NASA

Project Planning and Control Handbook

NASA /SP-2016-3424

PP&C Logo Symbolism

The PP&C logo on the cover features a gear motif to convey the cause-effect interrelations with all of the PP&C functions as well as the technical aspect of NASA's projects.

Each of the 7 gears represents a corresponding PP&C function and can be used independently to emphasize or highlight a section of a PP&C presentation or document; e.g., as part of a PowerPoint template or Word document chapter identifier.

Some gears reach into or exceed the diamond border with two-fold symbolization: managing "within the box" and creative solutions "outside the box."

Although the order of the gears is not significant, the size of the gears is meaningful. The gear sizes visually emphasize functions that are, in general, more consistently used in the project management decision process. In other words, the Acquisition and Contract Management function and the Configuration and Data Management function, while important, may be used less frequently than the other functions with the PP&C Integration function being the main gear to aid project management decision making.

Each gear is color-coded to match the functional color scheme in the handbook and clearly convey the identity of the function. One exception is the PP&C Integration function, which is depicted in the logo as black, a color that absorbs all colors and is therefore comprehensive of all PP&C functions. (The functional color scheme in the handbook uses red as the color for PP&C Integration.) Another exception is the Configuration and Data Management function, which is depicted in the logo as a shade of teal for visual clarity. (The functional color scheme in the handbook uses a light shade of green as the color for CM/DM.)

The logo features a diamond shape as the backdrop to visually group the gears. The diamond shape represents the decision making process just as it does in flow charts and reinforces the PP&C focus on programmatic analysis, assessment, and decisional support. Arrowheads are cleanly embedded into the diamond shape. In the left side of the diamond, an arrowhead represents an input into the decision diamond. An arrowhead in the right side represents a positive decision to proceed and one in the bottom represents a negative decision, which initiates an alternative, hold, or stop process.

The following are the individual icons in the functional order found in the handbook:

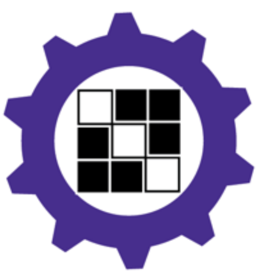
The PP&C Integration icon mimics the mathematical integral symbol for integration with the function of variable format. In this case, it expresses the integration as a function of a project's Technical, Cost, Schedule, and Risk performance.

The Resources Management icon represents the relationship between workforce (people) and budget (dollar sign).

The Scheduling icon is the widely recognized symbol of a calendar and timeliness.

The Cost Estimation and Assessment icon represents funds forecasting and performance over time.

The Acquisition and Contract Management icon represents signing off on a purchase order, contract, or agreement.



The Risk Management icon mimics NASA's 5x5 Likelihood versus Consequence risk scorecard although for simplicity, the icon is 3x3.

The Configuration Management/Data Management icon is the internationally recognized symbol for data management.

NASA/SP-2016-3424

Project Planning and Control Handbook

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

December 2016

Table of Contents

List of Figures

List of Tables

Foreword by Lightfoot

Acknowledgments

The Office of the Chief Engineer wishes to thank the many subject matter experts in the project planning and control community throughout the Agency who materially contributed to this endeavor. Their expertise and knowledge made this Agency-level guide possible.

OCE would like to acknowledge the time, effort, and expertise contributed by the following:

Integration Team

The handbook is part of a larger Agency PP&C initiative spearheaded by Robert Moreland of the Office of the Chief Engineer (OCE). The visionary for the central concept of the handbook was Kevin Rice (JPL). The core OCE handbook team, led by Brad Richards (MSFC [MTS, Inc.]) consisted of Linda Bromley (JSC-ret), Kathy Symons (JSC-ret), and Linda Voss (HQ [Dell]) supported by Mary Coan (KSC) and Ivette Aponte (KSC).

Structure Team

The Structure Team provided guidance and direction: Cathy Claunch (JSC), Yvonne Dellapenta (LaRC), Gordon Degear (KSC-ret), and Ted Mills (HQ).

Subject Matter Contribution

Heather Altizer, LaRC
Jimmy Black, MSFC-ret
William Dimmer, KSC-ret
Ennix-Sandhu, Kimberly, AFRC
Dan Graham, JPL
Thad Henry, MSFC
Arnold Hill, HQ
Charles Hunt, HQ
Karen Kelldorf, JSC
Walter Majerowicz, GSFC
Ken Poole, MSFC-ret
William Roets, HQ
Bob Sefcik, GRC
Marilyn Seppi, HQ
Michael Stelly, JSC
Steve Wilson, JSC
Mary Beth Zimmerman, HQ

Reviewers

John Anders, GSFC
Len Bell MSFC
Richard Berry, GSFC
Dan Blackwood, GSFC
Lynn Blackwood, GSFC
Chris Blake, GRC
Hiedemarie Borchardt, HQ
Jonathan Bryson, GSFC

Deirdra Bullock, AFRC
Rich Burns, GSFC
Tim Cannella, LaRC
Camilla Canty, MSFC
Diana Centeno-Gomez, GRC
Michael Chandler, JSC
John Decker, GSFC
Zachary Dolch, GSFC
Michael Donnelly, GSFC
Cristina Doria-Warner, GSFC
Vincent Elliott, GSFC
Vicky Essick, HQ
Kathryn Ferrare, LaRC
Cathy Freudinger, AFRC
Jim Frost, GSFC
Cindy Fryer, GSFC
Brad Gardner, LaRC
Janice Gassaway, GRC
Christopher Greco, GSFC
Cristina Guidi, HQ
Cheryl Harrell, MSFC
Keith Hefner, MSFC
William Hicks, MSFC
Arnold Hill, HQ
Charles Hunt, HQ
Greg Josselyn, ARC
Patricia Jewell, LaRC
Kristen Kehrer, KSC
Jerald Kerby, MSFC
Michele King, HQ
Teresa Kline, HQ
James Kolibas, GRC
Megan Krewson, GRC
Rodolfo Lavaque, GSFC
Sandra Marshall, GSFC
Winifred Martin, HQ
Marvalyn Sweeney GSFC
Anthony McNair, GSFC
Karilys Montanez, GSFC
Robert Montgomery, GSFC
Kelly Moses, HQ
Thomas Paine, ARC
Tom Parkey, GRC
Lauren Lyons Parsons, JSC
Laura Paschal, GSFC
Steven Patterson, MSFC
Eric Plumer, HQ
Kathleen Pollard, MSFC
Colleen Ponton, GSFC
Ben Powell, SSC
Rebecca Quigley, GSFC
Amy Radford, LaRC
Thomas Rathjen, HQ
Rhega Gordon MSFC
Chris Ridenour, GSFC
Matthew Ritsko, GSFC
Amarit Rojsirivit, GSFC
Nancy Rosenbaum, GSFC
Deborah Schumann, MSFC
Sharon Seipel, GSFC
Kendall Sherman, LaRC
Donald Shick, LaRC
Stephen Shinn, GSFC
Billie Smith, GSFC
Robin Smith, HQ
Johnny Stephenson, MSFC
Ellen Stigberg, HQ
Stephanie Stilson, HQ
James Taylor, HQ
Anita Tenteris-Noebe, GRC
Jack Trapp, AFRC
Lauri Via, GSFC
Cheryl Varney, GRC
Timothy Warner, LaRC
Sandeep Wilkhu, KSC
Lowell Wolfe, GRC
Heidi Wood, GSFC
Linda Wunderlick, GSFC
Michael Zernic, GRC

Preface

While reading and utilizing this handbook, it is important to note that it is premised on the following four core perspectives.

1. **PP&C Functions**. This handbook describes the functional Project Planning and Control (PP&C) disciplines as identified in the 2010 *Interim Results of the NASA Program Planning and Control (PP&C) Study*. These functional areas are: PP&C Integration, Cost Estimation/Cost Assessment, Resource Management, Scheduling, Acquisition and Contract Management, Risk Management, and Configuration Management/Data Management. In each of these functional areas, the handbook addresses three fundamental aspects:

    - A discussion of the subject content of that function including the primary activities performed in support of the project.

    - A discussion of how each function interfaces with each of the other PP&C functions. This aspect captures all the inputs each functional area expects from the other functions and identifies all the outputs each functional area provides to the other disciplines.

    - How each functional area supports the overarching integration function of PP&C.

    Hence throughout the handbook, each functional area describes its core subject matter content, identifies all required interface activities (inputs and outputs) needed between all PP&C functions, and then demonstrates how they all tie to the primary activity of integration.

2. **Integration**. The primary focus of the handbook is the integration of the PP&C function activities performed in support of the project. As such, the handbook is presented from the perspective of the integration activity rather than each functional area. Although the individual PP&C functional areas provide significant support and content to the overall process, the culmination of PP&C is the integrative activities and subsequent assessment and recommendations. These activities include coordinating and interfacing with all of the other PP&C functional areas to ensure those activities are performed in a seamless and effective manner. The fundamental focus of the integration activity is to gather, analyze, and assess project information to enable effective decision making in support of project success.

3. **Project Planning and Control Model**. The handbook is centered on a model that describes planning and control as two separate yet interrelated concepts. Planning is described as those activities involved in defining the approach the project will take to capture the scope of work in an executable plan. This approach is refined throughout the

Formulation Phase of the project. Upon completion of Formulation (at Key Decision Point (KDP) C), the planning process produces an integrated cost, schedule, and technical baseline and known risk list that is the basis for the Implementation Phase. Once in Implementation, the focus shifts to the control activities, which comprise managing the plan and identified risks. Although it can be argued that planning and control are iterative throughout the project, it is the premise of this handbook that once the planning activities result in producing the integrated technical/cost/schedule baseline, adjustments to the plan are part of the control process. As such, the planning process addresses creating the plan and control addresses managing the plan. However, if the change in the plan is major, such as change in scope, significant funding issues, significant technical issues, etc., then the process moves back into the planning process and the project rebaselines. Otherwise, adjustments to the plan are part of the control process. It is the integrative function that brings these activities together.

4. **Responsible Organization**. This handbook also focuses on the activities being performed, not on the organization or title of the person doing it. For example, the resource analyst may be the same person doing the schedule or any of the other PP&C functions, especially on smaller projects. Different Centers may organize functions differently between different offices. As such, the discussion will be from the perspective of the task being done, not on the organization responsible.

1. Introduction

1.1. Background

The impetus for the Project Planning and Control (PP&C) initiative comes from a 2009 meeting hosted by the Office of the Chief Engineer (OCE), which identified a need to strengthen the Agency's PP&C capability. The NASA Administrator's Office chartered a study to assess the health of and develop a strategy to enhance the Agency's PP&C capability. The study surveyed PP&C professionals throughout the Agency and launched the next level of effort to enhance and elevate the practice of PP&C at the Agency and revitalize the PP&C community. A PP&C road mapping team and Agency Working Group were established. The PP&C Agency Working Group identified a gap in documented Agency guidance on the activities and a need to standardize terminology and recommended best practices for the PP&C community.

This PP&C Handbook leverages this Agency-level work as well as work at the Centers to document PP&C best practices at NASA. NASA's Jet Propulsion Laboratory (JPL) developed a *Program Business Management Practices* (aka "Green Book") and Marshall Space Flight Center (MSFC) developed a *Project Planning and Control Handbook*. The Goddard Space Flight Center (GSFC) refers to their "Gold Standard" for PP&C practices.[1] In addition, this handbook references a number of discipline-specific handbooks, for example, the *NASA Work Breakdown Structure (WBS) Handbook (NASA/SP-2010-3404)*. The intention for this handbook is not to repeat information in these other handbooks, beyond providing context, but rather to reference and leverage that knowledge by extension.

1.2. Purpose and Audience

This handbook provides an overview of the fundamental principles and explains the functions and products that go into project planning and control. The 2010 *Interim Results of the NASA Program Planning and Control (PP&C) Study* identified seven categories of activities for PP&C, and those provide the basis for the seven functions described in this handbook. This handbook maps out the interfaces and interactions between PP&C functions, as well as their external interfaces. This integration of information and products within and between functions is necessary to form the whole picture of how a project is progressing. The handbook descriptions are meant to facilitate consistent, common, and comprehensive approaches for providing valued analysis, assessment, and evaluation focused on the project level at NASA. The handbook also describes activities in terms of function rather than the job title or the specific person or organization responsible for the activity, which could differ by Center or size of a project. This handbook is primarily guidance for project planning and control: however, the same principles apply to programs and generally apply to institutional planning and control.

This handbook is for the PP&C community, the heads of which are those who manage the business side of NASA enterprises. This handbook directly targets the audience of PP&C leads,

[1] *GSFC Rules for the Design, Development, Verification, and Operation of Flight Systems (Gold Rules)*

and its applicability includes everyone who has a stake to ensure that the project meets it programmatic and technical requirements. For those involved in managing NASA missions, this handbook describes and provides insight on how to use PP&C data products to support and enhance decision making. This is information that provides managers with a ground truth to measure project progress. Additionally, the handbook provides a source for PP&C best practices and guidance for PP&C practitioners and those in the technical community who need to learn the business side of NASA project management. Successful project management relies on good PP&C as well as good Systems Engineering (SE). The effective integration and synergy of these two disciplines is imperative for project managers and successful projects. The audience includes:

1. **Project Management**: Project management relies upon PP&C to work with the project team to ensure the integration of PP&C functions with the technical requirements and assess the corresponding technical work progress with respect to budget and schedule constraints. This handbook will help them better understand the functions, activities, and products of the PP&C community and its value to the project.

2. **PP&C Leads**: This handbook provides guidance to the PP&C leads and a description of the activities involved in integrating the PP&C content. The integration manager works with the technical community to capture project scope, assess impacts of change, measure progress against plan, and assist the project manager in making informed decisions based on the integration of both technical and programmatic inputs. The PP&C integration manager oversees all of the project's PP&C functions.

3. **PP&C Functional Practitioners**: This handbook will give individual PP&C function practitioners a background to aid their awareness of the ways in which their functions interact with other PP&C functions.

Whether contributing to the information database or using information to weigh decisions, practitioners will find in this handbook valuable insight into how to employ project planning, integration, analysis, assessment, and control tools. This guidance aids practitioners and managers in discovering and assessing issues that need attention, identifying beneficial course corrections, monitoring measures for success and how close or far away it is, and supporting a successful path forward for the mission.

Consistency in the PP&C functions and best practices for providing the most valuable inputs to management will elevate the level of professionalism to the Agency's best practices, raise visibility for the PP&C discipline for aiding decision making, and strengthen the legitimacy of the PP&C community at NASA. Having a structured PP&C approach will also facilitate the emergence of standards across the Agency, making portfolio management and independent assessments easier to perform, characterizing "good PP&C," and enabling evaluation of the quality of implementation of PP&C on projects and areas that could be brought to a higher standard.

A project's performance is judged to be successful only when cost and schedule commitments as well as technical requirements are met. PP&C practices support this goal by:

- Identifying PP&C stakeholder expectations;
- Developing and managing PP&C approaches and goals;
- Using best practices for developing effective estimates and plans;
- Utilizing effective means for estimating, planning, and tracking (e.g., Work Breakdown Structure (WBS) and Joint (cost and schedule) Confidence Level (JCL));
- Developing a realistic schedule, budget, and phasing profile;
- Effectively integrating technical progress, schedule, and costs (e.g., Earned Value Management (EVM), trends);
- Accurately assessing risk and enabling risk management;
- Providing valuable monitoring and assessment of progress against plan;
- Tracking trends and anticipating problems that can be avoided or mitigated; and
- Accurately reporting information to enable sound decision making and corrective actions.

1.3. Scope

This handbook focuses on PP&C at the project level, though the principles also apply to activities in programs.

Figure 1.3-1 places PP&C in the context of project management. As discussed in *NASA Procedural Requirements* (*NPR*) *7120.5, NASA Space Flight Program and Project Management Requirements*, project management is the function of planning, overseeing, and directing the numerous activities required to achieve the requirements, goals, and objectives of the customer and other stakeholders within specified cost, quality, and schedule constraints.

Project management can be thought of as having two major areas of emphasis, both of equal weight and importance: SE and PP&C. There are several competencies that are shared between these two disciplines: together they form a complementary set of capabilities needed to support good project management. While SE and PP&C are major project management areas, this is not to say that all functions of project management fall within these two areas. Figure 1.3-1 is a notional graphic depicting this concept. The figure shows the area where these two cornerstones of project management overlap. These are the activities that both the technical and business teams have in common and are often integrated activities. For example, both communities need to discuss with stakeholders what their expectations are for their activities. The stakeholders for the technical community may be completely different from those for the business community, so both areas need to be covered. Both communities provide inputs for the Project Plan. Likewise, each community is expected to identify risks, and the PP&C community is expected to estimate their cost and schedule impact and assess the programmatic impacts. In these overlapping activities, one or the other of the communities may take the lead based on the project's circumstances.

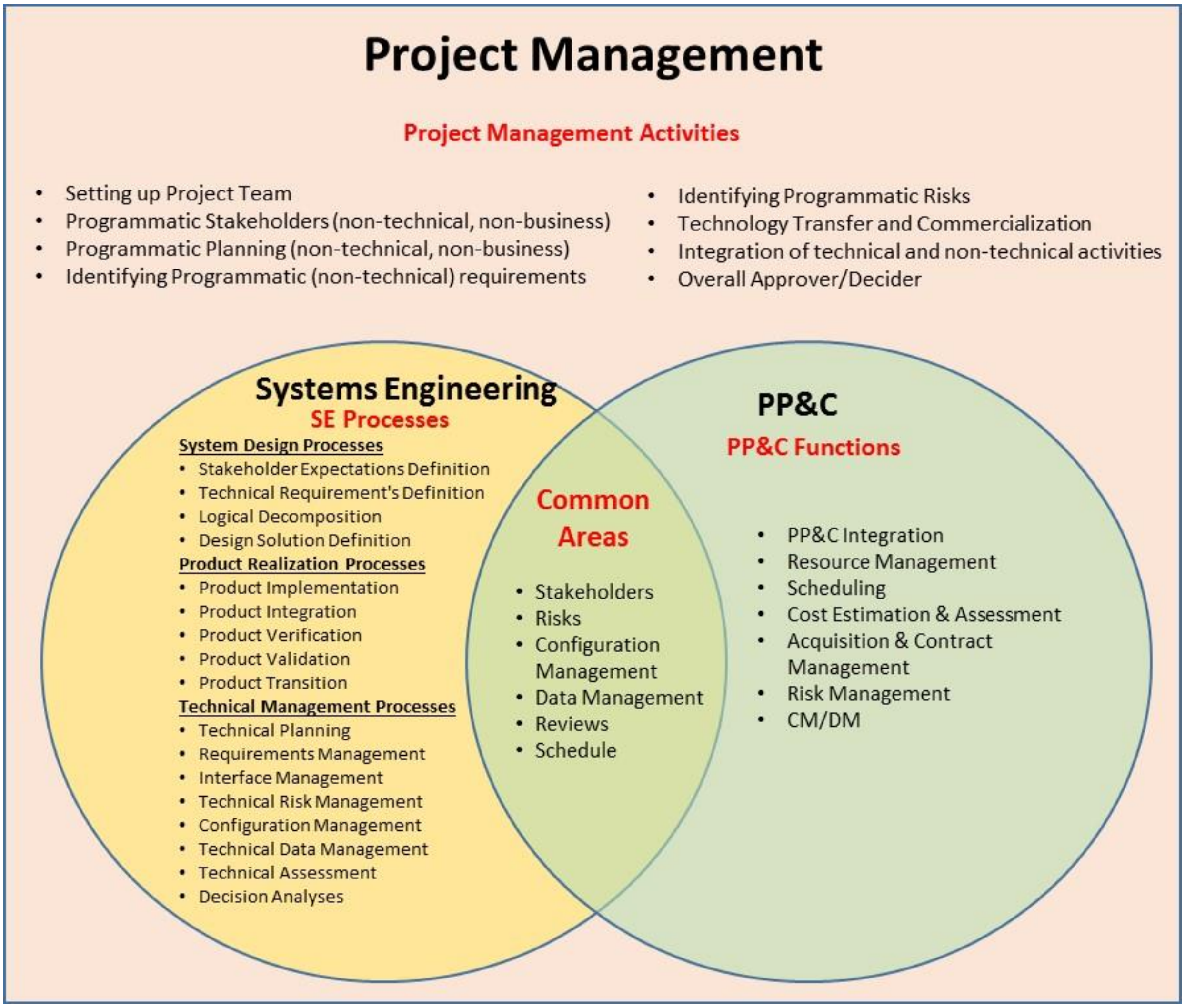


Figure 1.3-1 PP&C Activities in the Context of Project Management and Systems Engineering

1.4. Organization of this Handbook

Chapter 1 provides the background context, purpose, and audience for the handbook.

Chapter 2 describes the fundamental concepts and the basic structures and parameters that define PP&C at NASA. Section 2.1 describes the basic Planning and Control Model. Section 2.2, The Art of Business Management, provides a holistic perspective of the PP&C effort with an emphasis on the highest value that PP&C brings to a project, successfully integrating the business information and functions, assessing the information, and communicating it effectively to the appropriate decision makers. Section 2.3 provides a larger context for the different communities PP&C interacts with and how they function together for project success.

Chapter 3 describes the seven PP&C functions from the larger perspective of PP&C. It focuses on how the seven functions work together to implement the Project Planning and Control Model and to provide an integrated set of information for project management rather than on the specifics of how to perform the individual disciplines. In addition, the focus of these seven functions is on the work to be done, not the organization doing it. So the combination of tasks described under any given function in this handbook might be performed by different organizations in different Centers. Also, some of the functions, such as Risk Management, are performed in cooperation with other disciplines within the project, such as SE and Safety and Mission Assurance (SMA). Disciplines are found in the function that fits most logically with the flow of their products. For example, EVM is found in the Resource Management function. Activities and tasks such as development of the project's acquisition strategy that involve collaboration between multiple PP&C functions and/or external entities are generally addressed in the PP&C Integration function. When available, discipline handbooks are referenced for more details on how to perform specific tasks in the functions. For example, the Risk function section describes how risk interacts with other functions, but references the *NASA Risk Management Handbook (NASA/SP-2011-3422)* for more information on developing and managing a Risk Management System (RMS). From a PP&C perspective, the functions are described in terms of their key activities and tasks during the planning and control phases, significant interfaces, significant drivers, and important practices for successful execution during the planning and control phases.

2. Fundamentals of Project Planning and Control

Managing the business component of a project is a core capability for mission success. Project Planning and Control (PP&C) is a set of inter-related functions that supports developing the plans for executing a project and subsequently assesses and evaluates progress against the plan. The purpose of PP&C is to manage, assess, and improve integrated project cost and schedule performance, considering risk and technical content scope and mission objectives. PP&C works to integrate the expectations of project stakeholders. PP&C is integrally involved during project Formulation when a credible plan is developed that covers three aspects of performance: the technical scope of work (including risk), cost, and schedule. PP&C develops an executable plan in support of the project manager to be reviewed at the end of the Formulation Phase. The executable plan captures the integrated set of technical, cost, schedule, science, resource, and facility requirements of the project in the WBS, schedule, resource baseline, and budget. The Integrated Master Schedule (IMS), Life-Cycle Cost (LCC) estimate, and confidence levels are key elements of the executable plan and also part of the external Agency commitment. If the plan is approved at KDP C to proceed into the Implementation Phase, PP&C provides the framework for executing the plan and meeting its commitments.

PP&C is more than the synergy of disciplines and more than a sum of its parts, which are the individual products of its different disciplines. The value added in PP&C lies in the integration of these individual products, the synthesis, analysis, assessment, and interpretation to support effective project management decisions. PP&C is a multidisciplinary set of interrelated functions where the meaningful integration of data products results in value-added information to the project manager.

2.1. Planning and Control Model

This handbook is organized around a model of PP&C (shown in Figure 2.1-1) that describes planning and control as two separate yet interrelated phases. Planning includes those activities involved in capturing the scope of work of the project into an executable plan and focuses on the approach that the project will take to ensure that the work can be executed. This approach is refined throughout the Formulation Phase of the project. The planning process produces an integrated cost, schedule, technical baseline, and known risk list that form the basis for the Implementation Phase. Upon completion of KDP C (approval to go from Formulation to Implementation), the focus shifts to the control phase. Control reflects those activities related to assessing and analyzing the work and identified risks and managing them to the plan. Although it can be argued that planning and control are iterative throughout the project, it is the premise of this handbook that once the components of the executable plan are baselined, the planning process at the project level is complete. (The process of planning at lower levels may continue into Implementation but does not necessarily affect the baseline.) Updates to the plan are part of the control phase. However, a major change in the plan, such as a change in scope, significant funding issues, or significant technical issues, may require a rebaseline, which moves the project back into planning. Planning is highly iterative during Formulation but essentially non-recurring.

Once the executable plan is established, adjusting the executable plan is a recurring activity in the control phase.

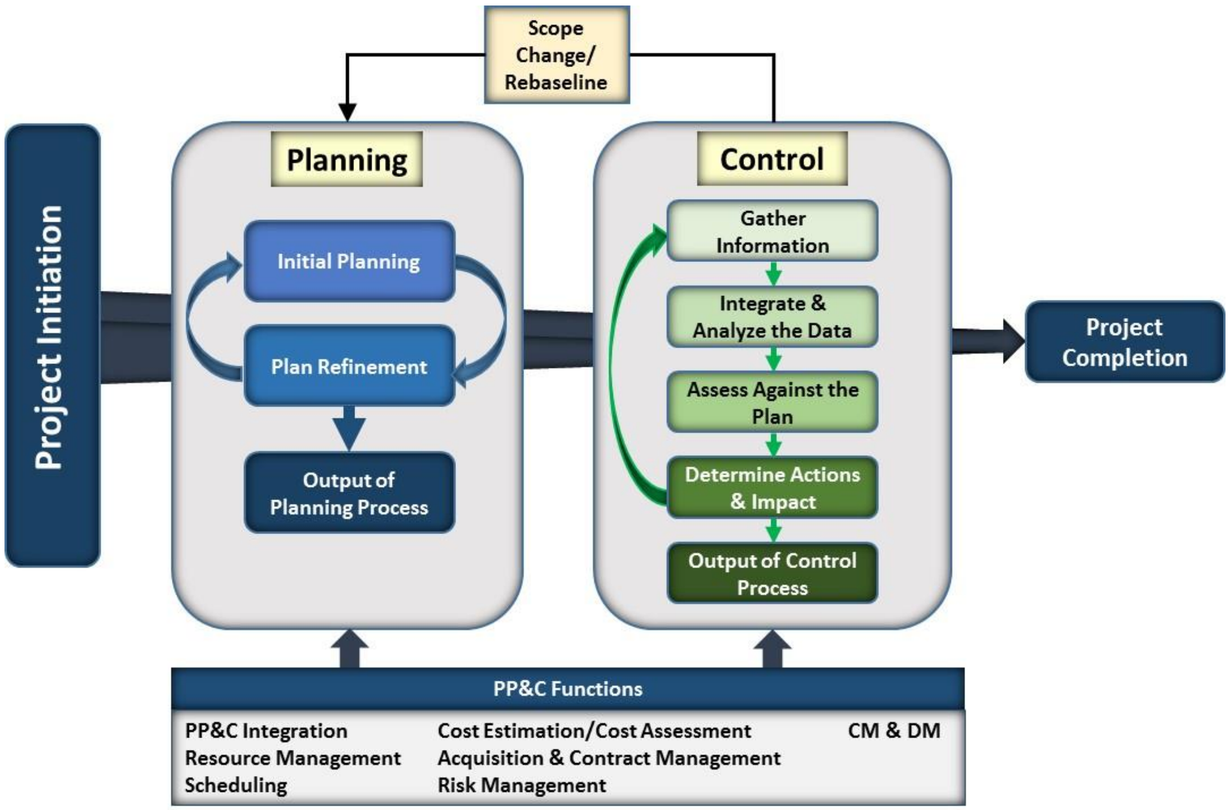


Figure 2.1-1 Project Planning and Control Model

The PP&C practitioner ensures the successful integration, analysis, and assessment among all the business activities. These business activities can be categorized into seven functions as defined by the *2010 Interim Results of the NASA Program Planning and Control (PP&C) Study*. The seven PP&C functions are: Integration, Cost Estimation/Cost Assessment, Resource Management, Scheduling, Acquisition and Contract Management, Risk Management, and Configuration Management/Data Management. Integration is overarching across the other functions.

On an Agency level, any description of PP&C functions must be somewhat generic to encompass all discipline- and Center-specific practices. The functions are described in terms of activities, tasks, and purpose rather than the organization or position responsible for the activity, which might vary considerably by Center or by size and importance of the project. For example, the integration manager may be a separate person or be one of the leads of another function. The resource analyst who performs the activities of the Resource Management function may be the same person who performs the activities of the Scheduling function, especially on smaller projects. Also, activities or tasks in a function or functions can themselves be delegated to other functions. For example, whether Configuration Management (CM) and Data Management (DM) are distributed to other disciplines or maintained centrally, the CM of the master schedule may be delegated to the Scheduling function. Activities or tasks described in one function might be mapped among different functions in different configurations by different Centers. For example, the PP&C Integration function task to develop the Estimate at Completion (EAC) may be performed by the Resource Management function. As such, the discussion will be from the perspective of the activity being done, not from the perspective of the person or organization responsible.

Many support activities, such as ongoing internal assessments, risk management, evaluation and decision analysis, and CM/DM are common to both planning and control and provide a constant and fluid set of activities throughout the project.

