Describes activities required to perform the mission. Discusses how program or project will implement the associated facilities, hardware, software, and procedures required to complete the mission. Describes mission operations plans, rules, and constraints, the Mission Operations System (MOS), and the Ground Data System (GDS)	• NPR 7120.5 • Sections 3.4.1.1, 3.4.1.2, 4.4.1.3, 4.4.3.3, 4.4.6.1, and 4.4.6.2 of this handbook
NEPA Compliance Documentation	Describes the level of NEPA analysis planned to comply with NPR 8580.1 and Executive Order 12114. Describes NEPA strategy at all affected Centers, including decisions regarding programmatic NEPA documents.	• NPR 8580.1 • Executive Order 12114 • Sections 3.3.4, 3.4.1.1, 4.3.4.3, and 4.3.6.2 of this handbook
Nuclear Launch Authorization Plan	Needed for U.S. space missions involving use of radioactive materials. Addresses procedures and levels of review and analysis required. These vary with quantity of radioactive material planned for use and potential risk to the general public and the environment.	• NPR 8715.26 • NSPM-20 • Sections 3.3.4 and 4.3.4.3 of this handbook
Orbital Collision Avoidance Plan	Describes how the program or project implements design considerations and preparation for operations to avoid in-space collisions.	• NID 7120.132 • Sections 3.3.4, 3.4.1.1, 4.3.6.3, and 4.4.1.3 of this handbook

Control Plan	Description	For Additional Information
Planetary Protection Plan	Addresses management of planetary protection activities which encompass control of terrestrial microbial contamination associated with space vehicles intended to land, orbit, flyby, or otherwise encounter extraterrestrial solar system bodies, and control of contamination of the Earth by extraterrestrial material collected and returned by missions	• NPD 8020.7 • NPR 8715.24 • Sections 3.3.4, 4.3.4.3, and 4.3.6.3 of this handbook
Project Protection Plan	Assesses applicable adversarial threats to the project or system, identifies system susceptibilities, potential vulnerabilities, countermeasures, resilience strategies, and risk mitigations. Results inform design and concept of operations, in context with requirements. Includes inputs from threat intelligence and candidate protection strategies. Identifies to institutional security providers critical nodes and single points-of-failure in the project or system. Provides technical information on NASA space systems to specific commands and agencies in Department of Defense and Intelligence Community to enable timely support in the event of an incident.	• NPR 1058.1 • NASA-STD-1006 • Sections 3.3.4, 4.3.4.3, 4.3.6.3, 4.4.1.3, 4.4.3.3, 4.4.6.3, and 4.4.8.2 of this handbook
Quality Assurance Surveillance Plan	Detailed instructions for the performance of Government contract quality assurance review and evaluation for the program or project.	• NPR 8735.2 • NASA FAR Supplement Part 1837.604 • Sections 3.3.4, 3.4.1.1, 4.3.4.3, 4.3.6.3, and 4.4.1.3 of this handbook
Range Safety Risk Management Process Documentation	Details the vehicle program or project Range Safety Risk Management process (applicable to launch and entry vehicle programs, scientific balloons, sounding rockets, drones and Unmanned Aircraft Systems). Focus is on protection of the public, workforce, and property during range flight operations.	• NPR 8715.5 • Sections 3.3.4, 3.4.1.1, 4.3.6.3, and 4.4.1.3 of this handbook
Review Plan	Summarizes the program or project's approach for conducting a series of reviews including internal reviews and program life-cycle reviews.	• NPR 7120.5 • Sections 3.1.2, 3.3.4, 4.1.2, 4.3.1.4, 4.3.4.3, 4.3.5.3, 4.3.6.3, and 4.3.7.2 of this handbook