Integration occurs at three levels and makes necessary connections across multiple functions:

1. **Project management level**: The PP&C integration manager works with the project manager and other members of the project team to ensure the integration of PP&C functions with the technical requirements and the corresponding technical work progress within budget and schedule constraints. The PP&C integration manager ensures the project manager has the information needed to keep the project on track.

2. **PP&C cross-cutting level**: The PP&C integration manager oversees integration across all of the project's PP&C functions and activities.

3. **PP&C functional level**: Those who manage the different PP&C functions integrate the data and products within their function. Also, individual PP&C functional practitioners are aware of the ways in which their functions interrelate with other PP&C functions and other communities.

2.1.1. Planning Phase

PP&C planning (see Figure 2.1-2) involves capturing the scope of work into an executable plan and giving consideration to the constraints, environment, and risks attendant to the project. An important role for PP&C is the development of realistic and achievable plans that allow for the measurement, monitoring, and evaluation of a project's progress. PP&C practitioners translate the science and technical work into an executable plan including consideration of the acquisition approach, cost, resources, and time phasing. This provides the basis for developing budget requests, the project schedule, and resource needs. When the project team is planning its approach to achieve the mission, the project's technical team contributes the technical approach and technical requirements, and the PP&C team contributes the business perspective, cost, and schedule needed to accomplish the work. All perspectives are essential to the planning process. The realism of the business approach, cost, and schedule is dependent on understanding the interrelationship of both the technical and business aspects of project planning and on communication between the two communities.

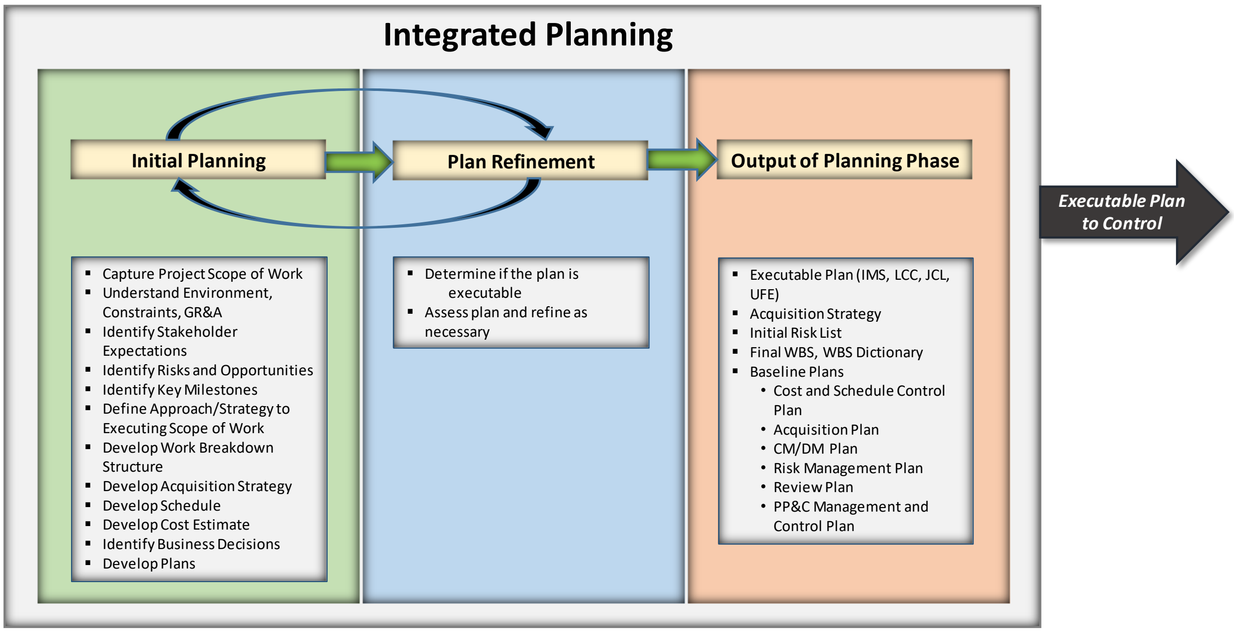


Figure 2.1-2 Planning Phase

While working on the initial planning and refining the plan, the PP&C practitioners in the seven functional areas including the PP&C integration manager are responsible for addressing the following considerations:

- **Environment**: Understand the current (and potentially future) environment that the project is in. Considerations include competition for resources, funding, technical and science objectives, risk posture, etc. Develop working relationships with Agency and other Center representatives and counterparts.

- **Constraints**: Identify the constraints that exist, such as fixed launch date, foreign contributions, key milestones, or a cost cap.

- **Acquisition strategy**: Support the development of the strategy for make/buy decisions and collaboration with other Centers, agencies, and entities. Establish the plan for procuring outside items and determine what items are to be flowed down to potential vendors.

- **Risk**: Identify major risks and opportunities that affect PP&C. Determine the likelihood and magnitude of their occurrence. Develop a strategy for managing Unallocated Future Expenses (UFE) (the portion of estimated cost required to meet specified confidence level that cannot yet be allocated to specific project subelements) for unknown risks as a consequence of the risk posture.

- **Requirements**: Understand and capture the technical and science requirements, cost, and facility needs of the project in the Work Breakdown Structure (WBS), schedule, resource baseline, and budget.

    - **WBS:** Develop a WBS (a hierarchical resource structure dividing work required to produce the project's end products) and associated WBS Dictionary. (See Appendix B: Glossary.) Part of this responsibility is to determine the number and complexity of the control accounts, work/planning packages, and charging structure.

    - **Key milestones:** Identify key PP&C products for activities such as Mission/System Definition Review (MDR/SDR), Preliminary Design Review (PDR), Critical Design Review (CDR), System Integration Review (SIR), and launch and other key deliverables and objectives.

    - **Schedule:** Develop the IMS.

    - **Cost estimate:** Determine cost methodology for developing the cost estimate (analogy, parametric estimate, probabilistic estimate, grass roots, models, etc.) and produce the cost estimate.

    - **JCL:** Develop the integrated cost and schedule risk-informed probabilistic analysis and target cost and schedule based on a Joint Confidence Level (JCL) if required by NPR 7120.5.

- **Business decisions:** Identify how the project will be controlled; how to interface with project personnel and the project organization as well as supplier personnel; what reports to generate when; how to implement the lien process; what process will be used to manage and incorporate changes into the baseline or EAC; etc.

- **Control plans (required by 7120.5):** Complete or support the PP&C part of the preparation of control plans such as:
    - Cost Control Plan (included in Project Plan)
    - Schedule Control Plan (included in Project Plan)
    - Acquisition Plan
    - Configuration and Data Management Plan
    - Risk Management Plan
    - Review Plan, and associated Life-Cycle Review (LCR) Terms of Reference (ToR)

- **Work plans**: Make plans for work to be accomplished in the next life-cycle phases; complete the preparation of work plans:
    - Formulation Agreement (FA) for work to be accomplished during Phases A and B;
    - Plans for work to be accomplished during the next Implementation life-cycle phase (for Phases C, D, E and F); and
- **Support plans**: Complete the preparation of recommended plans, as appropriate, such as the project PP&C Management and Control Plan, a recommended best practice in Section 3.2.

During pre-Phase A, the cost and schedule plans for work to be performed in Phases A and B are being developed. In Phase A and Phase B, performance against these plans is monitored, controlled, and updated as needed. In addition, during Phases A and B, the LCC and IMS are iteratively developed. As the planning process matures, more information becomes available and more detailed schedules and cost estimates are produced. Refinements to the plan occur throughout the planning process and the PP&C team integrates all the various business functions, activities, products, and decisions in support of producing the executable plan. The LCC and IMS are finalized and baselined at the end of Formulation. Performance to/against these baselines is monitored during the Implementation Phase. The completion of the planning process results in the output of key deliverables:

- LCC and IMS baselines: final schedule, budget, UFE, and cost estimate. This serves as the basis against which the plan is controlled and assessed.
- Defined risk list.
- Final WBS and WBS Dictionary: captures the final technical content and scope.
- Baseline plans.

2.1.2. Control Phase

Whereas planning reflects the approach to executing the scope, control reflects those activities related to assessing and managing the performance against the plan.

During project execution, PP&C is responsible for facilitating the achievement of schedule and cost goals and managing risks and resources by monitoring cost and schedule performance and trends and identifying events that may impact performance; identifying issues on a real-time basis; and providing actionable recommendations to decision makers. PP&C also manages project risk across all contributing disciplines by integrating controls that measure and influence risk. In essence, PP&C assimilates all relevant data to arrive at a comprehensive assessment of project health.

Effective PP&C practitioners anticipate the questions that a project manager will have or will have to answer and provide the information the project manager will need. The communication needed to anticipate and resolve potential issues comes from being aware of internal and external situations that might impact the project, being inquisitive, and constantly asking questions in one's functional discipline, across the other PP&C functions, and in other communities that affect the project activities. By continually assessing what is going on and looking ahead, PP&C practitioners can recommend actions to keep the project on track and support project success.

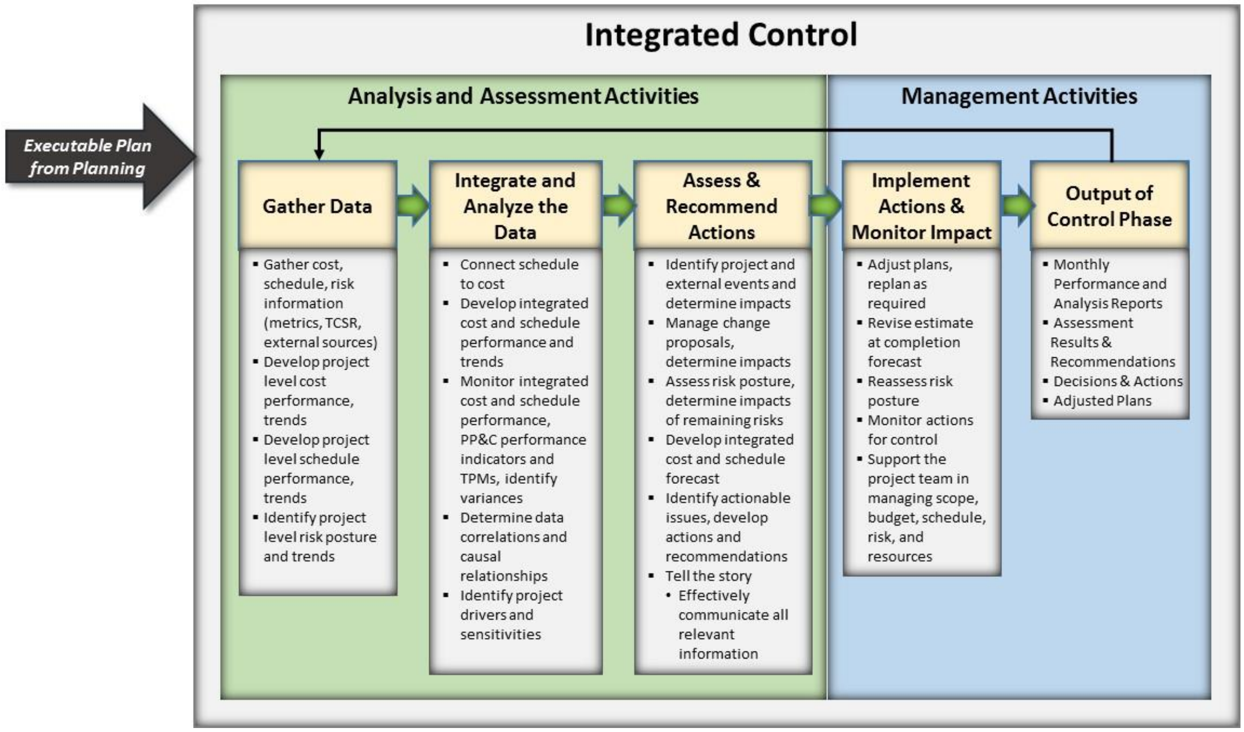


Figure 2.1-3 Control Phase

During the control process, the PP&C team is responsible for the following activities:

- **Gathering PP&C data** includes:
    - Having proactive conversations with necessary communities;
    - Engaging in informational meetings to solicit necessary data;
    - Participating in meetings where PP&C input is needed or implications to PP&C products and activities needs to be understood;
    - Receiving and compiling information from both internal and external sources;
    - Generating monthly reports; and
    - Providing the status of the technical, cost, schedule, and risk posture of the project.

- **Integrating and analyzing PP&C data** involves five primary activities:
    - Determining if there is a correlation between the data;
    - If there is a correlation, determining if there is a causal relationship;
    - Identifying performance and trends;
    - Connecting schedule performance to cost; and
    - Identifying project drivers and sensitivities.

- **Assessing the result,** which answers the question, “So what?” That is, the assessment explains what the data and analysis are telling the project about its status to date and where it is headed as well as options for course correction. (See "analysis" versus "assessment" in the box on the following pages.) Assessing the results involves five primary steps and underscores the value added to the project and leadership role of the PP&C team:
    1. The PP&C team needs to ask questions and engage in meaningful discussions with other members of the project team to get to the basis for what the PP&C data mean.
    2. The PP&C team assesses risk and determines the impact of the remaining risk on the PP&C products and activities.
    3. Based on the assessment, the PP&C team forecasts the project EAC using estimated cost and schedule and EVM data when available.
    4. Perhaps the most critical PP&C activity is telling the story. This involves effectively communicating relevant information and impacts, for example, increase or decrease to risk posture.
    5. The PP&C team provides project management with recommendations and options to adjust the approach to the executable plan. This relates to understanding variances and the need to provide corrective action or solutions.

As with the planning process, the control process also has a defined set of results and outputs:

- Monthly set of business reports such as Integrated Program Management Report (IPMR), NASA Form (NF) 533 contractor financial management report, cost and schedule status, workforce data, UFE utilization, review packages, EAC, etc.;
- Conversations with the rest of the project team on the results of the assessment;
- Summarized decisions and actions; and
- Input into next control period.

2.2. Art of Business Management

2.2.1. Role of Project PP&C Integration Manager

PP&C has its equivalent of the project manager or project chief engineer. Managing the business of a project is a core capability for enabling its successful development/design and implementation. The primary responsibility of the project PP&C integration manager is to establish and lead a PP&C team and integrate all the various business functions to support successful project execution throughout its life cycle. The PP&C integration manager also contributes to developing an approach and goals as they relate to PP&C activities including tailoring the PP&C requirements of *NPR 7120.5, NASA Space Flight Program and Project Management Requirements*, *NPR 7120.7, NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements*, and *NPR 7120.8, NASA Research and Technology Program and Project Management Requirements* as appropriate for the project. (See Appendix C: Scaling for guidance on tailoring requirements.) The person who performs this role at NASA may be called the business manager (JPL), project controls manager, Deputy Project Manager/Resources (DPMR) (GSFC), PP&C director (Johnson Space Center (JSC)), project control analyst (small project), deputy for PP&C, or other designation. For the purpose of this document, the manager of that function is referred to as the PP&C integration manager.

PP&C activity is dictated by the need for project control. To proactively aid the project manager in managing project resources and anticipating potential issues, the PP&C integration manager needs to understand the current environment in which the project is operating. As such the PP&C integration manager needs to understand both internal and external activities surrounding the project that might impact it. Externally, this includes balancing the sometimes conflicting fiduciary demands of stakeholders, for example, the White House, NASA, Congress, the Office of Management and Budget (OMB), supplier organizations, or other programs or projects. For example, impacts may arise during the Federal budget process relating to funding, workforce, project schedule shifts, contractor issues, and other priorities. Or, for example, a project may be oriented to meet science goals set in a National Academy of Sciences (NAS) *Decadal Survey* and strongly championed by specific science communities, but an operational priority for a larger NASA mission might shift resources away from a science investment and into a technology investment. Project managers might want to be parochial in their interests, but a better investment might use an existing software resource. On a larger scale, the Nation's priorities may shift the vision for the Agency, and missions may need to be adjusted accordingly. PP&C integration managers need to be fully aware of these and other events and risks. Due to the scope of this role, the PP&C integration manager is one of the early members of the project management team.

For the PP&C integration manager, projects operate within a framework programmatically bounded by the Management Agreement (MA), which defines the cost and schedule and other parameters and authorities over which the project manager has management control and fiduciary responsibility for executing the work. The MA sets the boundary conditions against which the progress of the project can be assessed. The MA is an agreement between the project, program, Mission Directorate, and Agency established at key decision points between phases in the project life cycle. In addition, the project is bounded by consideration of such things as labor laws, disclosure protocols, cost accounting standards, small business programs, and procurement regulations.

2.2.2. Primary Activities

The PP&C integration manager ensures the business activities needed to support a project are being properly performed. The PP&C team, as part of the project management team, manages a project's business function and supports the project in three fundamental ways.

First, the team ensures that all the basic business functions, policies, and activities are properly set up and implemented on the project. Some tasks such as allocating and setting up Information Technology (IT) systems and resources, export control, facility management and technology protection are included as part of PP&C at some Centers. However, these tasks are not included in the scope of this handbook. (Activities and tasks such as development of the project's acquisition strategy that involve collaboration between multiple PP&C functions and/or external entities are generally addressed in the PP&C Integration function.) As the technical concept is developed, the team defines the monthly business rhythm, develops the WBS and WBS Dictionary, establishes reporting requirements for contractors, establishes and subsequently maintains the project schedule and budget information, develops cost estimates, establishes control accounts and work packages, opens and closes work orders, establishes the workforce and funding infrastructure, tracks cost and schedule metrics, assesses project performance, runs reports, and monitors contractor performance. The PP&C team integrates business activities that encompass planning; scheduling; estimating; budgeting; performance assessment; data management; resource management (funds, obligations, workforce, EVM, etc.); contract management; forecasting; and risk management.

Secondly, the PP&C integration manager and team integrate PP&C data, which includes evaluating, analyzing, and assessing the technical, cost, and schedule data into a cohesive set of information. This is a critical aspect of the PP&C integration manager's role and provides the highest value to the project. To provide this value, the PP&C integration manager must understand what to look for during each phase of the project. (To better understand what questions to ask during planning and control phases, see Section 3.2 (blue boxes) and Appendix D: Sample Questions to Ask by Life-Cycle Phase.) Consequently, the PP&C integration manager and team develop a set of metrics that will help determine the significance of trends or risks. These metrics include areas relative to workforce, funds, schedules, cost, UFE, performance, contractor activities, and estimates, and provide measures for performing analysis and assessment to aid forecasting.

Analysis versus Assessment

In this handbook, "analysis" and "assessment" are used to describe two different activities.

"Analysis" involves determining the facts and the relationship between the facts. It includes understanding and evaluating trends, determining what is driving any variances, and forecasting the potential cost and schedule impacts of activities.

"Assessment," on the other hand, provides insight on what the information means and includes developing options for corrective actions based on the information. The final element of assessment is communicating this story to the decision makers so they can take the appropriate action.

For example, a trend analysis may reveal that the project continues to be behind schedule and over budget. This might indicate a "red" condition, a risk designation of danger for the project and a potential issue that needs attention. However, an assessment may indicate that the project has already taken action to mitigate this problem, or a deliverable that is driving the condition is expected in the next period and the problem will be resolved.

As such, the analysis correctly reflects a problem but the assessment indicates that it is not a concern. On the other hand, an analysis of the data could suggest that the project is under budget and ahead of schedule with no need to be concerned. However, an assessment of events might reveal a risk the project could lose funding or lose key resources needed in the future to another project. Action to mitigate this risk might be needed.

Thirdly, PP&C integration managers need to be aware of external events that can impact their project. External activities include activities external to the project but internal to NASA and activities outside of NASA. The project PP&C integration manager is most effective at anticipating issues when aware of events outside NASA that might influence the program and project. Such events might include disruptions to key suppliers in the industrial base or what is happening with funding in the Federal budget process. In addition, NASA or program priorities could change project funding profiles and schedules. These changes might impact project funding, workforce, schedule, contractor issues, and project priorities. For example, there may be issues surrounding one project that may require modifying other projects' funding profiles to support higher priorities. Similarly, schedule impacts on one project may impact work force needs on other projects. Events at contractor facilities (such as an increase or decrease in the number of projects) could impact project performance. Understanding these factors is essential to developing strategies for dealing with outside events, decreasing project risk, and ultimately shepherding the project to a successful mission.

2.2.3. Attributes

PP&C integration managers are key advisors to the project manager. They provide a level of expertise that enables them to offer advice and insight to decision makers based on their acumen in managing and controlling the business aspects of the project. The PP&C integration manager ensures that the PP&C team is looking at the right things, asking the right questions, engaging in the right conversation at the right time, and then communicating to stakeholders. To build credibility, the PP&C integration manager needs to possess the following mixture of demonstrated attributes to support the project manager throughout the project life cycle.

- **Leader**: Provides a clear vision for how the PP&C team will conduct project business. Focuses on meeting project objectives. Develops strategies for dealing with internal and external events to maximize project success.

- **Manager**: Needs to be able to direct and manage resources and processes to accomplish the responsibilities of the various business functions (controls, estimating, scheduling, resources, acquisition, etc.).

- **Advisor**: Serves as a sounding board for the project manager and provides good assessments and advice on cost and schedule issues.

- **Integrator**: Is able to integrate, assess, and summarize the appropriate business information and processes to facilitate project success.

- **Communicator**: Is able to effectively tell the project story and communicate it concisely to enable informed decision making.

- **Doer**: Possesses hands-on skills and the necessary business competency to understand and perform the required business policies and processes.

- **Credible**: Above all, consistently provides credible business guidance, insight, assessments, and information to the project manager.

As indicated above, the highest value that the PP&C integration manager brings to the project is the ability to successfully integrate the business information and processes, assess the information, and communicate it effectively to the project manager or other decision makers if requested. The PP&C integration manager helps PP&C team members understand disciplines outside their own and expects issues to be identified before they become problems. Effective PP&C integration managers have the ability to integrate different functions' data synergistically to create value-added information for project success.

2.3. PP&C in Context

PP&C is integral to keeping a project on track, but does not operate in isolation. Bringing a project from concept through execution requires the best efforts of four communities coordinated with the Planning, Programming, Budgeting, and Execution (PPBE) process. As pictured in Figure 2.3-1, project management, PP&C, SE, and PPBE are driven by different necessities and different cycles but work in alignment for the project's progress on an executable path. Scoping out and planning a project entails fitting together many pieces of a complex puzzle. The project manager manages resources and risks with information from the other communities. The SE community works to determine what is achievable. How much the technical options will cost in time and money comes from the PP&C community. These pieces are brought together into a trade space constrained by the PPBE process.

Each community contributes a valuable component to the development of the Project Plan, the executable plan, and the budget profile of a project. Each interfaces with the other communities and exchanges information and provides the right products at the right time for each community to do their work in their cycle. PP&C practitioners need to understand what is occurring in all communities to perform their functions.

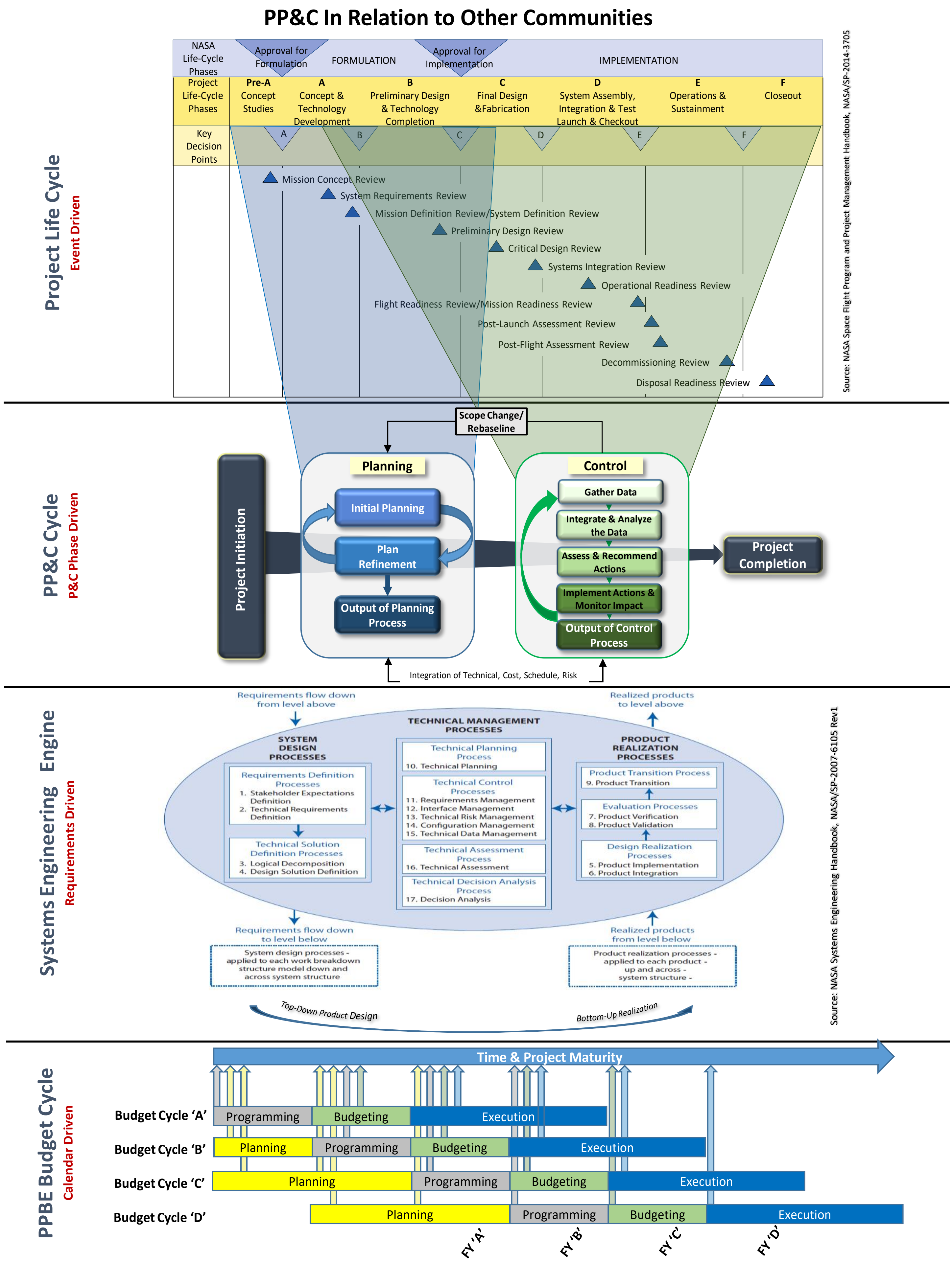


Figure 2.3-1 PP&C in Context

2.3.1. Project Life Cycle

The project management team is responsible for executing the plan for the project. The different perspectives and roles of the different communities all contribute to a Project Plan that is "just right." The project management team drives the project forward to meet a defined end state, which might be a launch, and orbital placement, or a technology readiness level, for instance, in accordance with the specified schedule. Safety may make requests that will add cost. The technical team may push the envelope to achieve the highest performance as they work the technical requirements. PP&C will raise any issues that threaten performance within plan. PPBE will provide the budget profile.

The backbone of project management is the project life cycle. In Figure 2.3-1, a simplified version of the space flight project life cycle with the major project execution phases and reviews is pictured at the top.

The project progresses through the life cycle beginning with the development of the concept, mission, and technology. The initial development of the project concept and approach occurs during Formulation. Once a project receives approval for a specific approach, it moves into Implementation. NASA segments a project's life cycle into phases of maturation towards completion. NASA policies, such as NPR 7120.5, establish expectations for the work to be accomplished by both the technical and PP&C teams during each life-cycle phase, as well as expectations for the maturity of technical and PP&C products at the end of each life-cycle phase. More detail on the project life cycle can be found in the *NASA Space Flight Program and Project Management Handbook (NASA/SP-2014-3705)*. The expected maturity states of space flight project products, or control plans, are elucidated in Appendix I of NPR 7120.5.

Each project life-cycle phase concludes with a gate review, the LCR preceding a KDP, which determines if a project is ready to proceed to the next life-cycle phase. A particularly important gate for a project is the transition from Formulation to Implementation at KDP C. That is when the project and the Agency make an external commitment in the form of the Agency Baseline Commitment (ABC) to a particular cost and schedule for the project. Details on PP&C roles and responsibilities for supporting LCRs can be found in Section 3.2 in this handbook.

The LCR 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.
- The LCR that immediately precedes a KDP provides 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.

In preparation for LCRs, the project team works together to ensure that the technical requirements and designs and the PP&C cost and schedule estimates are consistent and aligned. At the LCR, the project's technical progress and PP&C products are reviewed against alignment with and contribution to the Agency strategic goals and a set of assessment criteria, which may include the adequacy of the following:

- Requirements that flow down from the Agency strategic goals,
- Management approach,
- Technical approach,
- The integrated cost and schedule estimate and funding strategy,
- Availability of resources other than budget, and
- Risk management approach and risk identification and mitigation.

At a KDP, the Decision Authority determines whether and how the project progresses in its life cycle; authorizes and documents the key project cost, schedule, and content parameters that govern the remaining life-cycle activities; and approves any additional actions.

2.3.2. PP&C Cycle

The PP&C community responds to the events of the other communities, providing the data products needed to input into the budget cycle, supplying the information needed to support the LCRs of the project management community, and estimating time and materials as the technical team meets its milestones in developing technical designs and technologies and refines its requirements. In this sense, the community is event-driven, as labeled in Figure 2.3-1.

Figure 2.3-1 maps the planning and control phases of the PP&C model into the project life cycle. In the PP&C Model, the planning phase corresponds roughly to the Formulation Phase of the project life cycle, and the control phase corresponds to the Implementation Phase of the project life cycle. However, during Formulation (life-cycle phases A and B), PP&C monitors and controls cost and schedule performance against the planned Formulation cost and schedule, primarily based on the FA.[2] So the Formulation Phase also contains an element of control. In addition, some planning may continue into the Implementation Phase: an Integrated Baseline Review (IBR) may result in adjustment to plans. So some planning activities may occur in Implementation and some control activities may occur in Formulation, thus, the overlap in Figure 2.3-1 of the cones mapping planning and control from the PP&C model into the project life cycle.

The work of the technical team and the PP&C team during Formulation enables the project to develop accurate cost and schedule range estimates and associated confidence levels at the end of Phase A. The project Formulation Phase and the major part of the PP&C planning phase end at

---

[2] The FA prioritizes the resources to be applied in Phase A and Phase B to buy down risk and uncertainty. (For more information on the FA, see the *NASA Space Flight Program and Project Management Handbook*.)

the end of Phase B. Based on a successful high-fidelity LCC estimate, baselined IMS, and associated JCL (if required), the project is approved to proceed to Implementation and the Agency commits to the ABC established at KDP C. The LCC estimate and baseline IMS are essential elements of the ABC and the executable plan for the PP&C control phase of the project.

Once the project moves into the Implementation Phase and the PP&C team moves into the control phase, the PP&C activities and products develop a monthly business rhythm. The PP&C team assesses such things as performance, trends, risk impacts over time, plan adjustments, workforce level, margin burndown, and contract status, identifying variances and recommending actions necessary to maintain project performance within plans. Growth in cost or schedule that exceeds the ABC after KDP C may trigger external reporting requirements. Development cost growth exceeding 30 percent is considered a breach of the ABC and triggers a rebaseline. For projects with a LCC estimate greater than $250 million, congressional reauthorization is required for the project to continue after breaching its Agency commitment. PP&C will leave the control phase and go back into the planning phase if a rebaseline is authorized. (For more information on replanning and rebaselining, see the *NASA Space Flight Program and Project Management Handbook*.)

2.3.3. Systems Engineering Engine

The PP&C team works interdependently with the technical team throughout the life cycle, requiring an understanding of the interrelationship between technical requirements and business needs. The project's engineering team addresses the technical requirements and PP&C team addresses the business needs. Particularly during the project planning process, communication and interaction between the PP&C and the technical communities are vital to developing a comprehensive, achievable Project Plan. The SE engine, the third element in Figure 2.3-1, shows the 17 technical processes performed by the technical community. The left chamber of the engine depicts the processes that are used during the design phases. The right chamber shows the processes used during the realization of the product. The center chamber of the engine represents the technical management processes that are performed throughout the life cycle. This engine is applied recursively, on the left side, through the product hierarchy designing downward into finer and finer detail as subsystems, assemblies, and components are designed. The right side of the engine is applied recursively upward through the product hierarchy gradually assembling, verifying, and validating the pieces as they are assembled together. Since these processes are applied over and over again to refine a system, they recur throughout the project life cycle in both the PP&C planning and control phases. The engine is driven by the need to define, refine, and implement the technical requirements. In that sense, the technical requirements drive this community forward.

2.3.4. PPBE Budget Cycle

NASA develops its budget as part of the PPBE process, the fourth element in Figure 2.3-1. The PPBE process drives everything through the budget cycle. In planning, PPBE practitioners are working ahead on the budget horizon to ensure programs are funded within the Agency portfolio. PPBE requires an enhanced level of analysis during budget formulation to ensure that resources are appropriate and in alignment with Agency strategic goals and objectives (as outlined in the *NASA Strategic Plan*). Even before those funds are allocated, the PPBE community works to establish funding requirements for the next year through the budget cycle. So at any given moment, the PPBE process is simultaneously working on different phases of multiple consecutive fiscal years of budget planning. The PPBE team is continually working to the events of the annual budget cycle and is, therefore, driven by the calendar for the fiscal year budget cycle. (For more information, refer to *NPR 9420.1*, *Budget Formulation* and *NPR 9470.1*, *Budget Execution*. Also, the PPBE process is detailed in Section 5.8.3 and the budget cycle and linkages with project management are detailed in Section 5.8.4 of the *NASA Space Flight Program and Project Management Handbook*.) The PP&C community provides project specifications for procurements, workforce, travel, IT products and services, facilities, and other resources for the budget planning.

Formulating the budget occurs annually beginning at the end of the planning phase with the release of the *Strategic Programming Guidance (SPG)* and ending with Congressional approval of the budget level funded for the Agency through the enactment of an appropriation. (Since execution is an annual discrete event, there is only one blue execution line after each PPBE cycle line of yellow, gray, and green for each year in Figure 2.3-1.) NASA Headquarters (HQ) Office of the Chief Financial Officer (OCFO) Strategic Investments Division (SID) facilitates the Planning and Programming phases of PPBE while the NASA HQ OCFO Budget Division (BD) manages the Budgeting and Execution phases.

2.3.5. Interactions during the PP&C Planning Phase

The planning phase of a project is dynamic for the entire project team. The technical team is focused on developing, decomposing, evolving, and maturing the technical requirements and science objectives, the basic mission concept and mission timeframe, the technical architecture, the preliminary designs, and the technical plans and approaches needed to accomplish the work. The community identifies key technical milestones and high-level resource and infrastructure requirements. The PP&C team is focused on capturing the scope of work in the WBS, cost estimate, schedule estimate, and risk list; defining the business approach and strategy for executing the scope of work; and producing an achievable, executable plan. Their work is dependent on the technical approach as it evolves, and the technical approach is informed by resource constraints. PP&C tracks the implications of any changes that might bring the project out of alignment with its programmatic constraints. Sometimes, options that appear reasonable from a technical perspective can be unworkable in terms of resources or schedule. These options need to be discussed with stakeholders so an achievable set of requirements, architecture, and designs are defined. The WBS, cost estimate, schedule estimate, acquisition strategy, and executable plan evolve and mature throughout the planning phase.

Products developed by the technical team inform and impact products developed by the PP&C team, and vice versa. As the technical requirements, architecture, and designs evolve and mature, the WBS, cost estimate, schedule estimate, and risk list are updated, and the executable plan is refined. As the products mature, the level of fidelity and detail in these products increases. Products developed by the PP&C team inform and influence products developed by the technical team. For example, monthly reports on performance measures may indicate that a course correction is needed in the technical approach to remain within cost and schedule commitments or estimates. These monthly reports may indicate an inability to successfully implement proposed technical architectures and designs within the project's cost constraints.

Products developed by one PP&C function inform and impact products developed by other PP&C functions. Updates to the schedule estimate will require updates to the cost estimate. To ensure alignment with the acquisition strategy, the cost estimate, schedule estimate, and risk list may need to be updated. At key points, typically the project LCRs, the technical and PP&C products are assessed and aligned, requiring refinement and update of products and plans on both sides. It is important that PP&C management participates with technical management to control cost and schedule. As changes are identified, either as an internal proposal from the technical team or as a change request from a stakeholder, the PP&C integration manager needs to warn against unacceptable changes in cost and schedule. In conjunction with the project team, the end result of the planning phase includes the ABC, an integrated and baselined set of project requirements, technical designs and plans, cost and schedule, and an executable plan for implementing the project.

2.3.6. Interactions during the PP&C Control Phase

The control phase reflects the monthly PP&C activities to implement and maintain the project's executable plan. During the PP&C control phase (Implementation Phase for the project life cycle), PP&C monitors and controls cost and schedule performance against the executable plan and assesses variance impacts against the LCC estimate and baselined IMS. The approaches and methodologies for estimating, assessing, monitoring, and controlling cost, schedule, and risk are discussed within their respective functions in Chapter 3 in this handbook. The actual PP&C approaches and methodologies are determined by the PP&C integration manager and project team based on the size and complexity of the project.

During project Implementation and the PP&C control phase, the technical team is focused on final design, assembly, integration, test, and launch activities. The PP&C team is focused on cost and schedule performance and tracking, reporting, revising, analyzing, and assessing data and information from within and outside of the project with the objective of providing decision makers with credible, timely, integrated cost and schedule information and recommendations for maintaining project performance within plan.

Problems and challenges present themselves on a regular basis during the project life cycle. Risks are realized. Schedules are delayed. Changes need to be made to technical designs and plans. Perturbations outside of the project's control occur to resources, including funding and workforce. Even small changes and adjustments to technical designs and plans can have large impacts to cost, schedule, and risk. Similarly, changes to resources can have significant impact on technical plans.

The major focus of PP&C activities is to vigilantly monitor and address the project's cost and schedule performance. As long as project adjustments are within the Agency's commitments, they are considered replanning and expected. An example of this type of change is reallocation or distribution of UFE to a WBS account. Any potential for project cost and schedule performance to breach the ABC must be identified as soon as possible so the project, Center, Mission Directorate, and Agency can develop and implement corrective actions to avoid breaking the Agency commitment. (For more information on replanning and rebaselining, see the *NASA Space Flight Program and Project Management Handbook*.) For these activities to be effective, coordinated and timely communication between the different communities of practice is imperative.

3. Functions

3.1. Introduction to the PP&C Functions

3.1.1. PP&C Functions and the Project Planning and Control Model

The PP&C discipline can be described as seven interrelated PP&C functions. These are: PP&C Integration, Resource Management, Scheduling, Cost Estimation/Cost Assessment, Acquisition and Contract Management, Risk Management, and Configuration and Data Management. These functions are the foundation of the Project Planning and Control Model. Their logically linked activities and integrated products comprise the planning and control phases of the model.

The PP&C functions are all part of the project and must interact with each other effectively to support the project manager in developing an integrated, project-level executable plan during the planning phase, and in evaluating and controlling the entire project during the control phase. Additionally, some of the functions such as Risk Management are performed in cooperation with other disciplines within the project such as Systems Engineering (SE) and Safety and Mission Assurance (SMA). The PP&C Integration function is overarching across the other six PP&C functions and facilitates and leads the interactions between the PP&C functions, managing the flow of integrated cost, schedule, and risk information throughout the project and providing guidance, decisions, and adjustments to plans and products developed by the functions. The PP&C integration manager leads the PP&C Integration function and is a member of the project management team supporting the project manager.

As explained in the Preface, this handbook focuses on the activities performed by the PP&C functions, not on the organizations or titles of the persons doing the work. For example, the resource analyst may be the same person doing the schedule or any of the other PP&C functions, especially on smaller projects. Different Centers and projects may assign the activities of the PP&C functions differently between offices within the project. As such, PP&C functions are not equated to organizations, offices, or persons. The discussion is from the perspective of the work being done, not the organization or person responsible for that work.

Table 3.1-1 depicts how each PP&C function supports the Project Planning and Control Model by identifying each function's activities during the planning and control phases. The activities for each function are described in detail in that function's respective section (see Sections 3.2 through 3.8). For example, the Planning Phase and Control Phase activities for the PP&C Integration function are described in Section 3.2 (PP&C Integration Function).

Table 3.1-1 Planning and Control Phase Activities of the PP&C Functions

PP&C Function	Planning Phase Activities	Control Phase Activities
PP&C Integration	• Capture project scope of work • Define approach/strategy to executing scope of work (includes acquisition strategy)	• Gather data • Integrate and analyze data • Assess and recommend actions

PP&C Function	Planning Phase Activities	Control Phase Activities
	• Provide guidance, decisions, adjustments • Refine plan	• Implement actions and monitor impacts • Support reviews, audits, and external reporting
Resource Management	• Develop plans for resource management • Develop project cost budget based on available obligation authority • Implement EVM system	• Formulate/reaffirm and execute annual obligation authority • Develop integrated project status (actuals) • Implement EVM (as applicable)
Scheduling	• Develop a strategy for schedule estimation and assessment • Develop schedule • Assess and analyze schedule integrity • Validate schedule consistency with cost and labor plans (if not Resource-Loaded Schedule (RLS)) • Baseline schedule estimate • Provide analysis schedule	• Update schedule baseline as required • Assess and analyze schedule performance • Review status with management • Issue schedule reports & archive schedule data
Cost Estimation/ Cost Assessment	• Prepare cost analysis strategy • Execute cost assessment tasks • Execute cost estimating and supplementary analytical tasks • Conduct a Joint Confidence Level (JCL) analysis • Present analyses to stakeholders	• Develop cost impact estimates • Update the estimate as required
Acquisition and Contract Management	• Develop Acquisition Plan • Support establishment of contracts	• Manage contracts
Risk Management	• Execute an initial Risk Informed Decision Making (RIDM) iteration as a part of project Formulation • Develop a Risk Management Plan (RMP) that includes definition of a Continuous Risk Management (CRM) process	• Implement CRM • Execute other RIDM iterations as necessary throughout the project life cycle

PP&C Function	Planning Phase Activities	Control Phase Activities
Configuration and Data Management	• Develop CM/DM Plans • Identify items to be under configuration control • Identify items to be under data management	• Conduct change management • Collect and store data • Provide data to authorized parties • Conduct configuration audits • Capture work products

3.1.2. How to Navigate this Chapter

Sections 3.2 through 3.8 provide detailed descriptions of each PP&C function. The sections are written from the perspective of the project's PP&C practitioners involved in the work. (For example, Section 3.7 emphasizes PP&C's responsibility for ensuring that cost, budgetary, schedule, and other non-technical domains are accurately represented during the initial Risk-Informed Decision Making (RIDM) cycle.)

Each function section is organized in three parts.

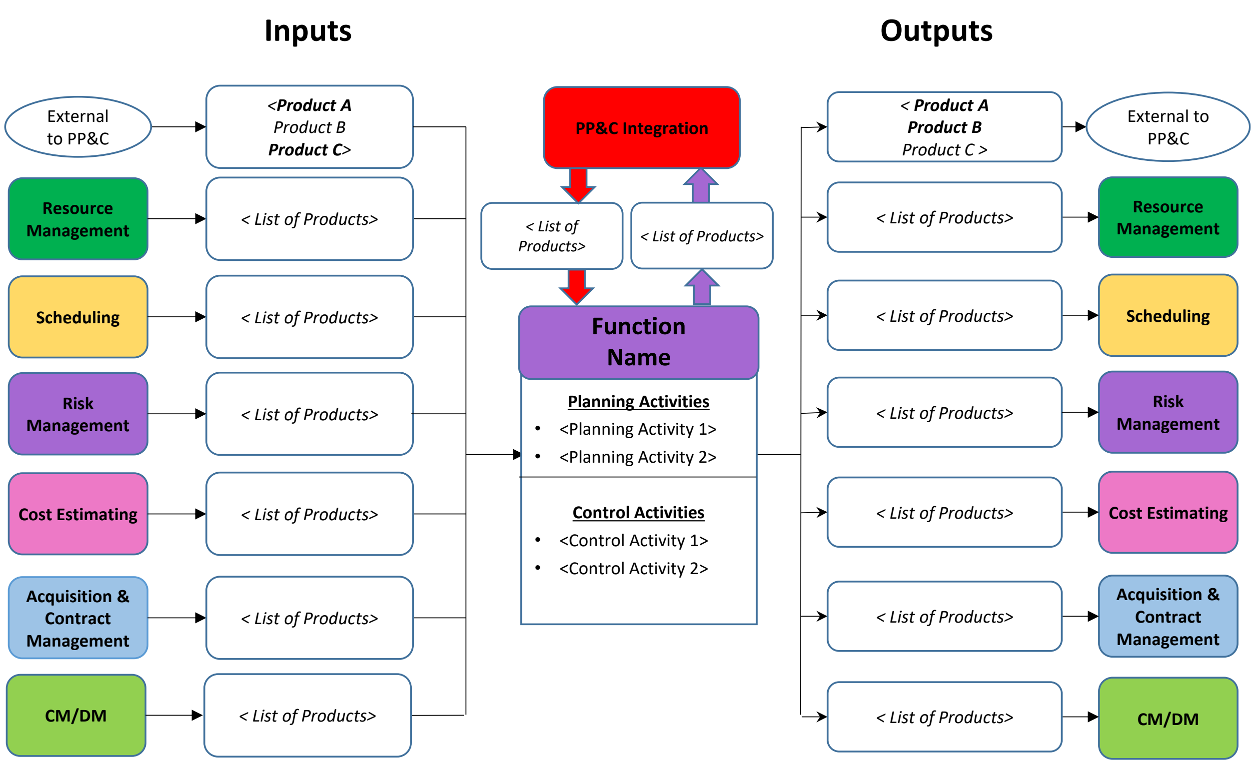
1. The first part provides an introduction and overview of the function.
2. The second part focuses on significant interfaces between the function and other PP&C functions and external entities, and how the functions interact with each other. Flow diagrams are used to depict major inputs and outputs received from and provided to other PP&C functions, as well as external entities. (The major inputs and outputs depicted in the flow diagrams are not necessarily an exhaustive list of all possible inputs and outputs.) Any given item may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the item or receiving it.
3. The third part provides detailed information about the function's activities during the planning and control phases (see Table 3.1-1), tasks associated with those activities, significant drivers impacting the function, and what is important to executing the function successfully. Where available in existing discipline handbooks, additional information on how to execute tasks is referenced.

Figure 3.1-1 illustrates the format of the flow diagrams in Sections 3.3 to 3.8. (Two flow diagrams are provided for the PP&C Integration function (Section 3.2): one for the planning phase and one for the control phase.)

- The subject PP&C function appears in the middle of the flow diagram along with a list of the function's activities in the planning and control phases. (The activities are the same as those listed in Table 3.1-1.)
- Inputs received from the PP&C Integration function and outputs provided to the PP&C Integration function are depicted in the middle of the flow diagram above the function's planning and control activities. Inputs and outputs are broken out into those provided during the planning phase and those provided during the control phase.
- Inputs received from other PP&C functions are depicted in the left-hand column of the diagram and outputs provided to other PP&C functions are depicted in the right-hand

column of the diagram. For all the functions except PP&C Integration, the inputs and outputs are for both the planning and control phases. Inputs and outputs from and to external entities, including the project, program, Mission Directorate, Agency, Congress and other stakeholders, and industry and other Federal agencies are also depicted as "External to PP&C."

- Following the flow diagram, descriptive information is provided for the inputs from external entities, and for the function's outputs.
- Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. Unique information on how the function uses the inputs from other PP&C functions is provided following the flow diagram and/or in the third part of the function section.
- Descriptions of all inputs and outputs in the flow diagrams can also be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.
- No single flow diagram provides "the full gamut" of the flow of inputs and outputs across all PP&C functions. You can get a sense of the full gamut by reviewing all the flow diagrams in Sections 3.2 through 3.8, and by reviewing Appendix F.



Note: Whatever function appears in the center of the flow diagram won't appear in the input or output columns

Figure 3.1-1 Typical Functional Flow Diagram for a PP&C Function with Major Inputs and Outputs

3.2. PP&C Integration Function

3.2.1. Function Overview

The PP&C Integration function ensures that a project is planned, evaluated, managed, and controlled from an overall integrated point of view in terms of cost, schedule, technical requirements, and risk. The PP&C Integration function is led by the PP&C integration manager. As explained in Chapter 2, the person who performs this role in a project may be called the business manager (JPL), project controls manager, Deputy Project Manager/Resources (DPMR) (GSFC), PP&C director (JSC), project control analyst (small project), deputy for PP&C, or other designation. For the purpose of this document, the manager of the PP&C Integration function is referred to as the PP&C integration manager. (Due to the scope of this role and the PP&C Integration function, the PP&C integration manager is one of the early members of the project management team.)

During the planning phase, this function captures the project scope of work in an integrated set of cost and schedule requirements and develops a business approach[3] for executing the scope of work that enables effective management and control of integrated cost and schedule performance. During the control phase, this function develops and manages the flow of integrated cost, schedule and risk information throughout the project; tracks and evaluates integrated cost and schedule performance; ensures that estimates of cost and schedule impacts of proposed changes are developed and provided to project management before decisions are made; interprets what is currently going on inside and outside the project; and develops systematic, objective forecasts of the project's future cost and schedule performance.

A core focus of PP&C Integration is assimilating, integrating, and assessing typically "stove-piped" information into a comprehensive picture/story and providing recommendations to assist project management in making effective, informed decisions to maintain cost and schedule performance within plans and ensure project success. The PP&C integration manager focuses on project performance, not necessarily status, and on plans versus actuals, avoiding the temptation to build a story of achievement that obscures whether or not the project is on track.

---

[3] NPR 7120.5 provides project management requirements for the project life cycle. This includes requirements affecting the technical approach aligned with *NPR 7123.1*, *NASA Systems Engineering Processes and Requirements* for systems engineering as well as requirements for the business approach such as EVM, JCL, Cost Analysis Data Requirement (CADRe), and WBS. The term "business approach" is a general term and should not be confused with content in the domain of the technical approach. It is useful and general enough to include unique project planning and control activities, and it embodies the best practices in this handbook.

Affordability

An essential role of PP&C Integration is to keep project management focused on affordability. Affordability, an often discussed but little understood aspect of project management, is defined as the ability to execute a project's technical requirements within the approved cost and schedule baselines. While the definition is simple, performing within the approved cost and schedule baselines can be challenging. The source of this challenge is a tendency to focus on short-term execution to budget rather than on long-term execution to what the work content is actually going to cost. The project PP&C organization, led by the PP&C integration manager, performs a vital function by helping the project manager understand how affordability can be achieved.

Several activities of the PP&C Integration function, detailed in Sections 3.2.3.1 and 3.2.3.2, are designed to ensure affordability.

The first element of affordability is to ensure complete alignment of technical requirements, design, risks, budget, cost, and schedule baselines. This is accomplished by developing a comprehensive, integrated executable plan as part of the "Capture Project Scope of Work" activity. The challenge to PP&C Integration is ensuring that these baselines are maintained during project Implementation and that the project has adequate margins to cover all known risks as well as unforeseen challenges.

The second element of affordability is to know which requirements are negotiable and which are non-negotiable. *Proactively developing candidate descope options, part of the "Define Approach/Strategy for Executing Scope of Work" activity, helps to drive out this information.* Knowing which requirements must be met and which ones can be relaxed to save money requires open and honest communication among all the key stakeholders, particularly the requirements holder, along with an understanding of how a particular requirement or set of requirements drives costs.

The third element of affordability is to develop an estimate of the cost and schedule impact of all changes to the technical and programmatic baselines before the fact. Given NASA's strong culture of technical excellence, PP&C Integration acts as a counterbalance to ensure that project managers are informed on the cost and schedule impacts of requirements changes. *This is a key focus of the "Assess and Recommend Actions" activity.* Making a decision to implement a change and then figuring out how to pay for it is a strong tendency. However, to be affordable, a project should estimate the cost and schedule impact of a change before the decision is made. The net effect is that the project can make informed, comprehensive, and holistic decisions based on a strong business case supported by data.

Affordability does not happen by accident. It takes a commitment by project management and it requires support from the entire project PP&C organization, led by the PP&C Integration function. By focusing on affordability, the PP&C organization can provide the situational awareness needed by project management to effectively and successfully manage the project to completion.

In many ways, PP&C Integration is about understanding the interrelationship and alignment of the business and project scope side of a project with the technical side. The PP&C integration manager makes connections horizontally and vertically across multiple functions and multiple levels of information. In addition, the PP&C integration manager helps team members understand disciplines outside their own, and provides guidance, decisions, and adjustments to the other PP&C functions.

3.2.2. Integration with Other PP&C Functions, Inputs, and Outputs

The PP&C Integration function needs to effectively interact with and lead other PP&C functions to coordinate, guide, and integrate the significant interactions required between the functions; develop an integrated, project-level executable plan during the planning phase; and evaluate and control the entire project during the control phase.

The PP&C Integration function also interacts with entities external to PP&C to obtain information, communicate results of PP&C activities, and provide PP&C products.

Figures 3.2-1a and 3.2-1b are flow diagrams for the PP&C Integration function for the planning phase and control phase, respectively. The flow diagrams depict major inputs and outputs received from and provided to other PP&C functions, as well as external entities. Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it.[4] The flow diagrams also summarize key activities to consider during the planning and control phases when implementing this function**.** Section 3.2.3 discusses these key activities in detail, and provides insight into the importance of the interactions with other PP&C functions.

[4] The PP&C Integration function flow diagrams are not intended to provide "the full gamut" of the flow of inputs and outputs across all PP&C functions. For example, even though the Scheduling function provides the Schedule Management Plan to PP&C Integration for review and approval (depicted in Figure 3.2-1a), the baseline Schedule Management Plan is an output of the Scheduling function (depicted in Figure 3.4-1). To understand the full gamut of inputs and outputs, it is necessary to review all the flow diagrams in Section 3.2 – 3.8 and/or the "N by N" format provided in Table F-1 in Appendix F: N-Squared Diagram of Inputs and Outputs.

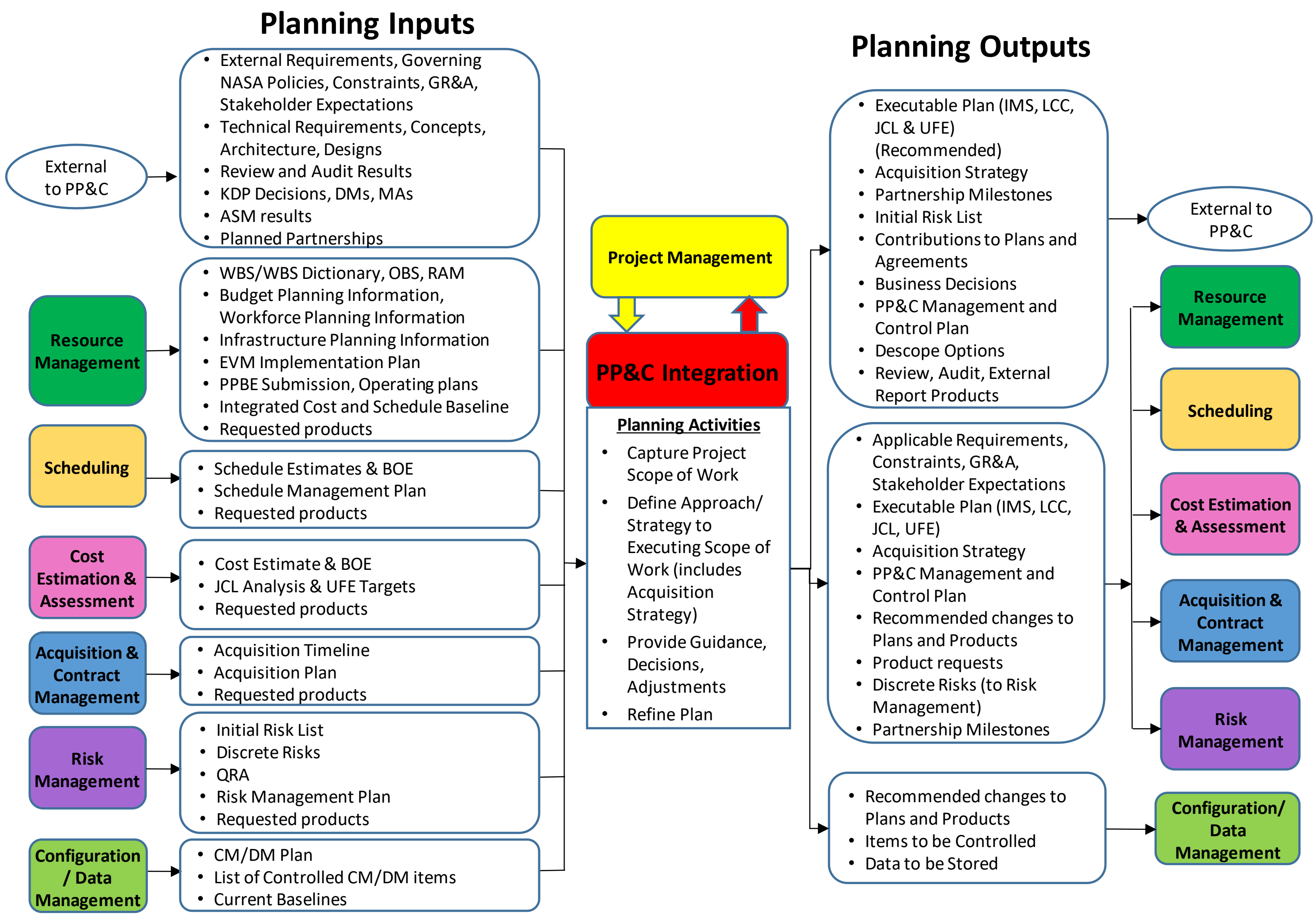


Figure 3.2-1a Typical Functional Flow Diagram for the PP&C Integration Function with Major Inputs and Outputs – Planning Phase

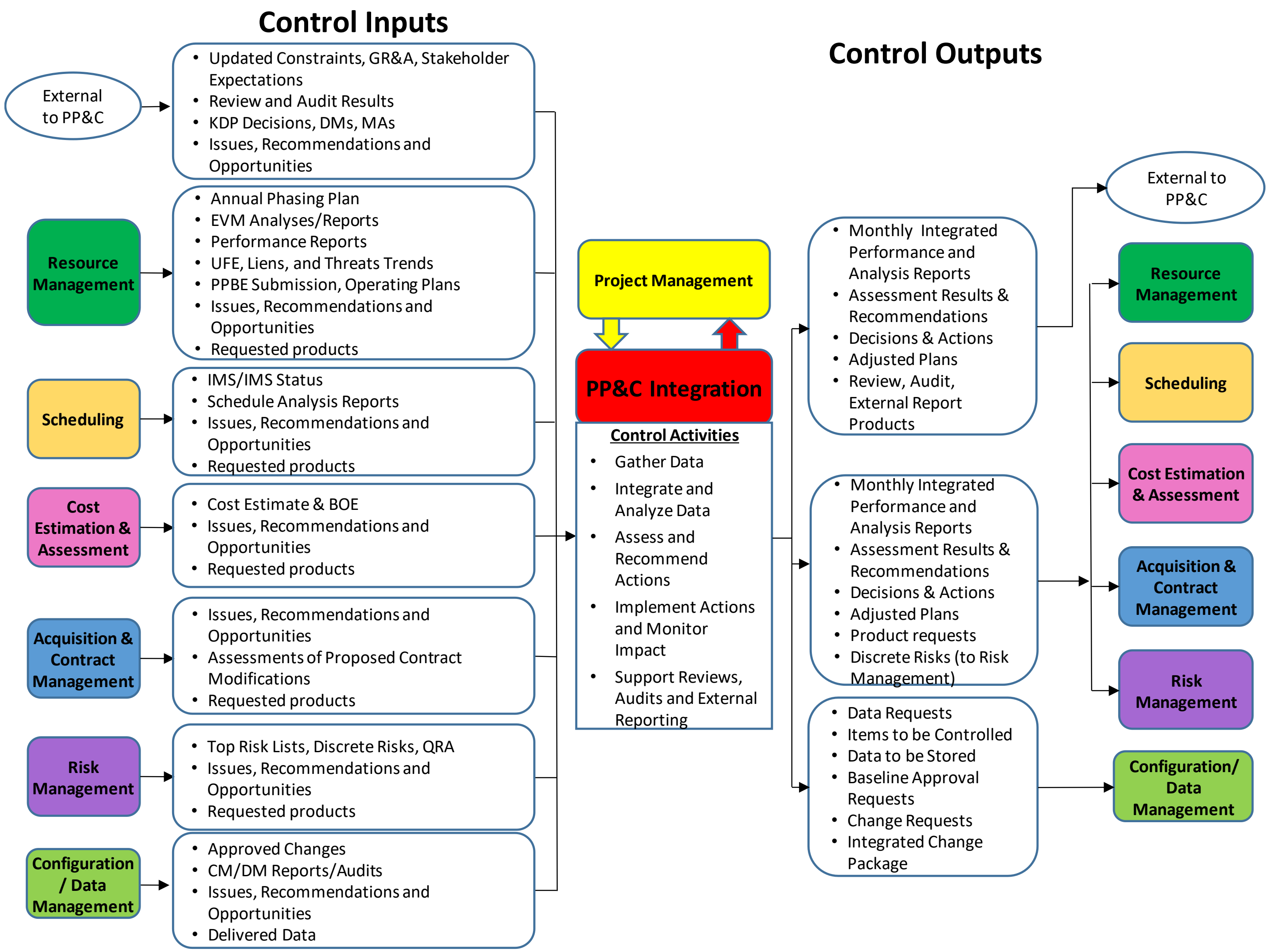


Figure 3.2-1b Typical Functional Flow Diagram for the PP&C Integration Function with Major Inputs and Outputs – Control Phase

Descriptive information is provided below for the inputs from external entities, and for the outputs depicted in Figures 3.2-1a and 3.2-1b. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. (In addition, descriptions for two inputs that are provided by all other PP&C functions to PP&C Integration, "Requested Products" and "Issues, Recommendations and Opportunities." are provided below.) Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.2.3.