Control Plan	Description	For Additional Information
Risk Management Plan	Summarizes how the program or project implements the NASA risk management process, including risk-informed decision making (RIDM) and continuous risk management (CRM).	• NPR 8000.4 • Sections 3.3.3.5, 4.3.1.4, 4.3.4.2, 4.3.4.3, and 4.3.6.2 of this handbook
Safety and Mission Assurance Plan	Reflects program or project life-cycle SMA process perspective, addressing SMA domain management and integration with other engineering and management functions; Closed-Loop Problem Reporting and Resolution System; flow down of requirements to external developers and suppliers; and evaluation of SMA program or project maturity and effectiveness.	• NPRs 8705.2 and 8705.4 • Sections 3.3.4, 3.4.1.1, 3.4.1.2, 4.3.4.3, 4.3.6.3, 4.4.1.3, 4.4.3.3, 4.4.6.3, and 4.4.8.1 of this handbook
Science Data Management Plan	Describes how the program or project will manage scientific data generated and captured by operational mission and any samples collected and returned for analysis. Describes how data will be generated, processed, distributed, analyzed, and archived, and how any samples will be collected, stored during the mission, and managed when returned to Earth.	• NPD 2200.1 • NPRs 2200.2, 1441,1, and 8715.24 • Sections 3.3.4, 3.4.1.2, 4.3.6.3, and 4.4.3.3 of this handbook
Security Plan	Describes the program or project plans for ensuring security. Describes approach for planning and implementing requirements for physical, personnel, and industrial security and for security awareness/education requirements. Describes the program or project's emergency response plan.	• NPRs 1600.1 and 1040.1 • Sections 3.3.4, 4.3.4.3, and 4.4.6.3 of this handbook
Software Management Plan	Summarizes how the project will develop and/or manage the acquisition of software required to achieve project and mission objectives. Plan should be coordinated with the SEMP.	• NPR 7150.2 • NASA-STD-8739.8 • Sections 3.3.4, 4.3.4.3, and 4.3.6.3 of this handbook
System Security Plan	For each information system, provides an overview of the security requirements and describes security controls in place or planned for meeting requirements. Controls selected within System Security Plan are included as system requirements. Documents approach to implementing cybersecurity requirements per NPR 2810.1 for requirements outside scope of the System Security Plan(s).	• NPR 2810.1 • Sections 3.3.4, 3.4.1.1, 3.4.1.2, 4.3.4.3, 4.3.6.3, 4.4.1.3, and 4.4.3.3 of this handbook

Control Plan	Description	For Additional Information
Systems Engineering Management Plan	Describes overall approach for systems engineering including system design and product realization processes as well as technical management processes.	• NPR 7123.1 • NASA/SP-2016-6105, Systems Engineering Handbook • Sections 3.3.4, 4.3.1.4, 4.3.4.3, and 4.3.6.3 of this handbook
Technical, Schedule, and Cost Control Plan	Describes how the program or project plans to control requirements, technical design, schedule, and cost to achieve its high-level requirements.	• NPR 7120.5 • Sections 3.3.3.5, 4.3.4.2.2, 4.3.6.2.2 and 4.4.3.2.2 of this handbook
Technology Development Plan	Describes technology assessment, development, management, and acquisition strategies (including intellectual property considerations) needed to achieve mission objectives.	• NPRs 7500.2, 7123.1, and 7120.5 • Sections 3.3.4, 4.3.1.4, 4.3.4.3, and 4.3.6.3 of this handbook
Technology Transfer Control Plan	Describes how the program or project will implement export control requirements.	• NPR 2190.1 • Sections 3.3.4, 3.4.1.1, 4.3.4.3, 4.3.6.3, and 4.4.1.3 of this handbook
Verification and Validation Plan	Summarizes approach for performing verification and validation of program or project products including methodology to be used.	• NPRs 7123.1 and 7120.5 • NASA/SP-2016-6105, Systems Engineering Handbook • Sections 3.3.4, 3.4.1.1, 4.3.4.3, 4.3.6.3, and 4.4.1.3 of this handbook

G. References

NASA References

NASA Directives and Instructions

NASA Advisory Implementing Instructions (NAII) 1000.1, Pre-Acquisition Strategy Meeting (Pre-ASM) Guide

NAII 1000.2, Acquisition Strategy Meeting (ASM) Guide

NASA Interim Directive (NID) 7120.132, Collision Avoidance for Space Environment Protection

NPD 1000.0, NASA Governance and Strategic Management Handbook

NPD 1000.3, The NASA Organization

NPD 1000.5, Policy for NASA Acquisition

NPD 1001.0, 2022 NASA Strategic Plan

NPR 1040.1, NASA Continuity of Operations (COOP) Planning Procedural Requirements

NPR 1058.1, NASA Enterprise Protection Program

NPD 1400.1, Documentation and Promulgation of Internal NASA Requirements and Charters

NPR 1400.1, NASA Directives and Charters Procedural Requirements

NPR 1441.1, NASA Records Management Program Requirements

NPR 1600.1, NASA Security Program Procedural Requirements

NPR 2190.1, NASA Export Control Program

NPD 2200.1, Management of NASA Scientific and Technical Information

NPR 2200.2, Requirements for Documentation, Approval and Dissemination of Scientific and Technical Information

NPR 2810.1, Security of Information and Information Systems

NPD 7120.4, NASA Engineering and Program/Project Management Policy

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

NPD 7120.6, Knowledge Policy for Programs and Projects

NPR 7120.8, NASA Research and Technology Program and Project Management Requirements

NPR 7120.10, Technical Standards for NASA Programs and Projects

NPR 7120.11, NASA Health and Medical Technical Authority (HMTA) Implementation

NPR 7123.1, NASA Systems Engineering Processes and Requirements

NPR 7150.2, NASA Software Engineering Requirements

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

NPR 7500.2, NASA Technology Transfer Requirements

NPR 8000.4, Agency Risk Management Procedural Requirements

NPD 8010.3, Notification of Intent to Decommission or Terminate Operating Space Systems and Terminate Missions

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

NPR 8580.1, Implementing the National Environmental Policy Act and Executive Order 12114

NPR 8600.1, NASA Capability Portfolio Management Requirements

NPD 8610.7, Launch Services Risk Mitigation Policy for NASA-Owned and/or NASA-Sponsored Payloads/Missions

NPD 8610.12, Orbital Space Transportation Services

NPD 8610.23, Launch Vehicle Technical Oversight Policy

NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping

NPD 8700.1, NASA Policy for Safety and Mission Success

NPR 8705.2, Human-Rating Requirements for Space Systems

NPR 8705.4, Risk Classification for NASA Payloads

NPR 8705.6, Safety and Mission Assurance (SMA) Audits, Reviews, and Assessments

NPD 8710.1, Emergency Management Program

NPR 8715.2, NASA Emergency Management Program Procedural Requirements

NPR 8715.3, NASA General Safety Program Requirements

NPR 8715.5, Range Flight Safety Program

NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments

NPR 8715.7, Payload Safety Program

NPR 8715.24, Planetary Protection Provisions for Robotic Extraterrestrial Missions

NPR 8715.26, Nuclear Flight Safety

NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects

NPD 8800.14, Policy for Real Estate Management

NPR 8800.15, Real Estate Management Program

NPR 8820.2, Facility Project Requirements (FPR)

NPR 9250.1, Property, Plant, and Equipment and Operating Materials and Supplies

NPR 9420.1, Budget Formulation

NPR 9470.1, Budget Execution

NASA Communities of Practice

NASA Engineering Network (NEN) Program and Project Management community of practice https://www.nasa.gov/open/nen-ntrs.html

NASA's Program and Project Management community of practice at https://nen.nasa.gov/web/evm

OCFO Cost and Schedule community of practice site https://max.omb.gov/community/pages/viewpage.action?pageId=646907686

The NASA Office of the Chief Financial Officer (OCFO) Strategic Investments Division (SID) maintains a Cost and Schedule community of practice page with updated information (including external reporting) at https://max.omb.gov/community/x/TQePJg . Contact OCFO to request access.