Descriptions of all inputs and outputs in can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.

3.2.2.1. Planning Inputs

- **External Requirements, Governing NASA Policies**: Applicable NASA Policy Directives (NPDs), NPRs, Federal regulations, Center policies, lessons learned, and best practices including Agency handbooks. Example NPRs and Federal regulations include *NPR 7120.5 NASA Space Flight Program and Project Management Requirements*, *NPR 7120.7 NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements*, or *NPR 7120.8 NASA Research and Technology Program and Project Management Requirements*, EVM policies, Federal Acquisition Regulation (FAR) and the NASA FAR Supplement (NFS), and OMB policies. Acquisition regulations and requirements applicable to partnerships include *NPD 1050.1 Authority to Enter into Space Act Agreements*, *NPD 1050.2 Authority to Enter into Cooperative Research and Development Agreements (CRADAs)*, *NPD 1360.2 Initiation and Development of International Cooperation in Space and Aeronautics Programs*, *NPD 1370.1, Reimbursable Utilization of NASA Facilities by Foreign Entities and Foreign-Sponsored Research*, *NPR 9090.1 Reimbursable Agreements*, and *NASA Advisory Implementing Instruction(NAII) 1050-1, Space Act Agreements Guide*.

- **Constraints and Ground Rules and Assumptions (GR&A)**: These include Mission Directorate and program constraints and GR&A levied on the project, including mission objectives, goals, and success criteria. They may be also derived from stakeholder expectations and project and programmatic requirements, including the project budget and project funding, and technical requirements. Constraints and GR&A may be documented in the Formulation Authorization Document (FAD), the Formulation Agreement (FAs), Decision Memoranda (DMs), Management Agreements (MAs), and Program and Project Plans.

- **Stakeholder Expectations**: The needs and objectives of the customer (project manager, program, Mission Directorate, and Agency) and other key stakeholders including anticipated products or support expected from the PP&C organization. The stakeholders' expectations need to be documented, and it is important to ensure a common understanding of the expectations between the customer, other key stakeholders, and the PP&C team.

- **Technical Requirements, Concepts, Architecture, and Designs**: PP&C practitioners translate these inputs into acquisition, cost, resources, and time-phasing requirements, which in turn provide the basis for the acquisition strategy, budget requests, the project schedule, and resource needs. The realism of the business approach and requirements is dependent on the interrelationship of the project management, technical, and business aspects of project planning.

- **Review and Audit Results**: Review team (e.g., Standing Review Board (SRB)) reports including findings and recommendations. Audit final reports including findings and agreed-to actions.

- **KDP Decisions, Decision Memoranda (DM), and Management Agreements (MA)**: At KDPs, the Decision Authority decides whether and how the project progresses in its life cycle; authorizes the project cost, schedule, and content parameters that govern remaining life-cycle activities; and assigns actions if needed. (See NPR 7120.5, Section 2.3.1 for a definition of the Decision Authority.) KDP decisions and actions are recorded in the KDP DM. The MA is part of the DM and defines the parameters including cost and schedule and authorities for which the project manager has management control and accountability. The KDP C DM and MA establish the Agency Baseline Commitment (ABC), JCL levels at which the project will be budgeted and funded (which may be different), and Unallocated Future Expenses (UFE) that will be held at the project level and above the project level.

- **Acquisition Strategy Meeting (ASM) Results**: The ASM is a review by senior Agency management of the project's proposed acquisition strategy. If required, it is held before authorization of resource expenditures for any major acquisitions. Impacts are considered to the Agency workforce and maintaining core capabilities, resource availability, make-or-buy decisions, Center assignments, and potential partners, risk, and other planning decisions from an Agency perspective. The ASM results in either approval or modification of the project's proposed acquisition strategy. Results of the ASM are also used to develop and finalize the Acquisition Plan.

- **Planned Partnerships:** Partnerships planned by the project. This information is used to facilitate identification of the appropriate NPDs and NPRs and selection of the appropriate type of agreement. For each planned partnership, information includes identification of the partner and beneficiaries, whether or not foreign entities are involved, description of the partner's responsibilities, and description of NASA's responsibilities (including provision of personnel, facilities, and laboratories), etc.

- **Integrated Cost and Schedule Baseline**: This cost, schedule, and UFEs are documented in the KDP C MA per the KDP DM. This baseline becomes the foundation against which the project's cost and schedule performance is assessed, adjustments are made, and Estimates at Completion (EACs) are developed.

- **EVM Implementation Plan**: The EVM Implementation Plan is provided to PP&C Integration for review and comment prior to approval.

- **Requested Products**: Products from the other PP&C functions needed to support internal reviews, independent reviews, such as LCRs, and KDPs, audits, and external reports.

- **Schedule Management Plan**: The Schedule Management Plan (SMP) is provided to PP&C Integration for review and comment prior to approval.

- **Acquisition Plan**: The Acquisition Plan is provided to PP&C Integration for review and comment prior to approval.

- **Discrete Risks**: Identified, documented potential events that each carry an estimated consequence and an associated likelihood (probability of occurrence). The Risk Management team frames the body of risks for project management decision making and programmatic analyses. Each discrete risk includes a risk statement and narrative description; a Risk Mitigation Plan; cost and schedule consequences; likelihood; and risk response. (For additional detail, see Section 3.7.2.)

- **Risk Management Plan**: The Risk Management Plan is provided to PP&C Integration for review and comment prior to approval.

- **CM/DM Plan**: The CM/DM Plan is provided to PP&C Integration for review and comment prior to approval.

3.2.2.2. Control Inputs

- **KDP Decisions, DMs, MAs**: See Planning Inputs.

- **Issues, Recommendations and Opportunities**: Issues, recommendations, and opportunities may be identified by external entities (including the project, program, Mission Directorate, Agency) and any of the PP&C functions. Issues include project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues, and are key inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance.
    - Examples of project events include adverse trends in technical performance measures, and an inability to develop planned technologies. It is essential to work closely with the entire project team to quickly identify issues and to help project coworkers better understand the interrelationships between technical events and the project's cost and schedule.
    - Examples of external events include an unexpected change to the project's funding profile, nationwide industry issues, and changes in the contractor's business profile.
    - Examples of opportunities range from leveraging beneficial external events, to taking innovative approaches to doing business, to capitalizing on identified synergies with another project.

- **Requested Products**: See Planning Inputs.

3.2.2.3. Planning Outputs

- **Executable Plan (IMS, LCC, JCL, UFE)**: A recommended executable plan is provided to the Decision Authority in support of KDP C. The executable plan, with or without modification, is approved and authorized by the project's Decision Authority at KDP C. It captures the integrated set of technical, science, cost, schedule, resource, and facility requirements of the project in the WBS, schedule, resource baseline, and budget. The baseline IMS, LCC estimate, JCL, and UFEs are key elements of the executable plan. These products are also part of the ABC.

- **Acquisition Strategy**: The project's approved Acquisition Strategy for using NASA's acquisition authorities to achieve the project's mission within planned cost and schedule. The strategy addresses plans for obtaining the systems, research, services, construction, and supplies needed to fulfill the mission, including in-house work plans, any known procurement(s), plans for partners and their roles and anticipated contributions, and plans for obtaining commitments for these contributions.

- **Partnership Milestones:** Partnership milestones establish the dates associated with partnerships such as when partnerships need to be executed and when partners are expected to complete events or international partners are expected to provide project deliverable(s). Partnership milestones may be identified within the baselined IMS.

- **Initial Risk List**: The initial set of risks to be accounted for in the PP&C analyses, including integrated cost and schedule estimates that characterize the executable plan.

- **Contributions to Plans and Agreements**: Contributions to the FA, Project Plan, Review Plan, and LCR Terms of Reference (ToR).

- **Business Decisions**: Decisions on how the project will plan, manage, and control cost and schedule including the identified and agreed-to set of PP&C indicators that will be used throughout the life cycle to monitor and trend PP&C-related activities; identification and definition of interfaces between PP&C functions and interfaces between PP&C functions and project technical processes and systems and organizations, systems, and processes external to the project including suppliers; what reports to generate and when they will be produced; and how changes will be incorporated into the executable plan, EAC, etc.

- **PP&C Management and Control Plan**: This plan is an optional, project-level document intended to support an integrated, organized summary of a project's PP&C activities in one document. The plan provides an overview of the PP&C organization and describes the guidelines and processes to be used for the different PP&C activities. Activities addressed in the plan include resource and funds management, work management, cost estimation and schedule development, and schedule, cost, and integrated performance management. (See Appendix G: PP&C Management and Control Plan for additional detail and a template for the plan.)

- **Descope Options**: A list of candidate descope options developed early in the project life cycle. These options can provide an orderly process should a reduction in scope be needed later during the life cycle of the project. PP&C Integration supports the development of candidate descope options and enables a systems view to ensure that all potential interactions are identified including impacts to cost, schedule, and risk. The project maintains the list of descope options, keeps records on descopes taken, and continues to solicit descopes to add to this list.

- **Review, Audit, External Report Products**: Products provided to review teams for internal and independent reviews, to the project's Decision Authority for KDPs, to audit leads for Government Accountability Office (GAO), Office of the Inspector General (OIG), and other audits, and to the Office of the Chief Financial Officer (OCFO) and the project's Mission Directorate for the quarterly data call, GAO Data Collection Instruments (DCIs), and external reports.

- **Applicable Requirements, Constraints, GR&A, and Stakeholder Expectations**: These define and bound the scope of PP&C products developed by all PP&C functions. Identification helps to minimize or eliminate oversights that can result in PP&C products that fail to meet the needs of the project, its customers, and stakeholders. An example of an applicable requirement is the requirement to produce a JCL. Examples of constraints include fixed launch dates and constraints on development costs. Examples of GR&A include participation by other foreign entities and the expected cost of institutional support. Examples of stakeholder expectations include types and frequencies of reports.

- **Recommended Changes to Plans and Products**: Recommendations to other PP&C functions for changes and/or adjustments to their plans and products.

- **Product Requests**: Requests for products from the other PP&C functions for support of internal reviews, independent reviews such as LCRs, KDPs, audits, and external reports.

- **Discrete Risks**: As an output, these are any specific risks identified by the PP&C Integration function.

- **Items to be Controlled**: Items developed by PP&C Integration that need to be placed under configuration control including the executable plan, acquisition strategy, and PP&C Management and Control Plan.

- **Data to be Stored**: Data developed by PP&C Integration and by external entities (e.g., review teams/boards, auditors) identified as needing to be stored.

3.2.2.4. Control Outputs

- **Monthly Integrated Performance and Analysis Reports**: Current integrated cost and schedule performance, trends and variances, and the project's risk posture; analyses of cost and schedule variances and trends; identification of data correlations and causal relationships, key drivers and sensitivities; and status of UFE, liens, and threats.

- **Assessment Results & Recommendations**: Analysis of remaining risk and project and external issues with the potential to impact performance. Forecast of integrated cost and schedule performance and EAC based on current performance, work remaining, and likely impacts of remaining risk and issues. Identification of key issues and performance drivers and any decisions that need to be made by project management. Recommendations including candidate options and/or corrective actions for controlling project performance and the expected impacts of each recommendation on integrated cost and schedule performance, EAC, and remaining risk.

- **Decisions & Actions**: Options and/or corrective actions approved for implementation by the project manager including associated decision packages. Plans for implementing, tracking, and reporting on the results of the options/corrective actions including:
    - Specific tasks, an implementation schedule, and responsible project organizations.
    - Expectations for when results will be realized including specific, quantified improvements and/or stability in integrated cost and schedule performance, EAC, and risk status performance over time.
    - Identification of any program, Mission Directorate, or Congressional approvals needed to implement the option/corrective action, including renegotiation of the project's MA and Decision Memorandum (DM).

- **Adjusted Plans**: Updates to the project's plans based on approved options/corrective actions. Examples include updates to the baselined IMS, LCC, EAC, and modification of existing contracts.

- **Discrete Risks**: See Planning Outputs.

- **Change Requests**: A request submitted to the Configuration Management and Data Management (CM/DM) function to change an item under configuration control.

- **Integrated Change Package**: Evaluation of a requested change to an item under configuration control. The package includes a description of the change; project organizations that evaluated the change; impacts of the change on other project products, activities, and documentation; and impacts to the project's cost, schedule, and risk. (For additional detail, see Section 3.8.2.)

3.2.3. Function Planning and Control Activities and Tasks

PP&C Integration planning and control activities and tasks are outlined in Table 3.2-1 PP&C Integration Activities and Tasks. The activities and associated tasks are described in more detail in the text below the table.

Table 3.2-1 PP&C Integration Activities and Tasks

PP&C Integration	
Planning Activities and Tasks	**Control Activities and Tasks**

Activity: Capture Project Scope of Work
• Identify/capture key milestones
• Identify environment, constraints, ground rules and assumptions
• Identify key opportunities and risks
Activity: Define Approach/Strategy for Executing Scope of Work
• Develop Acquisition Strategy
• Develop control plans
• Develop ABC
• Support development of descope options
Provide Guidance, Decisions and Adjustments to Other PP&C Functions
• Identify business decisions
  ○ Identify key interfaces
  ○ Identify PP&C performance indicators
  ○ Establish processes for managing and tracking liens and threats
• Develop PP&C Management and Control Plan
  ○ Identify PP&C requirements
  ○ Identify PP&C stakeholders and expectations
  ○ Document PP&C organization
  ○ Document guidelines and processes for PP&C activities
• Evaluate, provide feedback on plans and products from PP&C Functions
	Gather Data
	• Gather cost, schedule, risk information
	• Develop project level cost performance, schedule performance and trends
	• Identify project level risk posture and trends
	Integrate and Analyze the Data
	• Connect schedule to cost
	  ○ Develop integrated cost and schedule performance and trends
	• Monitor integrated cost and schedule performance, monitor PP&C performance indicators and Technical Performance Measures (TPMs), identify variances
	• Determine data correlations and causal relationships
	• Identify project drivers and sensitivities
	Activity: Assess and Recommend Actions
	• Identify project and external events impacting cost, schedule, and risk performance, and determine potential impacts
	• Assess risk posture and determine impacts of remaining risks
	• Develop integrated cost and schedule forecast
	• Develop options and/or corrective actions and recommendations for adjusting the plans
	• Tell the story, including recommendations, to management
	Activity: Implement Actions and Monitor Impact
	• Adjust plans, replan as required
	• Revise EAC forecast

PP&C Integration	
Planning Activities and Tasks	**Control Activities and Tasks**

Refine Plan
• Iteratively assess plan and refine as necessary
	• Reassess risk posture
	• Monitor actions for control
	
	Activity: Support Reviews, Audits and External Reporting
	• Support project LCRs, KDPs, internal reviews
	  ○ Provide PP&C products
	  ○ Assess PP&C related review findings, develop responses and necessary actions
	• Support Agency Baseline Performance Reviews (BPRs), external reporting, and audits

3.2.3.1. Planning Activities

This section discusses in detail the PP&C work required to capture the project scope of work; define the business approach and strategy; and develop the framework for the guidance, decisions, and adjustments provided by the PP&C Integration function. The questions provided in blue boxes throughout the following sections are examples that serve to illustrate the factors, situations, issues, and concerns that may influence PP&C's products and plans. Each project would customize its specific questions based on the project's circumstances.

3.2.3.1A Capture Project Scope of Work

PP&C Integration manages the activities of all PP&C functions necessary to capture the scope of work into an executable plan. Capturing the scope of work encompasses efforts to identify the environment, understand the constraints and GR&A that will impact the PP&C effort, and identify the attendant key opportunities and risks. A comprehensive, executable plan captures the integrated set of technical, science, cost, schedule, resource, facility, and acquisition requirements of the project in the WBS, schedule, resource baseline, and budget. The realism of the executable plan is dependent on the interrelationship and communication between the project's technical and business communities and on the interrelationship and communication between the seven PP&C functions. The following questions are examples of considerations for ensuring that the full scope of work is captured in the executable plan.

Capturing Project Scope of Work Considerations

- Does the WBS encompass all the work necessary to complete the project?
    - Are the number and complexity of the control accounts, work/planning packages, and charging structure appropriate?
- Are the Level 1, technical, science, and safety requirements captured in the cost and schedule estimates?
- Are the identified key milestones such as MDR, PDR, CDR, SIR, and launch, and other key deliverables and objectives captured in the WBS, cost, and schedule estimates?
- Is the WBS product focused?
- Does the WBS structure support EVM?
- Do the cost and schedule estimates accommodate the technical architecture and design, and the technical plans for assembly, integration, test, and launch operations?
- Are the workforce and infrastructure requirements reflected in the cost and schedule estimates?
    - Construction of new facilities and/or facility upgrade and modification requirements
    - Availability of workforce and facilities
- Are all costs included in the cost estimate?
    - Institutional support
    - Pass-through
    - Launch services
- Are the cost and schedule estimates compliant with all constraints and ground rules?
    - Ramification of partnerships, especially with foreign entities
- Are the Basis of Estimates (BOEs) for cost and schedule estimates based on reasonable assumptions?
- Do the cost and schedule requirements encompass the identified programmatic, technical, safety, cost, and schedule risks?
- Is the executable plan sufficiently comprehensive and detailed to allow for the measurement of the project's progress?

It is essential to understand the project's current and future environment. Both NASA and external environments may have profound impacts on the project and its ability to succeed. The NASA environment includes issues and events within the Agency, Mission Directorate, and program such as problems in other NASA programs and projects and competition for funds and other resources. External environment issues and events range from political events such as major policy shifts from the Executive Branch and changing support from Congress, to political issues in foreign governments that impact the ability of foreign partners to meet their commitments, to major changes in the business base for key project contractors that may result in impacts such as loss of key personnel, to national and international shortages of key supplies and materials. A major key to identifying and mitigating environmental issues and events early is developing effective protocols, communications, and working relationships with Agency, Mission Directorate, and other Center representatives and counterparts, and with partners and contract counterparts.

PP&C Integration identifies the constraints and GR&A that will impact the PP&C effort. These need to be documented and confirmed with the project manager, customers, stakeholders, vendors, end users, etc., to ensure their applicability and to avoid misunderstandings that could lead to problems such as inaccurate cost and schedule estimates. In addition, constraints and GR&A may change over time, so it is important to update and track their status throughout the project life cycle to determine if they remain valid, are being realized, or need to be modified.

Identifying PP&C constraints and GR&A is essential to defining and bounding the scope of PP&C products. For example, they clarify what costs are to be included in the cost estimate and what costs are to be excluded. When clearly documented, they also enable comparisons with future cost estimates and independent cost estimates. In addition, GR&A can focus attention on the most important elements of the cost estimate and provide temporary resolution of undefined technical and programmatic questions.

Examples of considerations for identifying and understanding the project's environment, constraints, and GR&A are provided below.

Environment, Constraints, Ground Rules and Assumptions (GR&A) Considerations

- What are the environment/political issues?
  - What is the competition for funds and other resources?
  - Is the project consistent with *NASA Strategic Plan*?
  - If applicable, is the project consistent with a *NAS Decadal Survey*?
  - What other external or internal factors exist?
- What are the key constraints?
  - Fixed launch date constraints (in particular for planetary missions)
  - Mission cost-cap constraints
  - Development cost (Phase C/D) and/or total LCC constraints
  - Budget constraints by fiscal year
  - Agency workforce constraints (e.g., workforce allocations and ceilings at Centers)
- What are the key ground rules?
  - Internal and external participants
    - Other NASA Centers, other entities (government agencies, foreign governments, etc.)
    - Roles, scope of work, known constraints related to their efforts
- What are the key assumptions?
  - Availability of required resources (workforce skills, infrastructure (e.g., test facilities), suppliers, materials)
  - Support from institutional organizations and cost of that support

PP&C Integration supports the PP&C team in identifying key opportunities and risks associated with the acquisition strategy and cost and schedule estimates. Due to the fact that opportunities are often overlooked, PP&C Integration needs to actively seek to identify opportunities that can be used to the project's advantage to reduce cost, shorten schedules, and reduce the potential cost and schedule impacts of risks.

It is important to understand the likelihood and determine the magnitude of the potential cost and schedule consequences of identified opportunities and risks to enable prioritization of efforts in pursuing opportunities and mitigating risks.

Opportunity Considerations

NASA Agreements

- Utilizing scarce skills at another Center
- Sharing infrastructure with another NASA project

Cost and Schedule

- Acquiring materials, products, or tools at a lower cost based on timing of the acquisition
- Completing specific tasks ahead of time based on availability of resources including funding, workforce, and infrastructure

Contracts

- Utilizing existing contract vehicles within NASA and across the Federal Government, such as contract vehicles at other Centers, General Services Administration (GSA) contracts, or contracts held by other Federal agencies.

Partnerships

- Leveraging other's resources aligned with project goals

All risks and opportunities identified during the planning phase need to be accounted for in the integrated cost and schedule estimates baselined at KDP C, and in the ABC. UFE established at KDP C should be used only for those risks that are unknown at the time plans are baselined. The PP&C integration manager works with the project manager early in the project life cycle to develop and document the project's strategy for managing UFEs. This strategy could include the following:

- Whether the project manager will hold all project UFEs at the project level or allocate some project UFEs to system and subsystem managers;
- Circumstances that may warrant allocation of UFEs, including unknown risks, and the circumstances that do not warrant allocation of UFEs;
- A plan for the "drawdown" of UFEs over the project's life cycle;
- Circumstances under which the project will request allocation of UFEs held at the program and Mission Directorate levels; and
- How utilization of UFEs will be tracked and the frequency of UFE status reports to the project manager.

Risk Considerations

Programmatic

- Is the initial risk list defined?
- What risks are inherent in the environment?
- What are the elements of risk in the constraints and assumptions?
- How defined are the Level 1 requirements?

Cost and Schedule Risks Associated with Technical Requirements and Plans

- What is the heritage assumption and what assessment of actual re-use or benefit will be made?
- Is there any technology development?
- Are there any unique requirements?
- Are the technical plans consistent with similar missions?
  - Prototypes, test and training units, flight units, spares
  - Test plans including test units, test systems and facilities, types and numbers of tests
  - Cost, mass and power margins and planned burn rates
  - Any significant omissions or atypical strategies to reduce cost and schedule with low probability of success?

Contracts

- Are there any special or unique provisions in solicitations or any special or unique contract clauses or special requirements that could increase risk, thereby increasing cost and impacting schedule?
- What are the risks in the contract proposals?
  - Any proposals from foreign entities or proposed foreign contractors?
- Any risks associated with single source or critical suppliers?
- Are there any long lead items that are problematic (e.g., actuators)?

Partnerships

- What risks are inherent in the partnerships?
  - Any foreign partnerships?

Cost and Schedule

- What are the biggest risks inherent in the estimates?
- Do the estimates address the identified risks?
- Are the schedule margin and UFE and associated burn down profiles reasonable?

3.2.3.1B Define Approach/Strategy for Executing Scope of Work

The PP&C Integration function leads the development of the business approach and strategy for executing the project's scope of work, and coordinates the activities of the other PP&C functions involved. PP&C Integration ensures that the business approach and strategy supports the full scope of work, can be accomplished within the available budget and schedule, and is consistent with the project's constraints, GR&A, and Level 1 requirements. The effort to develop the business approach and strategy encompasses the tasks listed below. Each task is discussed in detail in this section.

- Developing the project's acquisition strategy, that is, the project's approach for using NASA's acquisition authorities to achieve the project's mission within planned cost and schedule;
- Developing the control plans that establish the processes and parameters to be used during the control phase of the project to monitor, manage, and control the project's cost and schedule performance; implement the acquisition strategy; manage the project's risks; and implement CM/DM;
- Establishing the project's ABC, which incorporates the LCC and baselined IMS for implementing the project's scope of work; and
- Supporting the development of preplanned project descope options.

Develop Acquisition Strategy

PP&C Integration coordinates the development of the acquisition strategy with the technical and programmatic community and the Center's Office of Procurement, and, when applicable, Center and HQ partnership offices, including HQ's Office of General Counsel (OGC) and Office of International and Interagency Relations (OIIR). The project's acquisition strategy addresses the project's plans for obtaining the systems, research, services, construction, and supplies needed to fulfill its mission, including in-house work plans, any known procurement(s), and plans for partners (i.e., other Government agencies, domestic and international), their roles and anticipated contributions, and plans for obtaining commitments for these contributions. (See additional information on the appropriate use of partnerships below.) The strategy includes recommendations from make-or-buy analyses and competed/directed analyses, and proposed infrastructure use and needs that take into consideration the project's budget and any other applicable factors. It also addresses the availability of the industrial base capability and supply chain needed to design, develop, produce, and support the project. It identifies risks associated with single source or critical suppliers and attendant mechanisms that will be used to identify, monitor, and mitigate industrial base and supply chain risks.

The acquisition strategy is developed within the context of the Agency's strategic acquisition process. This process ensures 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.) As part of this process, NASA management considers the full spectrum of acquisition approaches for its projects from commercial off-the-shelf 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 goes through this "make or buy" decision on whether to acquire the 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 (taking into account 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. PP&C Integration needs to ensure that the project's acquisition strategy is consistent with the results of the Agency's strategic acquisition process.

PP&C Integration coordinates the development of the project's acquisition strategy with all functional representatives (engineering, SMA, IT, legal, financial, procurement, small business, and various technical authorities) as early as possible in Formulation and throughout the acquisition process. The acquisition strategy is developed in accordance with applicable Federal regulations and NASA policies. (See Section 3.2.2.1 (External Requirements, Governing NASA Policies.))

Business Approach and Strategy Considerations

Programmatic

- Are there any constraints and ground rules that influence the business approach and strategy?
    - Partnerships with foreign entities, other government agencies, assignments of roles to NASA Centers
- Are there any noncompliance issues with the approach/strategy? (e.g., NPR 7120 documents, International Traffic in Arms Regulations (ITAR), etc.)
- Could the business approach/strategy address any national policy objectives, e.g., partnerships with academia?