NASA Databases

NASA's Electronics Forms Database website https://nef.nasa.gov/

One NASA Cost Engineering (ONCE) database. To access the ONCE database, go to the ONCE website www.oncedata.com and click on the "request access" link on that page. The key requirement for access is to have a NASA identity in NASA's IDMAX system.

NASA Websites

Agency Tailoring Website https://appel.nasa.gov/npr-7120-5-tailoring-resources

APPEL PM certification website at https://appel.nasa.gov/career-resources/fac-ppm-certification/

More detailed current information on the PM competencies, including definitions and levels of proficiency, is available on the APPEL website http://appel.nasa.gov/pm-se/project-management-and-systems-engineering-competency-model/

NASA Engineering Network (NEN) (NASA only) https://nen.nasa.gov/web/pm/

NASA Engineering and Safety Center (NESC)
http://www.nasa.gov/offices/nesc/contacts/index.html

Katherine Johnson Independent Verification and Validation (IV&V) Facility
http://www.nasa.gov/centers/ivv/home/index.html

NASA Risk Information and Security Compliance System (RISCS) at https://riscs-info.nasa.gov/

Space Act Agreements information http://www.nasa.gov/open/plan/space-act.html

OCFO-SID Earned Value Management (EVM) Homepage (NASA only)
https://community.max.gov/display/NASA/Earned+Value+Management+HOMEPAGE

Center EVM Focal Points (EVMFPs) list https://nasa.gov/evm/evmwg

NASA Technical Standards

NASA-STD-1006, Space System Protection Standard
https://standards.nasa.gov/standard/NASA/NASA-STD-1006

NASA-STD-8719.14, Process for Limiting Orbital Debris
https://standards.nasa.gov/standard/nasa/nasa-std-871914

NASA-STD 8719.24, NASA Expendable Launch Vehicle Payload Safety
https://standards.nasa.gov/standard/nasa/nasa-std-871924

NASA-STD-8739.8, Software Assurance and Software Safety Standard
https://s3vi.ndc.nasa.gov/ssri-kb/static/resources/nasa-std-8739.8a.pdf

NASA Handbooks

NASA Cost Estimating Handbook https://www.nasa.gov/content/cost-estimating-handbook

NASA-HDBK-2203, NASA Software Engineering and Assurance Handbook
http://swehb.nasa.gov

NASA/SP-2010-3403, NASA Schedule Management Handbook
https://www.nasa.gov/content/schedule-management-handbook and
https://nasa.gov/evm/handbooks (Note that this document was updated in 2020, but the document number was not changed.)

NASA/SP-2011-3422, NASA Risk Management Handbook
https://ntrs.nasa.gov/api/citations/20120000033

NASA/SP-2016-3404, NASA Work Breakdown Structure (WBS) Handbook https://ntrs.nasa.gov/citations/20180000844 (Note that a more recent version of this document is available at https://www.nasa.gov/evm/handbooks. See below.)

NASA/SP-2016-3424, NASA Project Planning and Control Handbook https://www.nasa.gov/content/project-planning-control-handbook

NASA/SP-2016-3706, NASA Standing Review Board Handbook https://ntrs.nasa.gov/citations/20170000280

NASA/SP-2016-6105, Systems Engineering Handbook https://ntrs.nasa.gov/citations/20170001761

NASA/SP-2018-599, NASA Earned Value Management (EVM) Implementation Handbook https://ntrs.nasa.gov/api/citations/20180001499 (Note that a more recent version of this document is available at https://www.nasa.gov/evm/handbooks. See below.)

NASA/SP-20210010952, NASA Human Systems Integration Handbook https://ntrs.nasa.gov/citations/20210010952

NASA/SP-20210023927, NASA Work Breakdown Structure (WBS) Handbook https://www.nasa.gov/evm/handbooks

NASA/SP-20210024466, NASA Earned Value Management (EVM) Implementation Handbook https://www.nasa.gov/evm/handbooks

NASA/SP-20210026420, Integrated Baseline Review (IBR) Handbook https://nasa.gov/evm/handbooks

NASA Guides

NASA Common Leading Indicators Detailed Reference Guide https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_52.pdf

Guide for Successful Headquarters Procurement Strategy Meetings (NASA only) https://ooptechportal.hq.nasa.gov/Documents/NASA%20PSM%20Guide.pdf

NASA Integrated Program Management Report (IPMR) Data Requirements Description (DRD) Guide https://www.nasa.gov/evm/guidance

NASA/SP-20205003605, Technology Readiness Assessment Best Practices Guide https://ntrs.nasa.gov/citations/20205003605

NASA Business Case Guide for Real Property and Facilities Project Investments https://www.hq.nasa.gov/office/codej/codejx/Assets/Docs/NASA_Business_Case_Guide_11_29_10.pdf

NASA Guidance

NPR 7120.5F Compliance Matrix NPR 7120.5 Rev F Compliance Matrix https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_55.docx

Guidance for Tailoring 7120.5F Requirements for Small Category 3/Class D Projects https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_57.pdf

Capitalization Determination Form (CDF) NF 1739, NASA's Electronics Forms Database website https://nef.nasa.gov/

Communications Plan Template on the website for the Office of Communications http://communications.nasa.gov/content/nasa-comm-guidelines

NASA Earned Value Management (EVM) Contract Requirements Checklist (CRC) located at https://nasa.gov/evm/regulations.

A sample standard EVM data analysis package (Charts and Reports for Sample Analysis Package) https://nasa.gov/evm/guidance

Agency Policy Guidance to EVM and Create a Schedule Repository https://nasa.gov/evm/regulations

Requesting Access to EVM Tools (NASA Instructions for Access to Earned Value Management (EVM) Tools: Empower, Cobra, Windchill & Acumen Fuse) at https://nasa.gov/evm/guidance

NASA EVM Central Repository posting instructions at https://nasa.gov/evm/guidance.

NASA Agency-level EVMS Surveillance Plan (NASA only) https://nen.nasa.gov/web/pm/evm

The templates for all three parts of the Cost Analysis Data Requirement (CADRe) for space flight missions https://www.nasa.gov/offices/ocfo/functions/models_tools/CADRe_ONCE.html

NASA Accident Reports

Columbia Accident Investigation Board (CAIB) report accessible at CAIB Report Table of Contents (nasa.gov) or https://www.nasa.gov/columbia/caib/html/start.html

Report to the President By the Presidential Commission On the Space Shuttle Challenger Accident June 6th, 1986: Washington, D.C. Rogers Commission Report 1.doc (nasa.gov) or https://sma.nasa.gov/SignificantIncidents/assets/rogers_commission_report.pdf

NASA, NASA Statement on Decision to Launch Shuttle Discovery. (June 19, 2006) Available at http://www.nasa.gov/mission_pages/shuttle/news/121frr_oconnor_scolese.html. See Appendix 5 for a list of references.

External References

Office of the President

Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, Jan. 4, 1979.

Executive Order 12770, Metric Usage in Federal Government Programs, July 25, 1991

National Security Presidential Directive (NSPD) 49: U.S. National Space Policy, 31 August 2006. https://irp.fas.org/offdocs/nspd/space.html

National Security Presidential Memorandum (NSPM-20), Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems (August 2019) Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems – The White House (archives.gov)

Other Executive Branch

Office of Management and Budget (OMB)

White House, Office of Management and Budget (OMB) Circular A-11, Preparation, Submission and Execution of the Budget https://www.whitehouse.gov/omb/information-for-agencies/circulars/ Part 6: http://www.whitehouse.gov/sites/default/files/omb/assets/a11_current_year/s200.pdf. Some reporting requirements, such as the Annual Performance Plan (APP), are Government-wide to meet guidance in OMB Circular A-11. OMB Circular A-11 requires EVM for acquisitions with developmental effort and for both in-house government and contractor work using the EIA-748 guidelines.