Acquisition Strategy

- Is an ASM required to approve the Acquisition Strategy?
- Is the Acquisition Strategy consistent with results of the Agency's strategic acquisition process and the ASM?"
    - Does it take advantage of NASA's unique capability and capacity, or need to maintain/develop such capability and capacity?
    - Does it provide best value and maximize competition?
    - Does it encourage innovation and efficiency; take advantage of state-of-the-art solutions available within NASA and from industry, academia, other Federal agencies, and international partners?
    - Did we consider the full spectrum of acquisition approaches?
- What are the contributions from international partners?
- What industrial base capability and supply chain is needed to design, develop, produce, and support the project?
    - Availability of single source or critical suppliers
- Are the acquisition timeframes reasonable?
- What are the negotiation plans, goals and strategy?
- Was a vendor capability analysis performed for key vendors who are on the critical path?
    - What are the fallback options for sole source?
    - What are the risk mitigation plans?

Funding

- What funding profile is required for contracts and major tasks including funding for long-lead items and termination?
    - Does the funding profile support these requirements?

Risk management is a key focus in development of the acquisition strategy. Risks are identified as early as possible, including development of plans to manage and mitigate risks throughout the acquisition cycle consistent with FAR 7.105 (Contents of written acquisition plans); FAR 15.3 (Source Selection); NFS 1807.105 (Contents of written acquisition plans); NFS 1815.3 (Source Selection); *NPR 7120.5, NASA Space Flight Program and Project Management Requirements; NPR 8000.4, Agency Risk Management Procedural Requirements; NPR 2810.1, Security of*

Information Technology; and *NPR 8715.3*, *NASA General Safety Program Requirements*. The acquisition strategy for projects is required to address safety risks (including systems/operation safety and occupational health/safety); technical risks; schedule risks; cost risks; and institutional risks (including security, personnel, information technology, and facilities/property). The acquisition strategy is also required to address risks associated with the involvement of foreign sources (contractor and/or governmental); risks of unauthorized technology transfer (see *NPR 7500.2*, *NASA Technology Transfer Requirements*); and staffing (Full-Time Equivalent (FTE)/Work-Year Equivalent (WYE)) risks to ensure it includes the necessary NASA personnel resources available with the appropriate level and expertise to manage the project. For each area of risk identified, the acquisition strategy identifies and analyzes potential performance shortfalls.

The acquisition strategy also identifies specific actions taken to structure the acquisition approach to manage the risks throughout the acquisition process. For example, the acquisition strategy describes how safety risks will be addressed in contract requirements and evaluated in source selections, and explains how such risks will be managed and incentivized during contract performance. Decisions to accept, mitigate, track, and/or research risk factors are identified and documented as part of the acquisition planning process.

According to *NPD 1000.5*, *Policy for NASA Acquisition*, it is NASA policy to "consider, when developing an acquisition strategy, the full spectrum of acquisition approaches, as appropriate, to advance the Agency's objectives, taking into consideration providing best value, maximizing competition, and preserving the Agency's core capabilities." Tables 3.2-2a and 3.2-2b provide an overview of approaches available to NASA. These include acquisition approaches (Table 3.2-2a) such as in-house work, NASA agreements, and various types of contracts. (See Appendix J: Contract Types for more information.) These also include various partnership approaches (Table 3.2-2b) with industry, other federal agencies and foreign entities. Partnerships are established through mechanisms authorized under transaction authorities other than the FAR and NFS. (See Appendix L: Partnership Types for more information.)

Table 3.2-2a Acquisition Approaches Available to NASA

Approach	Description
In-House Builds	Conducted onsite or in the immediate vicinity of a NASA Center in which most major technical business and management tasks are performed primarily by the Centers' civil service and support contract workforce.
NASA Agreements	Agreements for goods or services from other NASA entities; e.g., space communications, launch services, inter-Center memoranda of agreement
Fixed Price Contract	Contract with fixed price terms to acquire goods/services.
Cost Share Contract	Contract that reimburses less than 100% of the costs for goods/services.

Approach	Description
Cost Plus Contract	Contract that reimburses costs to acquire goods/services, plus a fee.
Commercial Data or Service Contract	Contract to buy commercially available data/services where industry owns the system which produces the data/service, and can sell to other markets. Used when the government is not the only customer. Typically fixed-price.
Commercial Systems Contract	Contract to buy commercially available systems/hardware. May be appropriate when buying commercial off-the-self items for use in a NASA-owned facility or system. Typically fixed-price.

Table 3.2-2b Partnership Approaches Available to NASA[5]

Approach	Description
Non-Reimbursable Space Act Agreement (SAA)	Used for mutually beneficial partnerships with *no* exchange of funds.
Reimbursable SAA	Used for partnerships where NASA costs are reimbursed by the partner.
Funded SAA	Used when Agency objectives cannot be achieved through any other agreement instrument which must be primarily for public purposes.
International Agreements	Agreements to conduct activities pertaining to the work of NASA with foreign entities.
Interagency Agreements (IAA)	Non-reimbursable or reimbursable agreements in which the partner is another Federal agency or department.

Partnerships may be used to meet project requirements only under very limited circumstances. This is due to the fact that under the Chiles Act,[6] procurement contracts must be used when the principal purpose of the activity is to acquire (by purchase, lease or barter) property or services for the direct benefit or use of the U.S. Government. International partnerships with foreign entities may on occasion be used to meet a project requirement because there is additional Space Act authority to conduct international cooperative space activities under international agreements. (A foreign entity is a legal entity that is not established under a state or Federal law of the United States and includes a commercial or noncommercial entity or person or

---

[5] PP&C Integration coordinates with the Center agreement manager, the Space Act Agreement manager (if one is assigned), and the Technical Point of Contact (TPOC) within the project, and/or, when applicable, with the Mission Directorate, Center's Chief Counsel Office, OGC, and OIIR to ensure that appropriate support and data is provided by the PP&C functions for establishing and managing partnership agreements. (See *NAII 1050-1*, *Space Act Agreements Guide* for a detailed explanation of the NASA agreement practice and guidance for the formation, execution, and administration of SAAs.)

[6] Federal Grants and Cooperative Agreements Act of 1977 (also referred to as the Chiles Act), Public Law 95-224, 92 Stat. 3, 31 USC §6303.

governmental entity of a foreign sovereign.) Use of international partnerships for this purpose is very fact-dependent, and requires close coordination with OIIR and OGC.

Projects may establish partnerships for beneficial reasons other than to acquire property of services for meeting project requirements. One example is the collaborative development of a technology that has potential to mitigate project risk, decrease project costs or shorten the project's schedules. Such a development effort should be an alternate path for achieving project objectives.

The Mission Directorate Associate Administrator (MDAA) and NASA Associate Administrator determine whether an Agency-level Acquisition Strategy Meeting (ASM) is required to review and agree upon the project's acquisition strategy before authorizing resource expenditures for major acquisitions and making partnership commitments. (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 ASM is typically held early in Formulation, but the timing is determined by the Mission Directorate.

The ASM considers impacts to Agency workforce and maintaining core capabilities, resource availability, make-or-buy decisions, Center assignments and potential partners, risk, and other planning decisions from an Agency perspective. The ASM implements the decisions that flow out of the Agency's strategic acquisition process.

The ASM results in either approval or modification of the project's proposed acquisition strategy. Decisions are documented in the ASM meeting minutes. The results of the ASM are used to finalize the project's acquisition strategy and develop and finalize the Acquisition Plan. (See Section 3.6.3.1 for information on developing the project's Acquisition Plan.)

Develop Control Plans

NPR 7120.5 and other NPRs establish requirements for the development of several control plans. The efforts required to develop these plans are as valuable as the plans themselves. It is essential to document and follow the plans to keep PP&C activities aligned and on track throughout the project life cycle to enable project success. PP&C Integration supports the project in determining which plans need to be developed and the approach for developing those plans (e.g., as stand-alone documents or as part of other documents such as the Project Plan). PP&C also supports the project in requesting and obtaining approval for tailoring NPR requirements associated with plans if necessary.

PP&C is involved in the development of several control plans including the Project Plan, Cost and Schedule Control Plan, Acquisition Plan, Risk Management Plan, Configuration and Data Management Plan, and Review Plan. Whether PP&C's role is primary or contributory in the development of certain control plans is determined by project management. (Control plan content is addressed in the sections of this handbook associated with the PP&C functions responsible for their development. Maturity of the control plans increases as the project moves through the life cycle.) (See NPR 7120.5, Appendix I or other appropriate 7120 NPRs in the NASA Online Directive Information System (NODIS) library for maturity states for required control plans for each phase of the project life cycle. Tailoring these requirements is addressed in this handbook in Appendix C: Scaling and Appendix H: Letter on Guidance and Expectations for Small Projects.)

PP&C Integration supports development of the Project Plan and the Review Plan.

- The Project Plan is prepared by the project manager with the support of the project team. It is an agreement among the project manager, program manager, Center Director(s), and MDAA. It defines, at a high level, the scope of the project, the implementation approach, the environment within which the project operates, and the baseline commitments of the project. PP&C contributions may include, but are not limited to, the definition of stakeholders, WBS baseline, schedule baseline, resource (baseline), JCL, Cost and Schedule Control Plan, and Acquisition Plan. See NPR 7120.5, Appendix H, for detailed information on the Project Plan.
- The Review Plan summarizes the project's approach for conducting a series of reviews, including internal reviews and project LCRs. PP&C contributions include plans for development of PP&C products in support of LCRs and KDPs, as well as any plans for internal and peer reviews of PP&C functions and products. See NPR 7120.5, Appendix H, Section 3.10, and Table I-5; *NPR 7123.1, NASA Systems Engineering Processes and Requirements*; and *NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook*, Section 4.3.4.3 for detailed information on the Review Plan.

The PP&C Integration function also supports development of two key project planning products: the FA and the LCR ToR. Table 3.2-3 describes these products and identifies the source of their requirements.

Table 3.2-3 Other Key Planning Products

Product	Description and PP&C Contributions	Requirement Source
Formulation Agreement (FA)	The FA establishes 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. PP&C contributions include identification of acquisition work that needs to be conducted during Formulation and the project's schedule and funding requirements during Phase A and Phase B.	NPR 7120.5, Table I-4
LCR Terms of Reference (ToR)	The LCR ToR is developed in conjunction with the SRB. It documents the scope, requirements, and assessment criteria for each LCR, as well as the products the SRB needs to conduct its assessment and the schedule for delivery of the products. PP&C contributions include whether	(The *Standing Review Board (SRB) Handbook* provides a template for the LCR ToR.)

Product	Description and PP&C Contributions	Requirement Source
	LCRs will be conducted as one or two-step reviews, and identification of delivery schedules for PP&C plans and products to be reviewed.	

Develop Agency Baseline Commitment (ABC)

A key output of the planning process is the project's ABC, an integrated set of project requirements, cost, schedule, technical content, and when applicable, the JCL. PP&C Integration is responsible for establishing the PP&C products included in the ABC; i.e., LCC, JCL and UFE (from the Cost Estimation/Cost Assessment function), and baselined IMS (from the Scheduling function), and ensuring consistency between those products, project requirements, and technical content included in the ABC. The ABC is authorized by the Decision Authority at KDP C and documented in the KDP C DM.

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 an LCC of $250 million or more 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. The Agency expects a project to meet the commitments made at KDP C, and for the LCC and ABC authorized at KDP C to remain the same throughout Implementation. For projects with an LCC 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. ABC rebaselining is controlled through a formal approval process. (See Section 5.5.4 in the *NASA Space Flight Program and Project Management Handbook* for details on cost or schedule growth that triggers external reporting requirements and/or rebaselining. See the *NASA Space Flight Program and Project Management Handbook* for information on the formal rebaseline approval process.)

The KDP C DM also documents the MA, which defines the parameters and authorities over which the project manager has management control. The MA includes the schedule and cost (by year) at which the Agency agrees that funding will be made available to the project and at which the project manager and the Center agree to deliver the content defined in the Project Plan. UFEs and schedule margin available within the MA are also documented. The UFE and schedule margin held above the project by the program and/or Mission Directorate are documented in the DM and constitute the difference between the MA and the ABC. During planning and execution of the project, as risks are realized, the project manager may utilize the UFE or schedule margin documented in the MA. In addition, UFE and schedule margin held above the project may be released to the project through a change to the MA, which requires amending the DM. (See the *NASA Space Flight Program and Project Management Handbook* , Section 5.5.6 for additional information on the DM and MA).

While at the Agency level, the ABC is the baseline against which the Agency's performance is measured, at the project level, the project's performance is measured against the cost and schedule documented in the MA at KDP C. The project manages to that part of the cost included in the MA that can be allocated to a specific WBS subelement, i.e., the total cost in the MA minus the UFE in the MA.

Support Development of Descope Options

Proactively developing candidate descope options early in the project life cycle provides an orderly process should a reduction in scope be needed later during the life cycle of the project. (Descope simply means that the original project has been partly reduced in capability.) The project should maintain a descope list and keep records of descopes taken and continue to solicit descopes to add to this list. PP&C Integration supports the development of candidate descope options and enables a systems view to ensure that all potential interactions, including impacts to cost, schedule, and risk are identified. Descopes for projects may include removing parts of the project (e.g., an instrument, reducing the capability of a system, shortening the operational life of the mission). Establishing baseline requirements as well as a minimum acceptable project mission (a level below which the project should not go forward) is necessary prior to developing descope options. Candidate descopes should not cut a project below what is needed to carry out the minimum acceptable mission. (Some communities use "threshold" terminology to describe this minimum.)

Descope Considerations

- What is the project's minimum acceptable mission?
- What are the candidate descope options?
  - Are they realistic?
  - When does the decision to implement the descope need to be made?
  - What are the impacts to cost, schedule and risk if the descope is implemented?
  - Does the descope violate any constraints, ground rules or stakeholder expectations?

The need to exercise a descope option may be triggered by several different events such as the need to mitigate unexpected risks or to address the unavailability of a new technology that was expected but cannot be delivered on time. A descope may occur in reaction to an unplanned budget cut or a continuing resolution. Budget cuts and continuing resolutions are unfortunate situations and cannot be accurately predicted. However, the project can develop preplanned descope options for such events. In the event of a budget cut, the options can be adjusted or optimized to achieve the maximum project content or scope that the new budget (and/or schedule) allows. A descope may also be needed if the project is performing poorly against its plans and is overrunning cost and/or slipping the schedule. The descope is often used in this case to get the project back within the cost and schedule box.

It is important to identify and document meaningful descope options early in the project life cycle and to obtain buy in from stakeholders, the program, and for science projects, the Principal Investigator (PI). One strategy is to negotiate descope options and include them in the Project

Plan. Descope options can be presented at project LCRs and KDPs. This can be effective in building adequate scope margin into the Project Plan. Documentation of each potential descope option needs to include the following:

- A detailed description of the descope;
- The effect of the descope on the minimum acceptable mission and success criteria;
- The cost, schedule, and risk impacts resulting from the descope; and
- Key decision dates by when the descope needs to be exercised to realize cost and/or schedule savings.

Descopes taken as early as possible in the project (i.e., during Formulation) have the highest possible value. Many candidate descopes are possible and beneficial when taken early in the project life cycle. However, the need to descope may not be identified until late in the project life cycle when the descope may be much less useful or even increase overall project risk. Although descoping is sometimes necessary, it should be a last resort. Having a good plan, and monitoring and controlling cost and schedule performance are key to early problem identification.

3.2.3.1C Provide Guidance, Decisions, and Adjustments to Other PP&C Functions

PP&C Integration provides guidance to other PP&C functions in the form of key business decisions, the PP&C Management and Control Plan, and feedback on plans and products.

Identify Business Decisions

Key business decisions drive the business operations of the project and establish high-level guidance and a framework for how the PP&C functions conduct business. Decisions may include modification of standard business approaches; how PP&C functions will work with each other and with the project's technical and external organizations; how PP&C products will be developed, distributed, and used throughout the project life cycle; and the types of contracts the project will use.

Key business decisions include establishing key interfaces between the PP&C functions and the project technical organizations and systems, and interfaces with external organizations and systems. These include system-to-system interfaces that provide electronic access to technical information needed by the PP&C functions. Examples of system-to-system interfaces between PP&C functions and project technical systems include:

- Interfaces with the technical requirements database to identify changes in technical requirements;
- Interfaces with the technical design database to identify major technical architecture and design changes; and
- Interfaces with the Risk Management database to obtain information on risks that may drive cost and schedule, and cost and schedule confidence levels.

Interfaces between PP&C functions and organizations or systems external to the project include interfaces with contractor financial systems and interfaces with Center and Agency financial and budget systems.

Interfaces need to be documented and agreed to by the providers and users of the data. Interface definitions need to include descriptions of the specific data including the structure and format of the data, frequency requirements for the data, the source of the data, and descriptions of how the data will be used by the receiving function/process or system. (Note: Some interfaces, such as interfaces with Agency financial and budget systems, may be standardized and documented by the owners of those systems.)

PP&C Integration also ensures that an appropriate strategy is in place for tracking and managing liens, threats, and risks. In the absence of applicable Mission Directorate, Center, or program polices or guidelines, the PP&C integration manager develops the definition of liens and threats that will be used by the project and identifies any relationship between liens, threats, and risks. Processes are established for requesting, approving, and tracking liens and threats. In addition, guidelines are developed for encumbering liens, including liens in the EAC, and quantifying threats.

Business Decision Considerations

- Will we use any non-standard approaches to doing business?
  - Are any changes needed to the standard WBS approach?
- How will the project be controlled?
  - How and when will data be gathered, integrated and analyzed, assessed?
  - What PP&C performance indicators will be used to track and monitor cost and schedule performance?
  - How will actions needed to maintain cost and schedule performance be developed and implemented?
  - How will adjustments be incorporated into the plan (e.g., baseline, EAC)?
- How will we interface with other personnel and organizations to do business?
  - Internal project personnel and organizations?
  - Host Center, other Centers, and Mission Directorate personnel and organizations?
  - Contract and supplier personnel?
  - Other projects we are a part of, such as launch services?
- What are the communication protocols within the PP&C team?
- What is the business rhythm – team tag-ups, management meetings?
- What are the internal and external reporting requirements?
  - What reports need to be generated, who are they for, when will they be produced, who will produce them, who needs to review them prior to distribution?
  - What is the purpose of the reports? How will the information be used - information only, decision making?
- What types of contracts will we use and how will we work with Contracting Officers (COs) and Contracting Officer's Representatives (CORs) to manage the contracts?
  - What contract clauses and types of award or incentive fees will we use?
  - What are the termination liabilities and how will they be funded?
  - How will contract modifications be handled?
- How will we deal with contributions from partners, e.g., the European Space Agency (ESA)?
- How will the lien process be implemented?
- What is the project's understanding of UFEs held at the Mission Directorate and/or the program levels and how to request allocation of that UFE to the project if needed?
- What are the processes for managing and tracking liens and threats?

PP&C Integration establishes the PP&C performance indicators that will be used to monitor project cost and schedule performance over the life cycle of the project and identifies the frequency at which each indictor needs to be updated and tracked. Indicators may vary between projects based on project size and complexity. Table 3.2-4 identifies typical PP&C performance indicators. The appropriate set of indicators will provide insight and support control of the project. Note that PP&C needs to monitor key Technical Performance Measures (TPMs) as well as the PP&C performance indicators.

Table 3.2-4 Typical PP&C Performance Indicators

Function	Indicator	Description
Cost Trend	Actual cost	Shows actual costs accruals to current date
	Expenditure of UFE	Indicates a history of how the UFE has been spent in the past
	Cost/Obligations	Graphs the progression of the actuals, obligations and funding levels versus plans
Schedule Trend	Total slack time	Shows how much slack time there is in the IMS before key milestones are failed
Resource Trend	NOA	Current versus planned New Obligation Authority (NOA) per agreement
	Staffing	Shows current staffing resources versus planned
Integrated performance	EVM	Tracks earned value parameters including EAC
Risk Trends	Threats	Tracks the value of the items on the threats list over time
	Liens	Tracks the value of the items on the liens list over time
TPM Trends	See *SE Handbook*	See *NASA Systems Engineering (SE) Handbook*

Once PP&C performance indicators for the project have been selected, discussions should be held with all members of the project team to convey that these are the parameters that will be gathered and monitored. All PP&C functions should understand what kind of data they are expected to provide and how that data will be used to determine the performance of the project.

Develop PP&C Management and Control Plan

The PP&C Management and Control Plan is an optional, project-level document intended to support an integrated, organized summary of a project's PP&C activities in one document. The plan provides an overview of the PP&C organization and describes the guidelines and processes to be used for the different PP&C activities. It is recommended that the plan be used to document the following information (see Appendix G: PP&C Management and Control Plan for detailed information on recommended content and a template for the plan):

- **Requirements for the PP&C Effort**: The plan may be used to document requirements for the PP&C effort levied by governing Agency NPRs (e.g., NPR 7120.5, NPR 7120.7, NPR 7120.8) and any needs for tailoring the requirements. Requirements may include whether or not EVM is required; whether or not the project needs to develop cost and schedule range estimates, a cost confidence level, and a schedule confidence level in preparation for KDP B; whether or not a RLS or cost-loaded schedule and JCL are required for KDP C; which project control plans are required; and whether those plans are standalone documents or included in other documents. PP&C Integration implements the processes required for obtaining approval for tailoring requirements.

- **PP&C Stakeholders and Expectations**: The plan may be used to document PP&C stakeholders and expectations, including how they intend to use PP&C products. Stakeholders are personnel or organizations that have an influence on the way the PP&C products and data are developed, monitored, and reported. Customers (the project, program, and Mission Directorate) are key stakeholders, but other individuals or organizations may also have a stake or influence. Stakeholders may be either internal or external to the project. Internal stakeholders may include Control Account Managers (CAMs), support organization managers, and Center acquisition personnel. External stakeholders may include GAO, OMB, and Congress. As the project moves through the life-cycle phases, stakeholders may change. Some stakeholders may no longer be relevant, and new stakeholders may need to be identified.
    - For each PP&C stakeholder, it is important to develop an understanding and agreement on their expectations, concerns, needs, and objectives. This clarifies goals or objectives, such as expenditures, time to deliver, performance objectives, and support expectations. Stakeholders may have different viewpoints. For example, the customer may want to receive both detailed and summary information on current project cost and schedule estimates, whereas a Center organization may only be interested in their support personnel expenditures.
    - It is important to identify the measures that will be used to monitor satisfaction of the expectations. The expectations and measures need to be documented. It is a recommended practice to obtain some form of commitment through informal agreements such as email or formal agreements such as the Project Plan, LCR ToR, and KDP DM.

- **PP&C Organization**: The plan may be used to document the PP&C organization structure. If the project is large, the roles, responsibilities, and authorities required to perform the activities of each PP&C function need to be assigned to the PP&C suborganizations. These assignments may be documented in the plan. The plan may also be used to document key interfaces within and external to the PP&C organization, PP&C training requirements and PP&C workforce skills, staffing, and resource requirements, including plans to use workforce skills at other Centers to conduct PP&C efforts.

- **Guidelines and Processes:** The plan may be used to document guidelines and processes for PP&C activities, including establishing, tracking, and managing UFE and schedule margin; defining, tracking, and managing liens and threats; resource and funds management; work management, including development of the WBS, work agreements, and control accounts; cost estimation and schedule development, including methodologies to be used; and schedule, cost, and integrated performance management, including use of tools and analyses, development of products and associated processes for configuration and change management, identification of performance indicators, approaches for evaluation and tracking, strategies for controlling cost and schedule risks, and mitigation approaches for correcting cost growth and schedule extensions. (Note that many of these guidelines and processes are developed by other PP&C functions.)

Evaluate and Provide Feedback on Plans and Products

PP&C integration evaluates key plans and products from the other PP&C functions and provides feedback and recommendations on changes when needed. The overall objective is to ensure the adoption of reasonable approaches consistent with the project scope of work, including the environment, constraints and ground rules, and the strategy for executing the scope of work. PP&C integration also works to ensure that the key PP&C plans and products are, as a whole, consistent, cohesive, comprehensive, and complementary. Examples of these key plans and products include the cost methodology and cost estimate, schedule methodology and schedule estimate, WBS and final WBS Dictionary, Acquisition Plan, and identified risks.

Guidance, Decisions and Evaluations of other PP&C Functions Considerations

Resource Management

- How credible is the planning?
    - Are there any unique approaches?
    - What is the methodology for establishing control accounts?
    - Is it compliant with the EVM baseline? (Work packages, schedule, performance measuring techniques)
- Is the EVM planning commensurate with the project scope of work, i.e. right-sized?
- Has the WBS been established to the appropriate level of detail given the project scope of work?
- Is the WBS product-oriented (versus organizationally oriented)?
- Is the workforce profile consistent with the schedule and funding profile?
- Is the workforce profile reasonable? Is it achievable?
    - Are there any steep ramp-ups, ramp-downs, significant spikes, inconsistent man-loading (example: 20 FTE one month, 50 the next, then 10 the third and 30 the fourth)?
    - Is the workforce plan consistent with historical data? (Example: History shows project workforce tends to stay flat during the last 6 months of the project before launch. Plans to roll off the last 6 months of the project before launch represent a risk.)
    - Is the workforce front loaded? Back-loaded?
    - How does the project workforce profile line up with the workforce profile of the larger organization?

Acquisition and Contract Management

- Has the procurement office been contacted and involved early in the process?

Configuration and Data Management

- Have the PP&C products and data that need to be under configuration or data management been identified and documented?
- Do the methods for controlling data and documentation ensure the integrity and ready access to information?

Guidance, Decisions, and Evaluations of other PP&C Functions Considerations (cont'd)

Risk Management

- What mechanisms are in place to identify, monitor, and mitigate risks?
- What strategy is in place to track liens and threats?

Schedule

- Are there opportunities to favorably impact the schedule?
- Is the schedule consistent with similar missions?
- Is the incompressible test list consistent with the schedule?
- Is there a documented basis of estimate for the schedule?
  - Are the assumptions reasonable?
- Are schedule risks mapped to the baselined IMS and are mitigations incorporated?
- Are the schedule margins realistic and funded?
- Does the network logic make sense?
  - Was a health check performed?
- How credible is the schedule?
  - If there are separate schedule files, are the detailed schedules linked to the master schedule?
  - Is the critical path identifiable and without Level-Of-Effort (LOE) activities?
- If applicable, is the project schedule aligned and balanced with the line organization's internal schedule?
  - Number of line items, connection between the two schedules.

Cost

- Are there opportunities to favorably impact cost?
- How do the total cost estimate and the phased cost compare to similar missions?
  - Is the cost estimate credible, e.g., mission to Moon versus Mars, same price?
- Is there a documented basis of estimate for the cost estimate?
  - Are the assumptions reasonable?
- Does the cost estimate account for the identified cost risks and are mitigations incorporated?

3.2.3.1D Refine the Plan

As the project moves through the planning phase, the engineering team focus shifts to developing detailed requirements, developing the preliminary design, determining the number of instruments, and developing assembly, integration, test, and launch operations plans. PP&C Integration is focused on maturing, assessing, and refining the initial plan to produce an executable plan. Additional information becomes available enabling the PP&C team to further develop the WBS, produce more detailed schedules and cost estimates, update risks, finalize budgets, and develop the Phase C/D cost estimate. Refinements to the plan occur throughout the planning process and PP&C Integration integrates all the various business functions, activities, products, and decisions in support of producing the executable plan.

Development and refinement of the plan is an iterative process that results in the output of an executable plan and key deliverables, including a defined risk list, a final WBS and WBS Dictionary, baseline control plans, an integrated cost and schedule plan, which includes the LCC and IMS baselines, and the ABC, JCL, and UFE if applicable. The LCC and IMS baselines serve as the basis against which the plan is controlled and assessed during the control phase of the project. The following questions represent some key considerations in assessing and refining the plan to produce an executable plan.

Plan Refinement Considerations: Programmatic, Technical, Workforce

Programmatic

- Any changes in constraints, ground rules and assumptions, stakeholders or stakeholder expectations?
    - Center workforce allocations
- Any political/environment changes?
    - Personnel
    - Performance by other projects within the program?
    - Foreign partnerships

Technical Requirements, Designs, and Plans

- Any changes in technical requirements?
- Any changes in architectures or technical designs?
- Any new technical issues?

Workforce

- Are there any changes in the workforce makeup?
- Are the key team members in place?

Plan Refinement Considerations: Contracts, Risk, Funding, Cost, Schedule, Integrated Baseline

Contracts

- Are there any changes in the contract?
  - Contract rates – When was the last Defense Contract Audit Agency (DCAA) audit?
  - Termination and liability shift
- What is known about the system contractor?
  - Is their business base up or down?
  - What risks have been mitigated or eliminated?

Risk

- What new risks have emerged?
- What risks have been mitigated or eliminated?

Funding

- Is the recent PPBE funding forecast consistent with the project baseline (LCC, IMS) to be authorized at KDP C?
  - If not, what flexibility is available to modify the PPBE plan to better align with the desired cost profile?
  - How will the project have to adjust its schedule and cost estimate if flexibility is not available?

Cost

- Is there full cost and schedule integration in the baseline to be authorized at KDP C?
- Does the Independent Cost Estimate (ICE) show the Phase C/D estimate to be credible and realistic?
- Have the various ICE's been reconciled?
- How realistic is the project UFE?
- Have procedures been established for managing liens during Implementation?
- Are the cost estimate and UFE consistent with similar missions?

Schedule

- Are the schedule and schedule margin consistent with similar missions?
- How is the schedule margin quantified and held?

Integrated Baseline

- What is the plan for any IBR?
- Are the cost and schedule integrated?
- Has the integrated cost and schedule baseline captured the full scope of work for the project?