White House, Office of Management and Budget (OMB) Circular A-119, Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities. (02/10/1998; revised 01/22/2016). Revised Circular A-119 as of 1.22.2016 (whitehouse.gov) or https://www.whitehouse.gov/wp-content/uploads/2020/07/revised_circular_a-119_as_of_1_22.pdf

White House, OMB, Office of Federal Procurement Policy (OFPP), The Federal Acquisition Certification for Program and Project Managers (FAC-P/PM), April 25, 2007, sets requirements for project management certification that apply to all civilian agencies and outlines the baseline competencies, training, and experience required for program and project managers in the Federal government. See Memorandum for Chief Acquisition

Officers (fai.gov) or https://www.fai.gov/sites/default/files/2007-4-25-OFPP-Memo-FAC-PPM-Certification.pdf

U.S. Department of Commerce

U.S. Department of Commerce, National Institute of Standards and Technology (NIST), Special Publication (SP) 330, International System of Units (SI). 2019 Edition. The International System of Units (SI), 2019 Edition | NIST or https://www.nist.gov/publications/international-system-units-si-2019-edition. This is the United States version of the English text of the ninth edition (2019) of the International Bureau of Weights and Measures publication Le Système Internationale d'Unités (SI), commonly known as the metric system of measurement. Together NIST SP 330 and NIST SP 811, Guide for the Use of the International System of Units (SI), provide the official interpretation of the SI for the United States.

Code of Federal Regulations (C.F.R.)

14 C.F.R. Part 1216, Subpart 1216.3, Procedures for Implementing the National Environmental Policy Act (NEPA). Policy and procedures for implementing the National Environmental Policy Act of 1969.

48 C.F.R., Chapter 1. Federal Acquisition Regulation (FAR)
https://www.acquisition.gov/browse/index/far
FAR Subpart 7.1, Acquisition Plans
FAR Subpart 34.2, Earned Value Management System

48 C.F.R., Chapter 18. NASA FAR Supplement (NFS). https://www.acquisition.gov/nfs
NFS Subpart 1807.1, Acquisition Plans https://prod.nais.nasa.gov/far/far0595-nfs012617/1807.htm
NFS Subpart 1834.2, Earned Value Management System.
https://www.hq.nasa.gov/office/procurement/regs/NFS.pdf.
NASA FAR Supplement (NFS) Part 1837.604, Quality assurance surveillance plans.
NASA FAR Supplement (NFS) Part 1872 for regulatory coverage of AOs.

The contents of written acquisition plans and PSMs are delineated in the FAR in Subpart 7.1—Acquisition Plans, the NFS in Subpart 1807.1—Acquisition Plans.

EVM is required by OMB for compliance with FAR Subpart 34.2, Earned Value Management System and guided by industry best practice. NASA FAR Supplement (NFS) Subpart 1834.2, Earned Value Management System requires use of an Earned Value Management System (EVMS) on procurement for development or production work, including flight and ground support systems and components, prototypes, and institutional investments (facilities, IT infrastructure, etc.) when their estimated life cycle (Phases A–F) costs $20 million or more.

Legislative Branch

U.S. Code

National Aeronautics and Space Act of 1958, as amended (51 U.S.C. §20113(e)).

National Environmental Policy Act (NEPA), 42 U.S.C. § 4321 et seq.

Declaration of Policy, 15 U.S.C. §205b, reference: Metric Conversion Act, Pub. L. No. 94-168, December 23, 1975, as amended by the Omnibus Trade and Competitiveness Act of 1988, Pub. L. No. 100-418.