3.2.3.2. Control Activities

This section discusses in detail the PP&C work required to gather the data needed to effectively manage the integrated cost, schedule, and risk performance of the project; integrate and analyze that data; conduct assessments, develop and recommend options and/or corrective actions for maintaining project performance within plan, and effectively "tell the story;" and implement approved actions and monitor their impact. This section also provides insight into PP&C Integration's role in supporting reviews, audits, and external reporting. As in the Planning Activities section, questions and other information that the PP&C Integration function should consider are provided in blue boxes.

3.2.3.2A Gather Data

This activity is focused on gathering project data for determining where the project is with respect to cost, schedule, and risk, and answering the following questions:

- What are the project's current cost and schedule performance and trends?
- What is the project's resources status? What are the trends?
- What is the project's current risk status? What is the remaining risk on the project?
- What is the status of the PP&C performance indicators?

Data and information on current cost and schedule performance, resources status and risk status is received from both internal and external sources. There are numerous sources of this information such as technical, cost, schedule, and risk status and performance information from systems, subsystems, and contractors; EVM reports; PP&C performance indicator and TPM reports; UFE, liens and threats status reports; resource utilization status reports, and risk reports. The data and information are combined and compiled to produce project level information on the technical, cost, schedule, and risk posture of the project, and monthly reports are generated based on that information.

The gathering of data and generation of technical, cost, schedule, and risk status information is performed in large part by the other PP&C functions, with PP&C Integration providing oversight and guidance. On some projects, the compilation of the data into project level information may be performed by PP&C Integration instead of by the other PP&C functions.

3.2.3.2B Integrate and Analyze the Data

This activity is focused on determining the project's integrated cost and schedule performance and trends, comparing performance against the project's plans, identifying variances, and conducting analyses to develop the "big picture," i.e., an understanding of what is driving current performance at the project level. It is essential to identify the appropriate data and level of data needed to conduct a good analysis to thoroughly examine and ask questions about the data, identify correlations between the data and determine any causal relationships, and identify key drivers and sensitivities with respect to the project's integrated cost and schedule performance and risk status to produce useful information about where the project is, where it is supposed to be, and where it is headed. Data analysis should be at the subsystem level at least and should examine the WBS elements with the highest risk.

This activity answers the following questions:

- What is the project's current integrated cost and schedule performance?
- How does it compare to historical performance on similar projects?
- What are the integrated cost and schedule performance variances and trends? Where is project performance headed? What is causing the variances and trends? Can we identify key drivers and sensitivities?
- What are the relationships between the facts? Are some facts correlated with other facts? Are some trends causing other trends?
- Is the project's integrated cost and schedule performance on a track that will result in achieving project objectives within cost and on-time (i.e., within the approved ABC)?
- Are we in good shape or are there problems we need to address?

Status data and information is compiled and integrated to produce a cohesive and comprehensive set of project level information on integrated cost and schedule performance and trends and workforce and infrastructure utilization and trends. It is essential to integrate cost performance and trends with schedule performance and trends and to identify potential impacts of workforce and infrastructure utilization on both cost and schedule performance. For example, current project cost trends may not reflect the full impact of current schedule performance and trends, so the project analyst needs to account for what is happening with the schedule to produce an accurate integrated cost and schedule picture. (Risk status and project and external events including TPM trends may also have a huge impact on future cost and schedule performance.)

The following questions represent considerations for integrating the data and information, determining the project's current cost and schedule performance, identifying and analyzing variances and trends, discovering correlations and causal relationships between the facts, determining key drivers and sensitivities, and discovering problems and issues that may need to be addressed to maintain project cost and schedule performance within plans. The questions are grouped into seven major areas: schedule, cost, schedule margins and UFE, trends, funding, workforce and contractor effort.

Integrating and Analyzing the Data Considerations

Schedule

- What is the ratio between the number of planned starts versus actual starts on tasks for the period and cumulative-to-date?
- What is the ratio of the number of tasks planned to complete versus the number of tasks actually completed during the period and cumulative-to-date?
- What is the ratio of costs expended to complete tasks versus the planned costs to complete tasks for the period and cumulative-to date?
    - Example: If the plan was to spend $200,000 to complete four tasks during the period and the project completed only three but spent $250,000 on those three, then there is a problem.
- Are the hardware deliveries to assembly, test, launch and operations on track according to plan?
- How consistent is the critical path from period to period?
    - Does it change frequently? If so, why, and what resource impacts are there?
    - Are there significant workarounds? (Workarounds often add cost and schedule.)
- What are the key drivers? Are they aligned with the risk list and are there mitigation plans?

Cost

- How does the burn rate compare to the plan? If it stays flat, how does that compare to the EAC? Look at the budgeted work to go (i.e., unearned Budgeted Cost of Work Performed (BCWP)). If the burn rate per month remains stable, how does it compare with the project EAC?
    - Example: If the total budget for a major task is $20 million at launch and the project has earned $14 million and spent $15 million, the budgeted work to go is $6 million ($20-$14).
    - If the project is spending $1 million per month, which is expected to be flat until launch, and launch is 8 months away, it suggests the project will be over budget by $3 million. ($15 million spent + $8 million to go = $23 million. The budget is $20 million; therefore, the project will be over budget by $3 million.)
- What are the cost expenditure percentages by key milestones (PDR, CDR, SIR)?
    - If 40% of the budget was spent by CDR, is that consistent with previous similar missions?
- Are the cost ratios for key resources consistent with similar missions? e.g., $$ per kg; $$ per Watt, etc.)
- How are costs (and schedule) for key deliverables/subsystems performing as compared to similar missions? (e.g., risk areas such as power supply, reaction wheels, actuators, antennas, radar subsystem, cryo-coolers, etc.)
- Is there any uncertainty relative to the differences in cost and obligations?
- Is the project obligating and costing on a monthly basis consistent with plan?
    - If the project is exceeding its plan, is it at risk of requiring an operating plan change to accommodate needed additional funding to maintain schedule?
    - If it is behind its plan, is it at risk of work content slipping to a future year,

increasing out-year cost and budget requirements?

- Have cost overruns occurred to maintain or improve schedule or are cost and schedule indicators both deteriorating?

Integrating and Analyzing the Data Considerations (cont. (1))

Funding

- Does the current year funding profile support the project's current year cost and schedule requirements?
  - Is the project's carry-over of unobligated and uncosted funds consistent with its planned expenditures for the current year?
  - Has the project entered the fiscal year behind schedule or at a higher- or lower-than-planned 'burn rate' such that the current year's planned work content is in jeopardy?
  - Is international partner delivery slipping such that the project may have to slow down some of its planned current year expenditures?
  - Is the project keeping a focus on the funding requirements that bypass its direct budget, such as launch services or any space communication costs? (The project is responsible for tracking these costs even though the project may not directly execute these funds.)
  - Is the carry-forward into the next fiscal year sufficient to support the project under a Continuing Resolution (CR)? What is the current funds exhaustion date?
- Are there any potential issues that will impact the management of project funding?

Workforce

- Is the workforce plan consistent with the schedule and costs incurred and the Estimate To Complete (ETC)?
  - Example: Fractional FTEs on projects have significant impacts on the project's ETC. Compare fractional FTEs with actual people.
- What is the magnitude of the labor rate variance? What is the impact on the ETC and schedule?
  - Example: A high labor category was planned, but the project is using a lower labor category or vice versa.
- What is the performance, composition, and quality level of the people on the team?
  - Example: A senior level manager may perform less well than a junior on a lower level task or vice versa.
- Does the staffing correlate to the funding profile or the work schedule?

Contracts

- Are directed changes to the contracts priced and negotiated? Are they on the lien list or in the EAC?
  - Are there known and documented directions to proceed with the changes?
  - Or, are there any missing documented or verbal directions to proceed with the changes?
- How has the contractor performed on similar missions?
- How have contractor cost expenditures lined up against key milestones?

- Is the contractor workforce profile consistent with its cost and schedule?
- What is the timing of contract cost: actual versus accrual?
- Is there a significant difference between NF 533 and Systems Application Products (SAP) financial system data?

Integrating and Analyzing the Data Considerations (cont. (2))

Schedule Margin and UFE

- What are the margin and UFE burn-down percentage at key milestone events (CDR, SIR)?
- Have margin and UFE utilization retired the risks on the risk list?
- Is the project managing UFE and schedule margin within the current year such that it is not shifting current year liens, threats, or risks to be addressed in a subsequent year?
- Is the project pushing off current year content to accommodate a lower-than-required UFE level in the face of emerging unexpected risks?
- How have margin and UFE utilization affected the schedule? (e.g., added people, therefore created workarounds, slips?)
- What is schedule margin utilization and is the schedule margin funded?
  - How much float is in the schedule?
- Is the margin and UFE utilization consistent with the design principles?
  - Is the UFE balance sufficient, given the current ETC and adjustments for any projected cost growth?
- How are margins and UFE being utilized?
  - Scope change (this is generally not an appropriate use of UFE or schedule margin)
  - Growth (workmanship, technical issues, complexity, poor planning, omissions)
  - Risk buy down
- Is the margin and UFE balance reasonable after liens are incorporated?
  - Are liens managed in accordance with the procedures defined during the planning phase?
- Are margins and UFE being allocated realistically for WBS items that historically have a high overrun probability?
  - For example: Bypass; labor at assembly, test, launch, and operations

Trends

- What are the key performance trends (e.g., Cost Performance Index (CPI) and Schedule Performance Index (SPI)) for the past three months? Six months? What are the trends on key subsystems and high risk tasks? What are they saying?
- What are the workforce trends as compared to the plan over the past three months? Six months?
- Is the EAC sufficient to complete the scope?
- What do the major contractor performance trends indicate over the past 3 and 6 months? How are contractor workforce versus cost versus schedule comparisons?
- How are cost expenditures as compared to schedule accomplishment?
  - Are costs going up to maintain or improve schedule? Are costs going up and schedule deteriorating?
  - Are costs on plan and schedule on plan?
- How are performance trends as compared to similar missions at similar points in their life cycle?

- Has the project implemented any of the corrective actions identified in prior reviews and how has that impacted cost and schedule performance?
- Are the impacts to cost and schedule reflected in the most recent risk matrix?

3.2.3.2C Assess and Recommend Actions

This activity is focused on assessing all available, relevant data and information to determine likely future cost and schedule performance, forecasting the project's EAC, developing recommendations for project management for maintaining or returning project performance to the right track if needed, and effectively "telling the story," perhaps the most critical PP&C responsibility. This activity underscores the leadership role of the project control analyst on the project.

The PP&C Integration function assesses current performance, trends, and variances; the data relationships, key drivers, and sensitivities; and the issues and problems uncovered as part of the data integration and analysis activity. All constituencies of the project team need to be engaged in substantive discussions about project performance to make high-quality assessments of what is really going on and determine what actions need to be taken. A high-quality assessment must include consideration of the remaining risk on the project, and the likely impacts of that risk on future cost and schedule performance. Additionally, project and external events with the potential to impact the project's cost and schedule performance need to be identified and evaluated. Issues and problems that need to be addressed are identified. Recommendations are developed on options and/or corrective actions needed to in order to maintain or return project performance to plan. Finally, all the relevant information and impacts are communicated to project management and other stakeholders, with an emphasis on what the data is telling the project and what decisions need to be made.

This activity answers the following questions:

- What is the likely impact of remaining risk on project cost and schedule performance?
- What are the potential impacts of project and external events on cost and schedule performance?
- What is the integrated cost and schedule forecast and the EAC?
- "So what?" What is all this information and analyses telling us about the project?
- What does the project need to be concerned about, and to what extent?
- What actions are needed to maintain or return project cost and schedule performance within plan?

It is essential to assess the likely impact of remaining risk on the project in order to forecast future performance. The likely impact is highly correlated with the project's remaining schedule margin, UFE, and the status of project liens and threats. See Section 3.4 and Section 3.7 in this handbook for information on different methodologies and analysis techniques available to PP&C to assess the likely impact of remaining risk, including Schedule Risk Assessment (SRA) and Quantitative Risk Analysis (QRA), respectively.

Identify Project and External Events Impacting Cost, Schedule, and Risk Performance and Determine Potential Impacts

In addition to current integrated cost and schedule performance, variances, and trends and the remaining risk on the project, there are a myriad of project and external events that may impact the project's future performance. PP&C integration needs to continuously take proactive steps to identify these events and assess their potential impact. The sooner events are identified and assessed, the sooner and easier it will be to effectively address the impact of those events if necessary.

Examples of project and external events that may impact the project's performance are provided below. Project events may include programmatic, technical, workforce, cost, schedule, risk and acquisition issues, changes, trends, and decisions.

Examples of Project Events with Potential to Impact Cost and Schedule

- **Changes to the project and/or PP&C constraints, GR&A:** For example, the Agency may change the expected workforce allocation for participating Centers.
- **Proposed changes to the technical and programmatic baselines:** Changes to technical or programmatic requirements, and changes to technical designs may impact cost and schedule. It is essential to fully understand these impacts *before decisions are made*.
- **Inability to develop planned technologies:** There may be cases when the technical design includes plans to develop a specific technology, and the project decides that the technology is not maturing adequately.
- **Technical Performance Measure (TPM) trends:** TPM trends may represent a potential for future adverse impacts to cost and schedule.
- **Technical margin trades (power, mass, data rate, etc.):** For example, the project may decide to trade some mass for extra power. This may impact the cost forecast.
- **Trends in liens and threats:** Trends in liens and threats may represent a potential for future adverse impacts to cost and schedule.
- **Unexpected increases in cos**t: Examples include increases in the cost of materials or labor rates.
- **Workforce**: Inability to acquire needed staffing/expertise in a timely manner.
- **Realization of risks:** Previously identified risks that are realized.
- **Identification of new risks or changes to existing risks:** For example, a new risk with a significant likelihood and a risk mitigation plan with significant cost and schedule impacts is identified.
- **Unexpected delays:** Examples include a delay in the availability of a test facility or a delay in the delivery of materials. Delays often affect the ability of the project to maintain the planned schedule.
- **Acquisition delays:** The acquisition process for selecting and awarding a contract may take longer than anticipated.

External events may include programmatic, financial, budget, schedule and partnership issues, changes, trends, and decisions. (It should be noted that the examples may not be mutually exclusive, and it could be argued that some examples fit well in either or both categories.)

Some project and external events may be identified by other PP&C functions. For example, changes in labor rates may be identified by the Resource Management function, and delays in completion of tasks or in availability of facilities may be identified by the Scheduling function.

Examples of External Events with Potential to Impact Cost and Schedule

- **Changes in stakeholder expectations:** For example, the Mission Directorate may change expectations for participation by foreign partners.
- **Changes in other program projects:** For projects that are part of tightly coupled programs, schedule delays in other projects may have significant impacts to the project's cost and schedule.
- **Reduction or reassignment of civil servant FTE:** Changes in Agency or Center priorities may result in reductions and reassignments of FTE, which may impact the project's schedule.
- **Loss of a key supplier:** For example, a key supplier of a component may go out of business.
- **Industry issues:** National shortages in key materials, counterfeit parts, substandard materials, etc., may impact an entire industry.
- **Changes at the contractor facility:** Changes that could impact the project relative to cost, schedule and workforce, such as:
    - Loss of business at their facility on other projects or proposals might result in the workforce staying longer on the project and driving up rates.
    - Winning new business at their facility could mean key resources will be taken off the project and moved to new projects, which might have schedule implications.
- **Changes in major suppliers:** A major supplier may have scheduling/manufacturing issues, changes in volume capacity, higher demands on their resources, loss of key personnel, changes in rates, or shifts in physical locations.
- **Continuing Resolutions**: A project on the upward slope of its funding curve may be held to the previous year's funding limit. A CR has a very real potential for increasing the total cost of the project. Expect this type of perturbation and plan for it.
- **Budget events:** (It should be noted that changes may occur outside of the budget formulation process.)
    - **Decreased early funding**: There may be a problem getting sufficient funding early in the project.
    - **Budget cuts:** Factors outside the project can result in budget cuts during any fiscal year. Such cuts can be the result of events such as changes in Agency plans and Congressional cuts.
    - **Changes to funding profile:** The fiscal years in which funding is received may be changed. Even when there is no change to the project's total budget, a change in the project's funding profile may have a significant impact on the project's technical and acquisition plans, and on the project's cost and schedule estimates.
- **Reduction of UFE**: Any reductions to UFE by the program/Mission Directorate reduce the ability of the project to achieve cost and schedule targets. When UFE is a product of

the probabilistic JCL analysis, any reduction reduces the probability of achieving the project cost and schedule targets in a manner that can be explicitly quantified.

- **Inability of a partner to meet the terms of their agreement:** For example, independent funding for a partner may be reduced, impacting the partner's ability to provide their product on time.

The PP&C integration manager ensures that a conscious decision is made on the appropriate response to identified events. Appropriate responses range from placing an event on the project's threat list to fully assessing and quantifying the potential cost, schedule, and risk impact of an event. In all cases, identified events and the proposed project response need to be communicated to project management.

If needed, assessment and quantification of the potential impacts of an event need to be done in a timely manner. The impact assessment may be developed collaboratively by PP&C and another project organization. For example, the project SE organization will likely be involved in assessing potential cost, schedule, and risk impacts of changes in technical requirements or design or adverse trends in TPMs. Regardless of whether or not there is a formalized system in place to assess the potential impacts of events, the PP&C integration manager needs to ensure that the assessment is completed.

Early assessment of cost and schedule impacts due to proposed changes in technical and programmatic baselines is essential. This information is needed before the decision is made on whether or not to accept the proposed changes. Knowing the cost and schedule impacts in advance has three benefits:

1. First, it gives project management the data to decide if the change is worth the cost.
2. Second, it enables the PP&C organization to begin early development of options for incorporating the change that minimize cost and schedule impacts.
3. Third, an estimate provides the project with a basis for negotiating the cost of the work to be accomplished, whether in-house or with a contractor, and developing a plan against which to hold the performing organization accountable.

Some events can be anticipated well in advance of their occurrence. For example, CRs have become the norm in recent years. A percentage of high-probability risks will be realized. The potential impacts of these "high-probability events" can be assessed before the events actually occur, and the effective PP&C organization will have predefined strategies and a suite of potential corrective actions "at the ready" to address such events should they occur. Some events may not threaten the project's cost and schedule performance and may not require significant corrective action. Different factors will impact the integrated performance differently depending on the project life-cycle phase. For example, a CR occurring in a year when the project's funding curve is on a downward slope will have minimal to no impact on project performance, but a CR during life-cycle Phase C, Final Design and Fabrication, when increased funding is planned, will likely have a significant impact on the project's integrated performance.

The results of the impact assessment on the project’s integrated cost and schedule performance need to be documented, including:

- A detailed description of the event, and its underlying cause(s) if applicable;
- Assumptions used in the assessment;
- The assessment approach: techniques, methods and tools used to quantify the potential impact;
- The potential impact of the event to the project’s integrated cost and schedule performance, in quantitative cost and schedule terms, and to the project’s risk posture.

Develop Integrated Cost and Schedule Forecast

The PP&C Integration function develops forecasts of future cost and schedule performance and EAC based on current cost and schedule performance and trends, the estimated schedule and cost of work left to do on the project, and the quantified cost and schedule impacts of remaining risks and project and external events. In the absence of applicable Mission Directorate, Center, or program policies or guidelines, the PP&C integration manager determines a minimum frequency for development of the comprehensive forecast of future cost and schedule performance and EAC, and any requirements for validation and revalidation of the EAC. Certain LCRs and KDPs, such as PDR and KDP C, are “forcing functions” for development of a comprehensive forecast and EAC. However, LCRs and KDPs are not the only times that development of a comprehensive forecast and EAC are in order. In addition to a minimum frequency, there may be triggers for developing a comprehensive forecast and EAC. These triggers may be difficult to define ahead of time, but it is important to establish guidelines for identifying such triggers.

If current integrated cost and schedule performance and trends are not within plan, or the integrated performance forecast and EAC indicate that future performance will not be within plan, or that the project will not be able to meet its ABC, PP&C Integration works with project management to develop recommendations on options and/or corrective actions needed to maintain or return project performance to plan.

Develop Options and/or Corrective Actions and Recommendations for Adjusting the Plans

Options and/or corrective actions for managing the project’s integrated cost and schedule performance need to be developed as soon as possible after the need is identified. No single answer or approach can be applied for addressing all situations requiring adjustment of plans, and there may be more than one option. Each case is unique. Reviewing past situations and understanding historical approaches for correcting those situations may be useful when deciding how to proceed. It is also wise to seek out other PP&C integration managers who have dealt with similar issues for advice and insight. The PP&C integration manager needs to engage project management and the project’s technical team to collaboratively develop appropriate options and/or corrective actions that maintain alignment between the technical objectives, risk and available funds, and schedule. In some instances, the project may also need to engage the Center, program, and/or Mission Directorate. Some options and corrective actions may require negotiating changes in the project's cost estimate and/or schedule estimate, which may require updates to the project's MA and DM. Others may require negotiating changes in stakeholder expectations, or program or Mission Directorate requirements. A combination or sequence of options/corrective actions may be required. Examples of options and corrective actions are included below.

Example Options and Corrective Actions for Adjusting the Project Plan

- **Allocate project UFE:** UFE held at the project level may be allocated to a particular task to address project issues.
- **Request UFE held at the program or Mission Directorate level:** For cases when the project determines that allocation of UFE is the appropriate option, but UFE held at the project level is insufficient. This triggers the Agency's replanning process. (See *NASA Space Flight Program and Project Management Handbook*.)
- **Implement an existing risk mitigation or workaround plan:** For example, if a risk concerning insufficient technical margins is realized, the associated mitigation or workaround plan needs to be implemented.
- **Implement a previously identified technology off-ramp:** If the project decides that a specific technology is not maturing adequately, continued technology development may be terminated, and an alternate approach identified in the project's Technology Development Plan may be implemented.
- **Select alternate "suppliers":** In cases where a supplier goes out of business or loses the ability to fully meet the project's needs, an alternate or additional supplier needs to be identified and selected.
- **Negotiate additional support from NASA Centers:** For example, a specific expertise at another NASA Center is needed by the project to address an issue.
- **Descope project:** This may include implementation of a preplanned descope option or of a new descope option. The gain from implementing a descope option diminishes quickly as the project enters Phases C or D. It is important to monitor the political environment to assess whether there are external reasons one or more potential descopes should or should not be exercised.
- **Modify technical architecture and/or design:** The technical team may determine that the only viable option to a technical problem is to change the architecture or design.
- **Extend launch date:** There may be situations where the only viable option is to extend the schedule and slip the launch date.
- **Rebaseline project:** If there are situations that cannot be addressed within approved cost and schedule estimates or commitments, or external events that are outside the project's control such as budget cuts or changes to the project's funding profile, the project may need to be rebaselined. (See *NASA Space Flight Program and Project Management Handbook*.)

The likely outcome of implementing each option/corrective action needs to be evaluated in terms of impact to the project's integrated cost and schedule performance. Detailed analysis of the options may be required. A decision package that compares and contrasts the options/corrective actions needs to be developed, including:

- A description of the current integrated cost and schedule performance, trends and variances, including data relationships, key drivers and sensitivities;
- Remaining risk and project and external events impacting cost and schedule performance;
- Forecasted future performance and EAC if no actions are taken;
- A detailed description of each option/corrective action, including:
    - When it needs to be implemented;
    - The project organizations responsible for implementing the option;
    - The cost, schedule, and risks associated with the option;
    - A description of the likely outcome of implementing the option/corrective action, including the projected impact to the project's integrated cost and schedule performance and EAC;
    - Any program, Mission Directorate, or Congressional approvals needed to implement the option/corrective action, including renegotiation of the project's MA and DM if necessary.
- Recommended option/corrective action and rationale; and
- Plans for implementing, tracking, and reporting on the results of the option/corrective action. The implementation plan may be straightforward or complex. At a minimum, identify: specific tasks, an implementation schedule and expectations for when results will be realized including specific, quantified improvements and/or stability in the project's cost and schedule performance over time.

Tell the Story

The PP&C integration manager needs to continuously "tell the story" by keeping project management apprised of the project's integrated cost and schedule performance "health" at all times, and by ensuring that all relevant information and impacts are communicated to project management and other stakeholders, with an emphasis on what the data is telling the project and what decisions need to be made.

It is essential to ensure that a clear picture of the real story is presented to decision makers. Summarize and highlight information that management needs to know. Focus attention on major issues and on just the data that is needed to convey message. Deciding what is less important or what to leave out is extremely difficult. Generally, present data needed to communicate areas with high cost, high technical risk, high schedule risk, or key integration points. Remember to identify positives. Metrics should help decision makers make the right short and long term decisions. When preparing to "tell the story," keep the audience in mind. Different audiences require different approaches. Methods and details communicate well to technical experts. Executive summaries and facts communicate well to executives and decision makers.

"Telling the story" includes effectively conveying:

- Current cost and schedule performance with respect to plan, including relevant trends, and where the performance is heading, i.e., the forecasted performance and EAC;
- Data correlations and causal relationships, key drivers and sensitivities behind the data;
- Current project risk status, including remaining risk, and the project's capacity to manage remaining risk based on the status of schedule margin, UFE, and liens and threats;
- Project and external events with the potential to impact cost and schedule performance;
- What the project needs to be worried about, and to what extent;
- Any actions are needed to maintain project cost and schedule performance within plan or return performance to plan; and
- The status of any previously approved actions.

If options or corrective actions are needed, the PP&C integration manager needs to advise the project manager of the options/alternatives and make a recommendation based on the decision package described earlier. It is important to state recommendations clearly along with the supporting rationale.

Information may be provided in the form of tables or graphs to facilitate evaluation and understanding of current performance trends and forecasts. Depicting current performance and trends against pertinent information such as planned project performance or historical performance in similar projects is extremely helpful. The specific tables and graphs used may vary from project to project, and need to be based on the needs and expectations of the project manager, other customers and stakeholders, and on the key messages that need to be conveyed. Adding information on what is "behind the data," i.e., causal relationships and key drivers and sensitivities, can significantly enhance the effectiveness of the tables and graphs. Above all, tables and graphs should help to "tell the story" by providing a clear, unambiguous, and complete picture of the project's current and future performance, clearly portraying any need for decisions or actions, and depicting the impacts of recommended options or corrective actions.

Figures 3.2-2 through 3.2-4 below are examples of how information might be graphed.

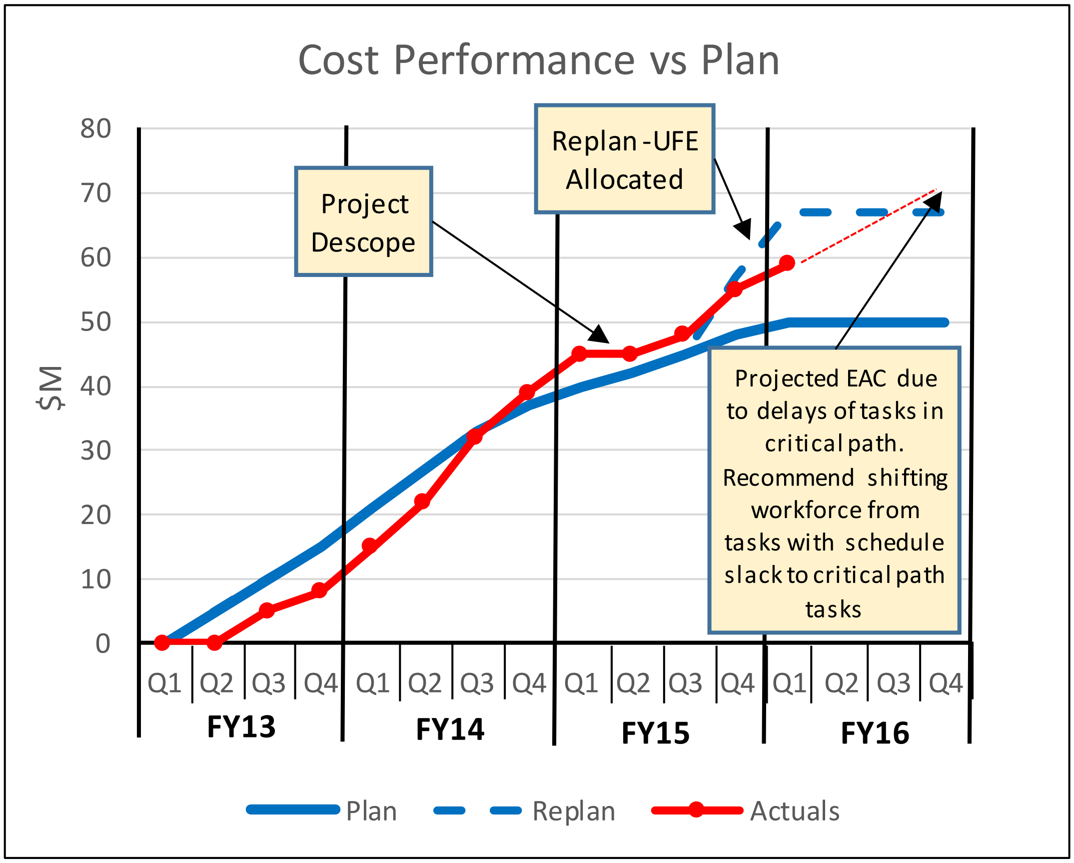


Figure 3.2-2 Example Cost Performance versus Plan Plot

Figure 3.2-2 compares the project's actual cost (solid red line with markers) and forecasted cost performance (dashed red line) to the project's cost plan (solid blue line). The figure shows that the project has had to replan and modify its cost plan by allocating UFE (dashed blue line). Despite the replan, the forecast indicates that costs may still exceed the cost plan. Comments added to the figure indicate steps taken previously to manage cost performance (descope), identify the replan (UFE allocated), explain what is driving the forecast (delay of tasks), and provide a recommendation for mitigating the resulting cost increase (shift workforce).