U.S. Statutes

Government Performance Reporting and Accountability Modernization Act of 2010 (GPRAMA), Public Law 111–352—Jan. 4, 2011, 124 STAT. 3866. Additional information on the GPRA Modernization Act can be found at http://www.gpo.gov/fdsys/pkg/PLAW-111publ352/pdf/PLAW-111publ352.pdf.

NASA Appropriations

2005, NASA Authorization Act of 2005 (P.L. 109-155).
Section 103. Congress created an external reporting requirement in this Act, i.e., the Major Program Annual Report (MPAR) for projects in development (whether or not they are space flight projects) with an estimated life-cycle cost exceeding $250 million.

FY 2008 House Appropriations Report H.R.2764 (P.L.110-161), Audit of NASA large-scale programs and projects. https://www.congress.gov/bill/110th-congress/house-bill/2764. Refer to the House report for the details. All appropriations since FY 2008 have included direction for the Government Accountability Office (GAO) to "identify and gauge the progress and potential risks associated with selected NASA acquisitions. This has resulted in GAO's annual "Assessment of Large-Scale NASA Programs and Projects," the audit known internally as the Quick Look Book.

2009, Omnibus Appropriations Act of 2009 (Pub. L. No. 111-8). The explanatory statement of the House Committee on Appropriations accompanying the Omnibus Appropriations Act of 2009 included a provision for GAO to prepare project status reports on selected large-scale NASA programs, projects, and activities. 155 Cong. Rec. H1653, 1824-25 (daily ed., Feb. 23, 2009), on H.R. 1105. In its reports, GAO refers to these projects as major projects rather than large-scale projects as this is the term used by NASA. GAO has generally chosen to review projects already required to file MPAR or NSPD-49 reports. The GAO report for 2021 (GAO-21-306) is the 13th annual report responding to that mandate.

2012, Consolidated and Further Continuing Appropriations Act, 2012 [P.L. 112-55].

2013, Consolidated and Further Continuing Appropriations Act 2013 [P.L. 113-6]. Section 522. Congress requires NASA to report on projects greater than $75 million that encounter a 10 percent LCC growth.

Commerce, Justice, Science, and Related Agencies' appropriations acts (annual), General Provisions, Section 505 describes reprogramming requirements and requires NASA to notify the House and Senate Committees on Appropriations of a decision to terminate a program or project 15 days in advance of the termination of a program or project. The NASA Office of Legislative and Intergovernmental Affairs (OLIA) is responsible for notifying the Committees on Appropriations pursuant to this reprogramming requirement.

Government Accountability Office (GAO) Reports

GAO-04-642, NASA: Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management, 2004. https://www.gao.gov/assets/gao-04-642.pdf

GAO-21-306, NASA: Assessments of Major Projects (Washington, D.C.: May, 20, 2021). GAO-21-306, NASA: Assessments of Major Projects or https://www.gao.gov/assets/gao-21-306.pdf

External Resources

Standards

SAE/EIA 649, Configuration Management Standard
In order to protect and ensure the integrity of NASA products, NASA's Office of the Chief Engineer (OCE) has endorsed the SAE/Electronics Industries Alliance (EIA) EIA-649C Configuration Management Standard, and SAE/EIA 649-2 Configuration Management Requirements for NASA Enterprises. These standards are accessible via the NASA Technical Standards Program (https://standards.nasa.gov). The Government Electronics Information Technology Association (GEIA), GEIA-HB-649A Configuration Management Standard Implementation Guide, 2016, is also available to guide practitioners in the planning and implementation of the five (5) Configuration Management functions and their associated underlying principles. These documents form the framework for CM requirements and activities.