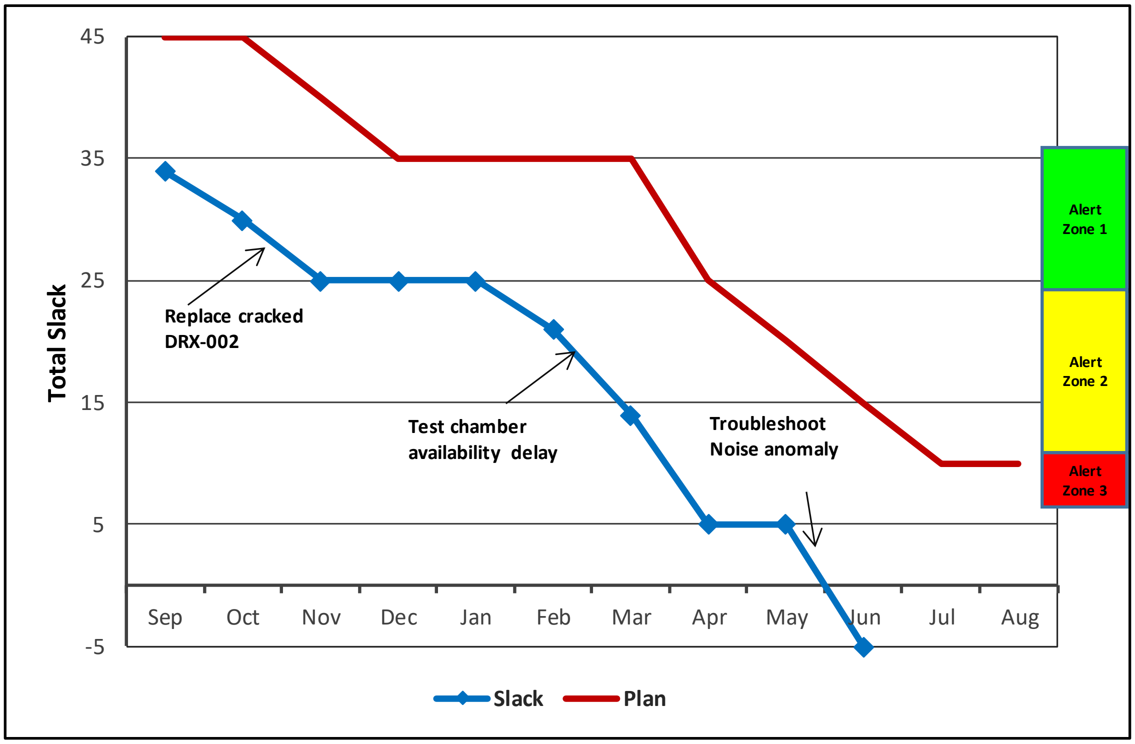


Figure 3.2-3 Example of Slack Trend Plot

Projects can track a variety of schedule metrics and indicators for understanding performance and forecasts. A key metric is total slack, which is the amount of duration a task can be delayed before impacting the project's completion such as launch, delivery, etc. While there is a variety of formats to track slack, Figure 3.2-3 shows the slack trend over time for a major deliverable. Comments added to the graph explain the unexpected issues that caused some of the schedule slack to be used. In this example, the project established "alert zones" which are thresholds that, when breached, may trigger action on the part of the project such as implementing a risk mitigation.

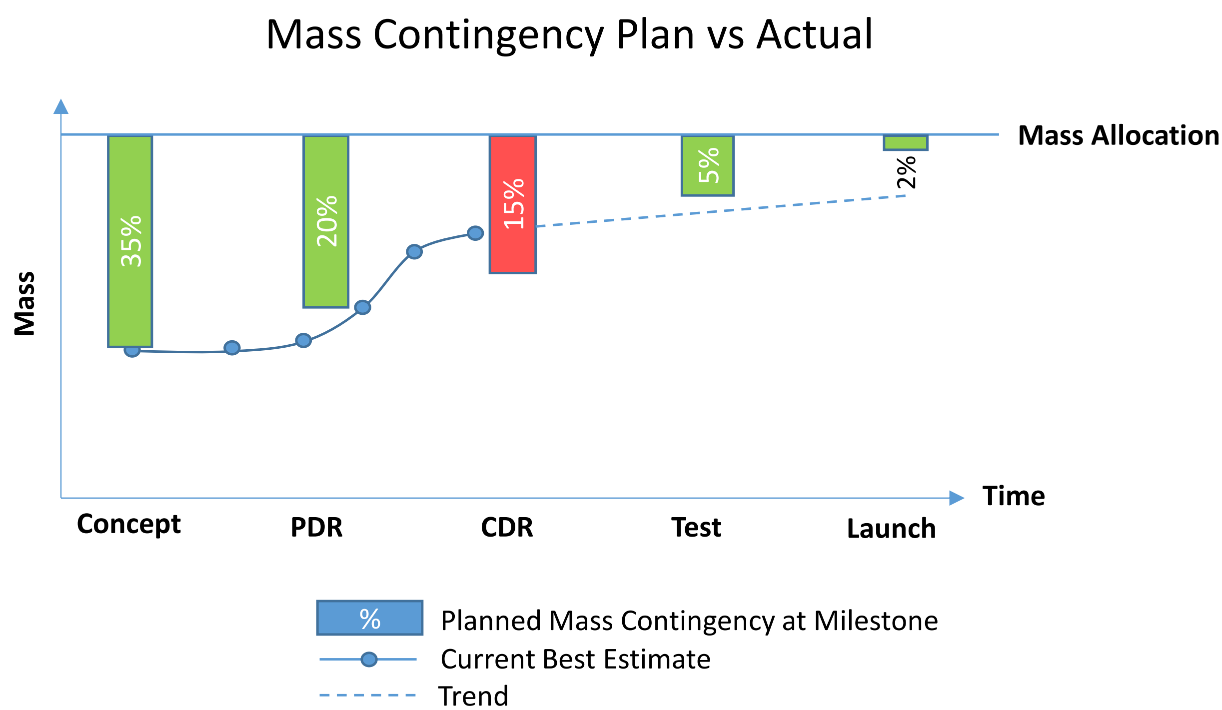


Figure 3.2-4 Example of Technical Performance Measure

Figure 3.2-4 shows the current mass of a system compared to the planned amount of remaining contingency and to the total allowable mass of the system. (TPMs and trends, such as current mass vs. planned contingency depicted in this figure, are developed by the project's technical team.) The PP&C team needs to evaluate the TPMs and trends to determine the potential impact to cost and schedule performance. The results of TPM analysis can be either positive or negative, so it is important to understand the impacts to the project (i.e., a positive TPM metric could result in cost savings, schedule improvements, risk reductions, and other opportunities. Conversely, a negative TPM could have an opposite effect, and decisions to reduce requirements or tolerances might be a potential solution). Analysts need to understand that there is a certain mass (or weight) ceiling that cannot be breached. The closer it is to launch, the less contingency is needed since most of the components have actual mass measurements rather than planned mass. (The contingency is only needed for mass that has not been actually measured.) Early detection of a breach in the contingency plan allows the project team to be proactive in determining if there is a real issue or not. If there is, analysts may see impacts to cost, schedule, and/or risks associated with resolution of the technical variance. The analysts should not rely on just the technical data without comparing it to variance reports and cost/schedule data. Assessments of the cost and schedule impacts and determination of appropriate corrective actions is a function of the PP&C team.

3.2.3.2D Implement Actions and Monitor Impact

This activity is focused on implementing and monitoring the outcomes of the option and/or corrective action approved by the project manager. Based on those outcomes, the EAC forecast is revised and the project's risk posture is reassessed.

This activity answers the following questions:

- Is implementation proceeding as planned, or are there problems that need to be addressed?
- How has the project's risk posture been impacted by implementation of the option/corrective action?
- How has the project's integrated cost and schedule performance and EAC been impacted?
- What adjustments are needed to the Project Plan for executing the scope of work, based on the approved option/corrective action?
- Do the adjustments trigger the Agency's replanning or rebaselining processes?

The plans for implementing, tracking, and reporting on the results of the option/corrective action are executed by the responsible organizations, including PP&C. PP&C adjusts the Project Plan, if needed, and tracks and reports on progress in improving the project's cost and schedule performance until the desired results are realized. If the desired results are not realized in the expected timeframe, the option/corrective action may need to be modified or a new option/corrective action may need to be identified.

The Project Plan is adjusted based on the approved option/corrective action. Adjustments may include the following:

- Updates to the schedule, including adding new tasks, changing the duration of or resources applied to existing tasks, changing the sequence of existing tasks, or deleting existing tasks.
- Updates to key milestone dates, including LCRs and launch dates.
- Distribution of UFE or allocation of schedule or technical margins, and associated updates to schedule margin, UFE, technical margins.
- Updates to the project's LCC.
- Updates to the project's EAC.
- Updates to planned cost and schedule performance, both short-term and long-term.
- Updates to the project's risk status, including updates to existing risks and associated mitigation plans, cost and schedule impacts, and entering new risks into the Risk Management System (RMS).

- Updates to the project's acquisition plans, including changes to and/or modification of existing contracts and partnerships and establishing new contracts or partnerships as needed.

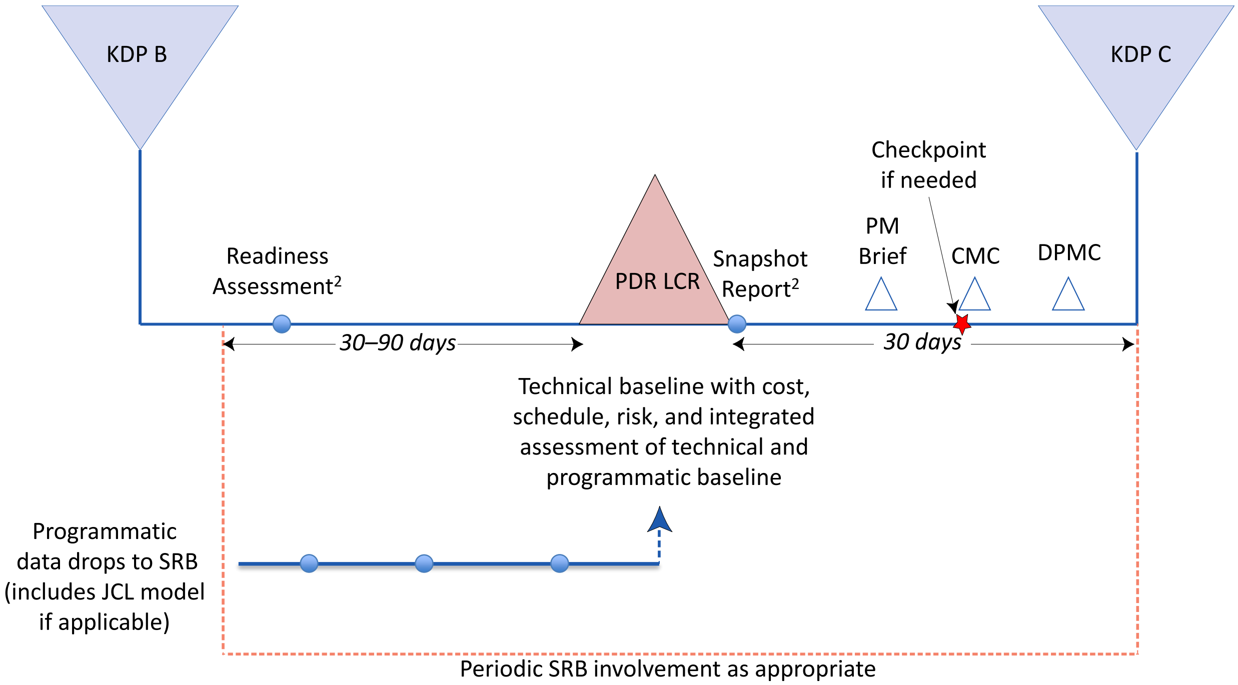
3.2.3.2E Support Reviews, Audits, and External Reporting

Support Project LCRs, KDPs, and Internal Reviews

The project's Review Plan identifies the project LCRs and planned internal reviews. Internal reviews range from peer reviews to reviews conducted by Center independent review organizations such as Center independent cost estimating organizations and may include technical reviews requiring support from PP&C as well as PP&C focused reviews.

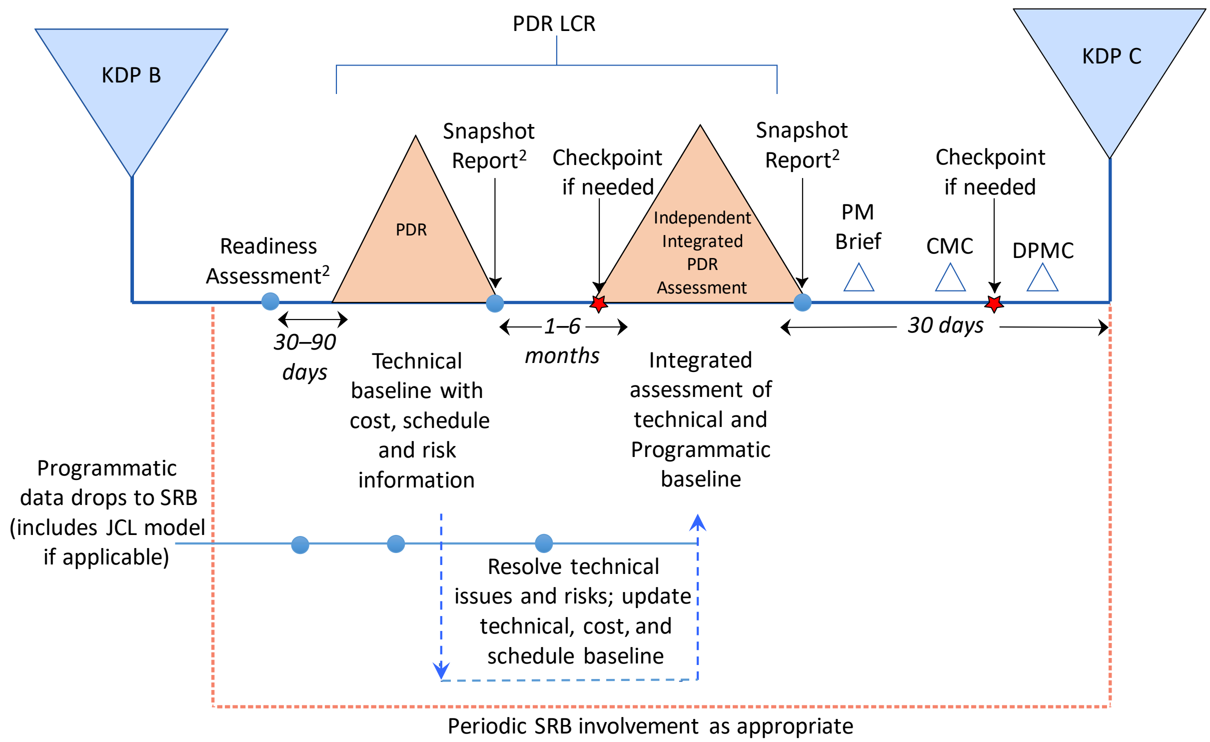
PP&C plays a significant role in supporting the project LCRs, which are essential elements of conducting, managing, evaluating, and approving space flight projects where major technical and programmatic requirements are assessed along with the system design and other implementation plans. The scope, requirements, assessment criteria, and review products for each LCR are documented in the LCR ToR, which the project team develops in coordination with the SRB. The PP&C integration manager needs to play a significant role in supporting the development and negotiation of the LCR ToR to ensure that schedules for the LCRs and agreements for provision of PP&C review products including delivery schedules to the SRB are reasonable and supportable.

Of significant importance to the project and to the PP&C organization is whether the LCRs are conducted as one-step or two-step reviews. The project manager determines whether to hold a one-step review or a two-step review in consultation with the technical and PP&C integration managers based on the state of the project's cost and schedule maturity and integration with the technical baseline. Descriptions of the one-step and two-step life-cycle review processes are provided in detail in Section 4.1 of the *NASA Space Flight Program and Project Management Handbook*. Figures 3.2-5 and 3.2-6 below, which are taken from the *NASA Space Flight Program and Project Management Handbook*, illustrate a one-step and two-step review using the PDR as an example.



Footnotes:
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 3.2-5 One-Step Life-Cycle Review Overview – PDR Example



Note: Time is not to scale

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 3.2-6 Two-Step Life-Cycle Review Overview – PDR Example

In a one-step review, the project’s technical and programmatic information are assessed together. In a two-step review, the project's technical approach is evaluated first. The programmatic aspects of the approved technical approach are then developed and evaluated in the second step. While the first step does consider the preliminary cost, schedule, and risk, it is the second step that takes the results of the first step and fully integrates and reconciles the technical scope with the cost, schedule, and risk.

In preparation for the LCRs, the PP&C integration manager ensures the various PP&C control plans, project cost and schedule estimates, current cost and schedule performance, trends and forecasts, project risks including risk mitigation plans and associated cost and schedule impact assessments, and if applicable the cost and schedule confidence levels, JCL and UFE products and data are developed and provided in accordance with the LCR ToR. PP&C provides data drops to the SRB in advance of the LCR. These data drops include the primary products; bases of cost and schedule estimates; tools, techniques, and models used to develop the cost and schedule estimates, and confidence levels and JCL.

In addition to the PP&C products and data required by the LCR ToR, PP&C may provide review presentations in support of the LCR. PP&C may also be involved in developing responses to

Requests for Action (RFAs) or Requests for Information (RFIs) from the SRB during the course of the LCR.

For example, some of the key messages that the PP&C integration manager should present at the PDR are:

- Assessment of the project's readiness to proceed to the next life-cycle phase
- Introduction of the PP&C team and scope of work to establish credibility
- Workforce profile reasonableness and any challenges
- Level of maturity of the LCR products managed by PP&C
- Process used to develop schedule and LCC
- WBS
- Progress against project's plans
- Top level schedule, vertical deliverables, margin, critical path
- LCC
- Additional cost charts needed to illustrate key cost features
- EVM approach
- JCL results
- Project UFE, demonstrate why UFE is adequate in consideration of risks and threats
- Project UFE management strategy

The findings of the SRB are provided to the project for review and response. When the SRB independent assessment results in cost and schedule estimates and/or a JCL that are different from those of the project, the PP&C integration manager works with the independent assessors to identify reasons for the differences. There are several ways to address differences. These may range from agreement on the part of the independent assessors to modify their underlying assumptions or methodologies to agreement on the part of the project to reconcile its cost and schedule estimates and/or JCL with those of the independent assessors. Where agreement cannot be reached, the rationale for disagreement is documented.

(The *Standing Review Board (SRB) Handbook* and the *NASA Space Flight Program and Project Management Handbook* contain more detailed information on managing and conducting life-cycle reviews.)

Support Agency Baseline Performance Reviews,
External Reporting, and Audits

The Agency BPR, which is conducted on a monthly basis, serves as NASA's internal senior performance management review. Co-chaired by the NASA Associate Administrator and Associate Deputy Administrator, the BPR provides an integrated review of institutional and project activities that is intended to provide ongoing performance assessment for projects between KDPs and to highlight interrelated issues that impact performance and project risk. Membership includes Agency senior management and Center Directors. A typical BPR agenda includes an assessment of each Mission Directorate's project performance against MAs and ABCs with rotating in-depth reviews of specific mission areas. (BPR reporting for each Mission Directorate is conducted on a quarterly basis.)

PP&C Integration collects and provides PP&C information needed by the project for the BPR. The *NASA Space Flight Program and Project Management Handbook* provides a list of typical information sources for BPR assessments, which may include the results of LCRs, presentations to Directorate Program Management Councils (DPMCs) and Agency Program Management Councils (APMCs), KDP DMs, quarterly cost and schedule reports provided to OCFO, and monthly EVM data. Additional information may be requested, depending on specific issues or concerns of interest to Agency management. Assessors use existing materials when possible.

The BPR does not generally result in findings to which the project needs to respond. While not a council, the BPR is closely linked with the councils and integral to council operations and may result in referral to the governing councils for decision if needed.

PP&C Integration ensures that the necessary PP&C data is provided for external reports and audits. External reporting by NASA to the White House and Congress is provided in a number of ongoing major reports. This external reporting includes project decisions, technical performance, baselines, and cost and schedule estimates. The GAO is the audit, evaluation, and investigative arm of the Congress. GAO assesses NASA technical, cost, and schedule performance via its *Quick Look Book* and audits of specific programs and projects. Audits may also be conducted by the OIG.

As part of the Executive Branch, NASA reports on its performance to the White House through the OMB. NASA is also required to report on its performance directly to Congress in various ways including through budget submissions.

Major reports provided to Congress are the Major Program Annual Report (MPAR), 10 Percent Cost Growth Report, Threshold Report, KDP B Cost Range Report, and the *OMB Circular A-11* report. The major report provided to OMB is the National Security Presidential Directive (NSPD) NSPD-49 report. (The MPAR and the NSPD-49 report include common components.) Major reports to Congress and OMB are applicable to projects with an LCC exceeding $250M with the exception of the 10 Percent Cost Growth Report, which is applicable to projects with an LCC greater than $75M experiencing cost growth of 10% or more. The major report provided to GAO is the *Quick Look Book*. Specific projects may be required to provide information for the GAO *Quick Look Book*.

NASA has an integrated process for collecting project technical, cost, and schedule data and developing reports. The KDP DM and a single quarterly data call issued by the OCFO to the Mission Directorates are used to collect the information needed to generate the various required reports. (The Mission Directorates collect and verify project submissions and forward the submissions to OCFO.) A number of reports are incorporated directly into NASA's budget submission to Congress to minimize workload.

The quarterly data call collects core data common to many reports and data necessary for explaining any differences between a project's cost estimate and its budget request. The core data elements are as follows:

- **Current Estimate:** The project's LCC, which includes Phase A through Phase F costs. 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 WBS element as well as by year during development.
- **Schedule:** Key milestones including KDPs and 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.

The GAO also uses its DCIs to gather data for its *Quick Look Book*. There are four separate GAO DCIs for each project in the Quick Look audit: Cost, Schedule, Project, and Contract. OCFO completes the Cost and Schedule DCIs. Projects complete the Project DCI. The Office of Procurement completes the Contract DCI. In addition to these data elements, monthly EVM reports and Center-level review packages are provided to the GAO on a recurring basis. Documentation from major milestones such as PDR, CDR, and KDPs are also provided to auditors. 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.

OCFO transmits reports that go to OMB and GAO. OCFO provides final reports for Congress to the Office of Legislative and Intergovernmental Affairs (OLIA), which transmits the reports to Congress. OCFO maintains a record of data and reports provided to Congress, GAO, or OMB.

Audit activities are coordinated by the Mission Directorate Audit Liaison Representative (ALR) and the NASA Audit Liaison Program Manager in the Mission Support Directorate. When additional information is required over and above information gathered through the quarterly data call and the GAO DCIs, the rules of engagement are negotiated with GAO, ideally at the beginning of each audit. OCFO works with GAO to ensure that the Cost and Schedule DCI reporting and additional GAO reporting are closely coordinated. Requests for PP&C data are issued directly to the projects with notification to the program executive, the Mission Directorate ALR, and the NASA audit lead. GAO provides a draft report to NASA following conclusion of the audit. The Mission Directorate and project have an opportunity to provide responses to the draft report prior to its finalization.

For detailed information on external reporting requirements and processes including details on major reports such as content, when the reports are required, and applicable projects, and on audits, see Section 5.12, External Reporting in the *NASA Space Flight Program and Project Management Handbook*.

3.2.4. Function Activities by Life-Cycle Phase

Table 3.2-5 depicts PP&C Integration activities by life-cycle phase.

Table 3.2-5 PP&C Integration Activities by Life-Cycle Phase

Pre-Phase A	Phase A	Phase B	Phase C	Phase D	Phase E	Phase F
Develop Formulation Agreement	Update Formulation Agreement					
Identify environment, constraints and GR&A			Update environment, constraints and GR&A, if needed			
Develop preliminary Acquisition Strategy	Baseline Acquisition Strategy	Update Acquisition Strategy, if needed				
Develop preliminary Project Plan		Baseline Project Plan, Develop Descope Options	Update Project Plan, if needed Update Descope Options			
Develop preliminary Control Plans	Baseline Control Plans	Update Control Plans, if needed				
Develop preliminary cost range estimate Develop Phase D completion range		Baseline LCC, IMS	Adjust LCC and IMS, if needed			
	Develop cost, schedule confidence levels	Propose ABC with LCC, IMS, JCL, UFE	Update only if Project is Rebaselined			
Preliminary Business Decisions & PP&C Management and Control Plan		Final Business Decisions & PP&C Management and Control Plan	Updates to Business Decisions & PP&C Management and Control Plan			
			Develop Monthly Integrated Performance and Analysis Reports			
			Conduct Assessments and recommend options and/or corrective actions Identify results of implemented options/corrective actions			
Provide PP&C Products for Reviews (Internal, LCRs, KDPs, Other) and Document Review Results Provide PP&C Products for Agency/External Reporting and Audits						

Notes: Formulation Agreement: PP&C inputs include cost and schedule risks; cost and schedule requirements for Phases A and B
Project Plan: PP&C inputs include definition of stakeholders, WBS baseline, schedule baseline, resource (baseline), and JCL
Descope Options: PP&C inputs include cost and schedule impacts of each option
Control Plans: PP&C inputs include Cost and Schedule Control Plan and Acquisition Plan (both may be included in Project Plan); and inputs to CM/DM, Risk Management, and Review Plans

3.3. Resource Management Function

3.3.1. Function Overview

There is not a single project in the world that can be conducted without resources. Without funds, people, facilities, equipment, etc., nothing would happen. Even if they have these types of resources, projects can fail completely if the resources are inadequate to complete the work, or if the resources are improperly planned and poorly managed. Resource management should be conducted in an efficient and effective manner throughout the entire project life cycle in order to facilitate a project's success.

The activities inherent in cost estimation, assessment, tracking, and forecasting are allocated in this handbook to both Cost Estimation/Cost Assessment and Resource Management. Cost Estimation/Cost Assessment is focused on developing estimates and assessments at three key times: for planning purposes, at key project milestones, and when needed due to significant changes to the project. Resource Management is focused on tracking and forecasting based on actual cost performance on a regular monthly basis. This includes estimating costs of changes to scope when specialized cost estimating methodologies and datasets are not needed.

The primary functions of Resource Management in support of a project are to:

- Identify all necessary resources by element of cost (i.e., facilities and usage rates, FTE, travel, and procurements).
- Establish the necessary funding profile to execute scope and schedule.
- Establish the time-phased budgeted cost plan to achieve project execution in concert with scheduling.
- Capture and accumulate known risks, and establish a process for allocating resources for unknown risks.
- Measure, analyze, and assess actual performance against the budget cost plan.
- Develop and implement EVM.
- Ensure that the funding profile is sufficient to cover projected costs for the fiscal year.
- Measure and assess the costs against the annual funding plan.
- Reassess the project's ETC based on monthly cost and schedule performance.
- Generate and communicate monthly financial (costs and funds) performance for reporting including all contractors/suppliers.

As shown in Figure 3.3-1, the resources that are typically planned, implemented, monitored, and adjusted include funds and costs for civil servant and contractor labor, procurement, travel, IT products and services, laboratories, and other facilities.

Figure 3.3-1 Examples of Project Resources to be Managed

A project's resources can be impacted for many reasons, including milestone slips in the schedule, increased technical requirements, increased contract costs, revised cost estimates, modified risk mitigations, a government shutdown, etc.

At the same time, changes to resources can occur that have a direct impact on the technical requirements, the schedule, project risks, cost estimates, and contracts. Examples include losing key personnel, budget reductions, a workforce labor strike, loss of equipment, unplanned unavailability of laboratories, etc.

3.3.2. Integration with Other PP&C Functions, Inputs, and Outputs

The Resource Management function needs to effectively interact with other PP&C functions to develop the products, plans, and strategies that comprise an integrated, project-level, executable plan. This is necessary during the planning phase and for evaluating and controlling the entire project during the control phase while communicating with entities external to PP&C. Figure 3.3-1 is a flow diagram for the Resource Management function that depicts major inputs and outputs received from and provided to other PP&C functions as well as external entities. Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it. The flow diagram also summarizes key activities to consider during the planning and control phases when implementing this function. Section 3.3.3 discusses these key activities in detail, and provides insight into the importance of the interactions with other PP&C functions.