EIA-748, Earned Value Management Systems
The National Defense Industrial Association (NDIA) Integrated Program Management Division (IPMD) is the author and responsible for the EIA-748. It is approved by the Society of Automotive Engineers (SAE) and published as SAE Electronic Industries Alliance (EIA) 748. The current version is SAE EIA-748 D:2019-01-08, Earned Value Management Systems.

Publications

1991. Air Force Space Command Manual 91-710, Range Safety User Requirements Manual Volume 3 - Launch Vehicles, Payloads, and Ground Support Systems Requirements (for ELVs).

1995. INCOSE, "Metric Guidebook for Integrated Systems and Product Development"

2000. Garvey, P.R., Probability Methods for Cost Uncertainty Analysis: A Systems Engineering Perspective, New York: Marcel Dekker.

2004. MSNBC, "NASA Says It's Fixed Shuttle Foam Problem." (August 31, 2004) http://www.msnbc.msn.com/id/5831547/.

2005. BAE Presentation "Technical Performance Measure" Jim Oakes, Rick Botta and Terry Bahill.

2005. PSM, INCOSE and Industry Collaborative Project. "Technical Measurement."

2006. John Kelly, "NASA Chief Michael Griffin's STS-121 Flight Rationale Explained." Florida Today, (June 21, 2006). Reproduced in *Space.com*: http://www.space.com/2525-nasa-chief-michael-griffin-sts-121-flight-rationale-explained.html

2006. Mike Schneider, "Shuttle Launch a Go Despite Damaged Foam." (July 4, 2006) *Washington Post*: http://www.washingtonpost.com/wp-dyn/content/article/2006/07/03/AR2006070300996.html

2007. Michael D. Griffin, "The Role of Governance." *ASK*, Issue 26 (Spring 2007).

2008. Rhodes, Donna H., Ricardo Valerdi, Garry J. Roedler. "Systems Engineering Leading Indicators for Assessing Program and Technical Effectiveness," Massachusetts Institute of Technology and Lockheed Martin Corporation. Reprint of an article accepted for publication in *Systems Engineering*.

2010. MIT, INCOSE and PSM. "Systems Engineering Leading Indicators Guide," Version 2.0.

H. Technical Products and Tightly Coupled Programs (Temporary Appendix)

This is a temporary Appendix that documents the approach taken in this handbook for technical products for tightly coupled programs. Once updates related to technical products for tightly coupled programs are determined for NPR 7120.5F, this handbook will be updated to reflect those updates and this Appendix can be deleted.

Background Information

- The Tightly Coupled Program I-Tables do not include any technical products (other than "Industrial Base and Supply Chain Risk Management").
- The original version of this handbook was written as if technical products were required for tightly coupled programs.

Added to NPR 7120.5 List of Potential Updates

- Tightly coupled program technical products: There are no technical products in I-Tables. Should there be?

Interim Approach for This Handbook

- Identify technical products that should be developed by *all tightly coupled programs* (Technical Products are in I-Table for Single-Project Programs).
- State that tightly coupled programs should determine responsibility for the other technical products, i.e., developed by program, developed by all constituent projects, developed by specific constituent project(s).
- Encourage that all development of hardware and software be performed by a project, i.e., managed as a separate project or assigned to one of the constituent projects.

Technical Products that should be developed by all Tightly Coupled Programs
Concept Documentation
Mission, Spacecraft, Ground, and Payload Architectures
Operations Concept Documentation
Systems Safety Analyses
Verification and Validation Report
Operations Handbook
End of Mission Plans
Final Mission Report
Industrial Base and Supply Chain Risk Management (SCRM) Strategy and Status
Tightly Coupled Programs determine level of Responsibility for Technical Products
Project-level, System, and Subsystem Requirements
Design Documentation
Technology Readiness Assessment Documentation
Engineering Development Assessment Documentation

Heritage Assessment Documentation
Payload Safety Process Deliverables
Orbital Debris Assessment
Decommissioning/Disposal Plan
Criticality Identification Method for Hardware
Hardware Quality Data Management Analytics