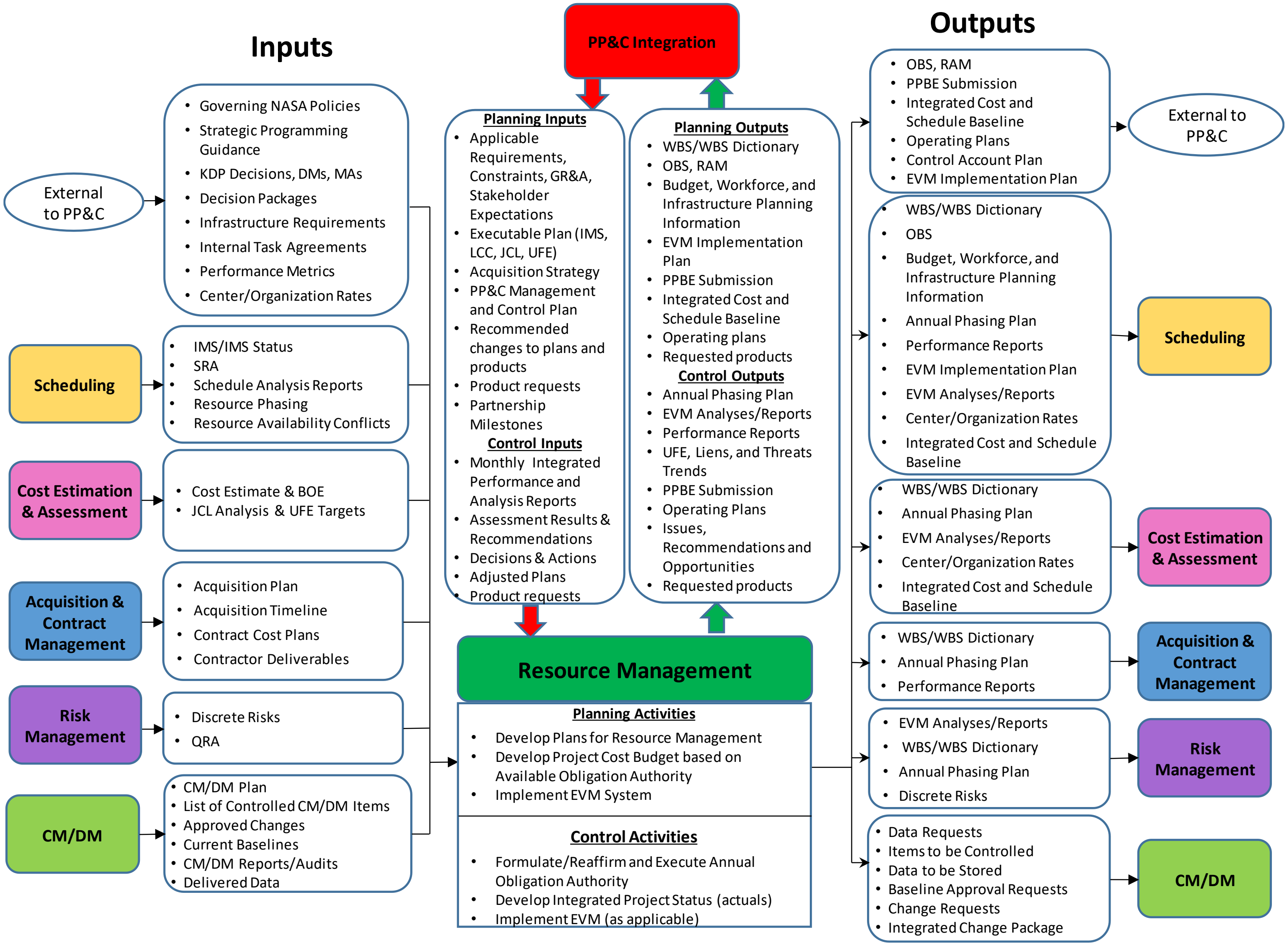


Figure 3.3-2 Typical Functional Flow Diagram for the Resource Management Function with Major Inputs and Outputs

Descriptive information is provided below for the inputs from external entities and for the outputs depicted in Figure 3.3-2. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.3.3.

Descriptions of all inputs and outputs in can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.

3.3.2.1. Inputs

- **Governing NASA Policies:** Applicable Agency NPDs, NPRs, Center policies, lessons learned, and best practices including Agency handbooks. Applicable Agency handbooks include *NASA/SP-2010-3404*, *NASA Work Breakdown Structure (WBS) Handbook*, which can be found on the Office of the Chief Engineer (OCE) tab under the "Other Policy Documents," *NASA/SP-2012-599*, *NASA Earned Value Management (EVM) Implementation Handbook*, and the *NASA EVM System Description*, which can be found at https://nen.nasa.gov/web/pm/evm.

- **Strategic Programming Guidance**: Flowing from the Agency's OCFO through the Mission Directorates, budget guidelines as part of the PPBE process are updated annually to support the February release of the President's Budget Request to Congress for the upcoming fiscal year appropriations. The *Strategic Programming Guidance (SPG)* provides high-level resource guidance that includes the initial funding controls based on decisions from a SPG senior managers' review of new or open issues, disconnects, revisions needed to address OMB settlement, and the Acquisition Strategy Planning (ASP) review. The SPG provides high-level program and institutional guidance on the strategic priorities, directions, and assumptions to develop budgets and performance measurements. The SPG is focused on the budget year + 4 out years and can request data for projects extending into the future and plan for new initiatives, but it is not used to review competitive project selection within existing programs. The resulting Agency guidance is coordinated with and released to the Mission Directorates as a data call to projects to provide budget estimates into the PPBE process (assumptions, deadlines, and formats).

- **KDP Decisions, Decision Memoranda (DM), and Management Agreements (MA)**: KDP decisions and actions are recorded in the KDP DM. The MA is part of the DM and defines the parameters including cost and schedule and authorities for which the project manager has management control and accountability. The KDP C DM and MA establish the project's ABC, JCL levels at which the project will be budgeted and funded (which may be different), and UFE that will be held at the project level and above the project level. (For additional detail, see Section 3.2.2.)

- **Decision Packages:** The supporting organizations identify the amount of funding, workforce, and infrastructure that is needed to accomplish the responsibilities and tasks assigned to them by the project. These needs are documented in decision packages or other guidance documents and are supported with rationale. The project manager reviews and approves decision packages.

- **Infrastructure Requirements:** The facilities, aircraft, personal property, equipment, environmental, and information technology resources that are needed to support the project. Facility requirements may include modification or upgrade of existing facilities to modify capability or increase capacity.

- **Internal Task Agreements:** Documented agreements and commitments with Center organizations for the work to be performed including scope of work, receivables/ deliverables, schedule, budget, assumptions, and other information as required such as EVM reporting.

- **Performance Metrics:** Project measurements that communicate vital information about the status or performance of a system, process, or activity for contractor and in-house efforts. This may include metrics for technical performance measures, costs, schedules, risks, and EVM. Information from partners necessary for insight into partners' activities may also be included, in accordance with terms documented in the associated agreements. Effective metrics improve accountability and transparency into the project's progress as an indicator of future performance, enabling insightful analysis so appropriate actions can take place.

- **Center/Organization Rates:** Current and projected rates by NASA Center for cost elements such as civil service labor, benefits, and facilities usage.

- **Resource Phasing**: If the IMS is resource-loaded, it provides time-phased requirements for labor, material, and equipment for use by the Resource Management function. RLSs help to ensure cost and schedule integration and provide the resource requirements needed to ensure that project resources are available.

- **Resource Availability Conflicts:** RLSs provide the capability for over-allocation reporting, which can identify those tasks where resource conflicts exist.

- **Cost Estimate & BOE:** Provides the Resource Management function a base from which the resources can be managed. This estimate and the decision packages will enable the function and project to provide an output into the PPBE process, either within budget guidelines or with an overguide request. (For additional detail, see Section 3.5.2.)

- **Contract Cost Plans:** An estimate of when funds will be obligated to each of a project's applicable contracts and when work is expected to be completed for contractual costing purposes. For cost reimbursable contracts, the contractor is required to submit a time-phased baseline cost plan. Proper funding of termination liability should be taken into consideration. This information informs the Resource Management function on any potential impacts to planned resources.

- **Contractor Deliverables:** The Acquisition and Contract Management function accepts and reviews deliverables to ensure they are consistent with contract requirements and provides the deliverables to the Resource Management and Scheduling functions for analysis and assessment of contract performance. Deliverables include contractor financial management reports and contractor invoices, the WBS and baseline IMS, EVM deliverables when applicable, and other deliverables required by the contract. Other deliverables may include monthly progress reports.

- **Discrete Risks**: Identified, documented, potential events that carry an estimated consequence and an associated likelihood (probability of occurrence). The Resource Management function monitors these risks that could have an impact on planned resources.

- **QRA:** Quantitative Risk Analysis (QRA) is a risk-intensive method for probabilistically summarizing risks for use in UFE assessment, resource management, cost estimating, and other PP&C-related activities.

- **Constraints and GR&A**: These include Mission Directorate and program constraints and GR&A levied on the project, including mission objectives, goals, and success criteria. They may be also derived from stakeholder expectations and project and programmatic requirements, including the project budget and project funding and technical requirements. Constraints and GR&A may be documented in the FAD, the FA, DMs, MAs, and Program and Project Plans.

- **Executable Plan (IMS, LCC, JCL, UFE):** The executable plan captures the integrated set of technical, science, cost, schedule, resource, and facility requirements of the project in the WBS, schedule, resource baseline, and budget. The baseline IMS, LCC estimate, JCL, and UFE are key elements of the executable plan. These products are also part of the project’s ABC.

- **PP&C Management and Control Plan:** This plan is an optional, project-level document intended to support an integrated, organized summary of a project's PP&C activities in one document. The plan provides an overview of the PP&C organization and describes the guidelines and processes to be used for the different PP&C activities. (For additional detail, see Section 3.2.2 and Appendix G: PP&C Management and Control Plan.)

- **Partnership Milestones:** Partnership milestones establish the dates associated with partnerships including when partnerships need to be established. The Resource Management function supports establishing partnership agreements by identifying funding sources for NASA’s responsibilities under an agreement; developing Estimated Price Reports (EPR) including justification for any waived or excluded cost and obtaining all required concurrences/approvals; and establishing a unique WBS element for each agreement. (For additional detail, see Appendix L: Partnership Types. For detailed guidance on developing EPRs, see *NPR 9090.1*, *Reimbursable Agreements*. All types of partnership agreements require an EPR.)

- **Monthly Integrated Performance and Analysis Reports:** Current integrated cost and schedule performance, trends and variances, and the project's risk posture; analyses of cost and schedule variances and trends; identification of data correlations and causal relationships, key drivers and sensitivities; and status of UFE, liens, and threats.

- **Assessment Results and Recommendations:** Forecast of integrated cost and schedule performance and EAC based on current performance, work remaining, and likely impacts of remaining risk and issues. Identification of key issues and decisions that need to be made by project management. Recommendations for controlling project performance. (For additional detail, see Section 3.2.2.)

- **Decisions & Actions:** Options and/or corrective actions approved for implementation by the project manager, including associated decision packages. Plans for implementing, tracking, and reporting on the results of the options/corrective actions. (For additional detail, see Section 3.2.2.)

- **Adjusted Plans:** Updates to the project's plans based on approved options/corrective actions. These may include updates to the baseline IMS, LCC, and EAC.

3.3.2.2. Outputs

- **OBS:** The Organizational Breakdown Structure (OBS) or organizational structure displays the organizational relationships and uses them for assigning work in a project, providing an organizational structure for the project.

- **RAM:** An intersection of the WBS and the OBS, the Responsibility Assignment Matrix (RAM) describes the participative roles in completing tasks or deliverables for a project. The RAM is especially useful in clarifying roles and responsibilities for the support provided by matrix organizations.

- **PPBE Submission:** The Planning, Programming, Budgeting, and Execution (PPBE) process of resource alignment and control is a comprehensive, top-down approach to support the Agency's vision and mission. It includes complete budget formulation, development of fully executable Agency operating plans and Agency execution plans, and ends with execution of the budget during performance. The submission for the current PPBE cycle includes the NOA required for project-budgeted resources, the ensuing year (draft operating plan), the budget request year, and forward leaning budgets reflecting a total life-cycle requirement. It also includes overguide requests and rationale. The content of the PPBE submission is codified in the N2 data collection system (per Mission Directorate guidance), which itemizes the NOA in terms of procurements dollars, FTE, and travel.

- **Integrated Cost and Schedule Baseline:** The integrated cost and schedule baseline is established based on the cost, schedule, and UFE for which the project manager has management control. This cost, schedule, and UFE is documented in the KDP C MA per the KDP DM. The integrated cost and schedule baseline needs to be consistent with the available funding plan. This baseline becomes the foundation against which the project's cost and schedule performance is assessed, adjustments are made, and EACs are developed. (This project-level integrated cost and schedule baseline is not to be confused with the Performance Measurement Baseline (PMB). A subset of this baseline without UFE allocated and specific for a particular contract or at the project level is often referred to as the PMB.)

- **Operating Plans:** Operating plans are the funding execution plans after the annual appropriations levels are received based on Mission Directorate guidance. Plans may be revised as needed during the year. Revisions to operating plans require approval.

- **Control Account Plan:** A Control Account Plan (CAP) displays the control account scope and budget in time-phased work packages and planning packages, cost element visibility, and performance measurement techniques for each work package. It also reflects responsible performing organizations and includes at least one WBS charge number.

- **EVM Implementation Plan:** The EVM Implementation Plan establishes guidance for the effective application, implementation, and utilization of EVM on NASA projects. Projects describe how they will implement and scale the *NASA EVM System Description* identifying how the project EVM capability complies with the EVM requirements of the EIA-748 standard for Earned Value Management Systems (EVMS). The plan includes the schedule and resources required to ensure proper and effective design, documentation, implementation, and maintenance of the management system. The EVM Implementation Plan is provided to PP&C Integration for review and comment prior to approval. (See Appendix H: Letter on Guidance and Expectations for Small Projects for more information on scaling EVM requirements for small projects.)

- **Work Breakdown Structure and WBS Dictionary:** The WBS is a product-oriented family tree that decomposes the scope of work into manageable segments to facilitate planning and control of cost, schedule, and technical content. The WBS Dictionary is a document that describes the work content of each WBS element in product-oriented terms and relates each element to the respective, progressively higher levels of the structure.

- **Budget Planning Information**: Budget planning information includes all estimated project costs and obligations to include FTEs, WYEs, Other Direct Costs (ODCs), procurements, partnerships, travel, facilities, and other costs for each fiscal year during all phases of a project.

- **Workforce Planning Information:** The number of civil service FTEs and contractor WYEs required for each fiscal year. The PPBE process enables negotiation of any differences considering conflicts identified by the Resource Availability Conflicts input and Center and Mission Directorate guidance.

- **Infrastructure Planning Information:** All Center equipment, facilities, technical capability, and other services required for project completion, identified for each project life-cycle phase by fiscal year. The PPBE process enables negotiation of any differences considering conflicts identified by the Resource Availability Conflicts input and Center and Mission Directorate guidance.

- **Annual Phasing Plan:** A plan of obligations, costs, FTEs, WYEs, and ODCs for each fiscal year in the project's life cycle provided at the WBS level deemed appropriate by project management. The plan is typically broken out by month for the current fiscal year and actuals are reported against the plan on a monthly basis.

- **Performance Reports:** A comparison of actual versus planned obligations, actual versus planned accomplishments, costs, WYE, and FTE with corresponding characterization of notable variances. These reports should include estimates for status of UFE, liens and threats, accrued costs, cost-to-go, assessment of work accomplished, cumulative cost and schedule impacts of risks, EAC based on current trends and identified variances, and identification of data correlations and causal relationships, key drivers, and sensitivities. (When performance issues appear in the data, the performance report should include specific identification of the troubled contract or activity.)

- **UFE, Liens, and Threats Trends:** A comparison of available UFE versus the risk list, often described in terms of threats, liens, and sometimes, encumbrances. A threat is a risk that might be realized and needs to be watched. A lien is a threat that is likely to be realized or has been realized and may require additional funding or use of UFE. A lien identifies a specific task, a justification, and a cost and schedule impact. Encumbrance is the process by which a hold against UFE is made. The money has not necessarily been moved yet to the account that created the need, but the hold has been placed. Encumbrance is a monetary amount associated with a lien. Trend data is useful on these measures.

- **Earned Value Management Analyses and Reports:** For contracts, a project-level Integrated Program Management Report (IPMR) is typically provided on a monthly basis to provide technical, schedule, and cost status information. The purpose of the IPMR is to provide early identification of problems that may have significant cost, schedule, and/or technical impacts and report the effects of management actions and project status information for use in making and validating management decisions. Projects integrate contract IPMR, in-house, and other data to produce a project level IPMR.

- **Center/Organization Rates:** See Inputs.

- **Integrated Change Package:** Evaluation of a requested change to an item under configuration control. Package includes a description of the change; project organizations that evaluated the change; impacts of the change on other project products, activities, and documentation; and impacts on the project's cost, schedule, and risk. (For additional detail, see Section 3.8.2.)

- **Issues, Recommendations and Opportunities:** Issues include project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues, and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance. (For additional detail and examples, see Section 3.2.2.)

- **Data Requests:** Requests to the CM/DM function for any of the PP&C or other data under data control.

- **Items to be Controlled:** Items developed by the Resource Management function that need to be placed under configuration control.

- **Data to be Stored:** Data developed by the Resource Management function identified as needing to be stored

- **Baseline Approval Requests:** Requests to place an item under baseline control.

- **Change Requests**: A request submitted to the CM/DM function to change an item under configuration control.

- **Discrete Risks:** As an output, these are any specific risks identified by the Resource Management function.

- **Requested Products**: Products requested from the other PP&C functions needed to support internal reviews, independent reviews such as LCRs and KDPs, audits, and external reports.

3.3.3. Function Planning and Control Activities and Tasks

Resource Management planning and control activities and tasks are outlined in Table 3.3-1 Resource Management Activities and Tasks. The activities and associated tasks are described in more detail in the text below the table.

Table 3.3-1 Resource Management Activities and Tasks

Resource Management	
Planning Activities and Tasks	**Control Activity and Tasks**
Activity: Develop Plans for Resource Management • Implement resource management processes and approaches • Develop operating plan • Develop WBS • Develop workforce planning information	**Activity: Formulate/Reaffirm & Execute Annual Obligation Authority** • Develop and update funding, workforce, and infrastructure requirements • Prepare annual phasing plan • Develop and update PPBE submittals

Resource Management	
Planning Activities and Tasks	**Control Activity and Tasks**
• Develop budget planning information (cost and OBS) • Develop infrastructure planning information **Activity: Develop Project Cost Budget based on Available Obligation Authority** • Establish integrated cost and schedule baseline • Develop and update PPBE submittals **Activity: Implement EVM System** • Develop EVM implementation schedule • Incorporate EVM Implementation Plan approach into Project Plan • Ensure compliance with the Agency EVM System Description • Establish PMB	• Execute budget by managing allocation of funds, workforce, and UFE **Activity: Develop Integrated Project Status (Actuals)** • Analyze and assess cost and schedule performance impacts • Integrate cost and schedule updates • Provide reports and recommend actions **Activity: Implement EVM (as Applicable)** • Maintain PMB, gather EVM data, conduct analyses, and conduct surveillance • Provide reports • Conduct/participate in IBRs, validation and compliance reviews, surveillance, etc.

3.3.3.1. Planning Activities

3.3.3.1A Develop Plans for Resource Management

As a project is planned and approved, an initial plan is developed and thereafter updated to assure that all required resources are planned and documented within the project as part of the annual Agency PPBE submittal. Estimates should increase in accuracy as the planning matures and reflect the annual resources required to accomplish the plan.

Implement Resource Management Processes and Approaches

Resource Management implements the project's processes and approaches for obtaining resources, and distributing, tracking, and controlling project funds. These include approaches for phasing costs by fiscal year, ensuring adequate funding to continue work uninterrupted at the change of the fiscal year, and validating contractor funding requests. This function also establishes how obligations will be planned, tracked, and reviewed, and when obligation profiles will be updated and provided to the Agency.

Resource Management also defines PP&C's role in the annual PPBE process and identifies documentation required to support the PPBE process. This includes approaches for reconciling the project's NOA submission with the guideline, making adjustments to planned work when the annual NOA guideline or disbursement of funds by NASA HQ is different from the project's submitted plans, and negotiating revised current year and/or future year funding

The Resource Management processes and approaches are implemented in collaboration with PP&C Integration and may be documented in the PP&C Management and Control Plan.

Develop Operating Plan

The Resource Management lead will receive a request for data from the Mission Directorate for projects required to provide input into the operating plan. The operating plan is the Agency's funding execution plan for each fiscal year at the Mission Directorate and major program level. The operating plan establishes approved programs reflecting Congressional action and Administration policy, defines the amount of appropriated dollars that will be spent on specific activities, and forms the basis for how funds will be distributed and used. Any inputs required from the project for the preparation of the operating plan will be requested by the Mission Directorate through its program hierarchy and once approved, project spending may commence only after approval of the operating plan by Congress. The operating plan should use the same month-end dates for both schedule and cost plans. If different month-end dates are used for these two products, there is a strong possibility that this will result in artificial variances. (Additional information on Agency/Congressional operating plans is included in *NPR 9420.1 Budget Formulation*.)

Develop Work Breakdown Structure

The WBS is a product-oriented hierarchical division of the hardware, software, services, and data required to produce the project's end product(s), structured according to the way the work will be performed and reflecting the way in which project costs and schedule, technical, and risk data are to be accumulated, summarized, and reported. The purpose of a WBS is to subdivide the project's work content into manageable segments to facilitate planning and control of cost, schedule, and technical content. It will serve as the basis for uniform planning, progress and performance reporting, project visibility and communication, and the assignment of responsibility. The ability to reconcile the WBS to the scope in the Statement of Work (SOW) at the control account level is crucial to the ability to subsequently integrate cost and schedule. Therefore, at the outset of the project, the WBS and WBS Dictionary should be carefully developed and correlated with the SOW on a detailed level. Note the WBS is for technical planning and accomplishments and should not be added solely to accumulate costs. The WBS will be updated as required to reflect changes to the technical content and contractual changes. Beyond its utility to manage work, the WBS is also used as an input into the CADRe and represents the Agency need to collect project cost data in a normalized way to facilitate future cost estimates. Most projects require a common WBS to be used for level 1 and 2. The standard WBS can be found in the projects governing documents (NPR 7120.5 for space flight projects, NPR 7120.8 for research and technology projects, etc.). Guidance can also be found in the *Cost Estimating Handbook*, Appendix B, in the *NASA Work Breakdown Structure (WBS) Handbook (NASA/SP-2010-3404)*, and in the *NASA Space Flight Program and Project Management Handbook (NASA/SP-2014-3705)* for the lower-level WBS elements.

Develop Workforce Planning Information

To develop information for workforce planning, project managers and analysts estimate the number of civil service FTEs that are required each fiscal year during the phases of a project life cycle and apply the most current applicable civil service labor rates to arrive at the cost. Typically there is a process at each Center for requesting and negotiating the civil service workforce required for the project. The number of contractor WYEs is also typically planned as a means for ensuring scheduled work completion. Major considerations in planning a project's workforce are the required skill mix and the availability of personnel with those skills. This information is updated annually as part of the PPBE data request from the Mission Directorate.

Develop Budget Planning Information (Cost and OBS)

The yearly PPBE planning process includes all estimated project costs (resources) including WYEs, FTEs, procurements, travel, facilities, launch services costs, NASA costs of resources associated with partnerships[7], and other costs for each fiscal year during current and future phases of a project. Using Center/organization rates, the FTE costs to the project are fully loaded by Fiscal Year (FY), including base pay, fringe benefits, and leave. Resources are revalidated annually by Resource Management and typically supported by project personnel identified in the RAM. These personnel are often known as Project Control Account Managers (P-CAM), and their budget plan (using a term from the EVM community) is often referred to as the Control Account Plan (CAP).

Develop Infrastructure Planning Information

All Center equipment, facilities, technical capability, and other services that are required for project completion are identified for each project life-cycle phase. The resources activity coordinates all of the activities required by the project with the facility point of contact to get the most current rates and availability and compares them to the available time and budget to ensure alignment.

3.3.3.1B Develop Project Cost Budget Based on Available Obligation Authority

Establish Integrated Cost and Schedule Baseline

The integrated cost and schedule baseline captures the scope of work in the WBS in accordance with the established schedule and known risks. The integrated cost and schedule baseline must be consistent with the available funding plan. This baseline becomes the foundation against which performance is assessed, adjustments are made, and EACs are developed.

(Note: This activity is performed by Resource Management in collaboration with PP&C Integration. A complementary description of this activity is provided in the PP&C Integration

[7] Identified in EPRs. May include goods, services, facilities, or equipment.

Function, Section 3.2.3.1. (See the activity Define Approach/Strategy for Executing Scope of Work.)

Develop and Update PPBE Submittals

See Section 3.3.3.2 on developing and updating PPBE submittals.

3.3.3.1C Implement Earned Value Management System

EVM is a program management process that integrates technical performance requirements, resource planning, and schedules while taking risk into consideration. The major objectives of applying earned value to a contract are to encourage projects and/or contractors to use effective internal technical, cost, and schedule management control systems and to permit the customer to rely on timely data produced by those systems for better management insight. This data is in turn used for determining product-oriented contract status and projecting future performance based on trends to date. In addition, EVM allows better and more effective management decision making to minimize adverse impacts to the project. For in-house projects, the implementation and reporting of EVM data should be considered early during Formulation of the project, although reporting isn't required until entering Phase C. The WBS, schedule, and cost phasing plans should be in alignment from the start to finish of the project. The schedule should be developed using a methodology for identifying control accounts, work packages, tasks, etc. to accommodate the updating and reporting of EVM data. Otherwise, it will be difficult to report EVM when the requirement is applied in Phase C.

Develop Earned Value Management Implementation Schedule

During project Formulation, the project prepares for the implementation of EVM. If it has been determined that EVM will be required on a project, the project prepares an EVM implementation schedule during pre-Phase A. The schedule addresses the efforts required to develop the project EVM capabilities including the project EVM Implementation Plan development. The schedule considers when EVM resource support will be needed to assist in the preparation of the EVM Implementation Plan as well as the tools and training that will be needed for the project EVM team. The EVM implementation schedule is incorporated into the FA (see NPR 7120.5, Appendix F, Section 13) or the Project Plan for KDP A. During Phase A, development of the project EVM Implementation Plan is initiated and the EVM implementation schedule is updated to incorporate plans for the development of the project EVM processes. An assessment of the EVM capabilities is made and any gaps identified are addressed as part of the updated schedule prepared for KDP B.

Incorporate EVM Implementation Plan Approach into Project Plan

The EVM implementation approach can be a stand-alone document or can be included as part of the Project Plan and includes:

- The methodology for developing and maintaining the PMB.
- How UFE will be established and controlled.

- The methods the project will use to authorize the work and communicate changes for the scope, schedule, and budget of all suppliers.
- The process to be used to communicate time-phased levels of funding to be made available to each supplier.
- The contractor performance reports (such as IPMRs) that are to be required.
- How the cost and schedule data from all partners/suppliers will be integrated to form a total project-level assessment of cost and schedule performance.
- A description of any additional tools necessary to implement the project's control processes.
- The process for establishing, monitoring, and controlling the IMS.
- The process for utilizing the project's technical and schedule margins and UFE to meet the management and commitment baselines.
- The plan for the required IBRs.

Ensure Compliance with the Agency EVM System Description

Projects that require EVM also require a management system that meets the requirements of EIA-748 *EVMS*. NASA has developed an in-house EVM capability that meets all the requirements of EIA-748. The *NASA EVM System Description* can be found at https://nen.nasa.gov/web/pm/evm. Projects are encouraged to use these processes to avoid the cost of developing their own EVM system description. When applying the *NASA EVM System Description*, projects should describe any scaling of the processes or procedures for their specific application in their EVM Implementation Plan. If projects create their own EVM system description, then it must fully describe the EVM processes, procedures, tools, and training that will be implemented on the project and include a matrix that describes how this approach complies with the 32 guidelines of EIA-748. The project EVM system description development begins in Phase A and is completed in Phase B in preparation for the Implementation Phase of the project and the establishment of the initial PMB.

Within NASA's OCE, there is an EVM community of practice. Each of the NASA Centers and several Mission Directorates have an Earned Value Management Focal Point (EVMFP) that can assist in EVM planning and assure that EVM management requirements are properly implemented on a project. NASA's OCE and EVMFP resources can provide guidance to projects requiring EVM. This support encompasses EVM planning including the development of an EVM implementation schedule, EVM Implementation Plan, project EVM System Description, types of tools available, roles and responsibilities of the project EVM team, and all associated EVM management activities and requisite EVM training needs. See http://evm.nasa.gov/ or https://nen.nasa.gov/web/pm/evm for more information.

Establish Performance Measurement Baseline (PMB)

The project PMB is a time-phased cost 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 established prior to KDP C. The previously mentioned integrated cost and schedule baseline is not to be confused with the PMB. A subset of this baseline, without UFE allocated and specific for a particular contract or at the project level, is often referred to as the PMB. Note: The Agency has EVM tools that are readily available to the projects at no cost that can help reduce the burden of documentation and reporting. (The *NASA Earned Value Management (EVM) Implementation Handbook*, *NASA/SP-2012-599*, provides detail on implementing EVM on a project.)

3.3.3.2. Control Activities

3.3.3.2A Formulate / Reaffirm and Execute Annual Obligation Authority

Budget formulation in this context, for the Resource Management function, is the process of developing and annually reaffirming, assessing, integrating, and justifying all the funding requirements necessary for completion of the project, assuring consistency with the schedule and technical milestones and funds availability. Budget execution is the process of making planned resources available and managing them to achieve the mission. Budget formulation and budget execution both occur throughout the project life cycle.

Develop and Update Funding, Workforce, and Infrastructure Requirements

During each annual PPBE budget formulation cycle, a project budget is updated within the defined constraints of the project's scope, schedule, and budget authority. The process establishes the resource requirements necessary for meeting project objectives and assists in the identification of issues and challenges. Included is the update of plans for all labor, travel, procurement, facilities, contracted services, and other support.

Prepare Annual Phasing Plan

A basic requirement of budget execution is the formulation of an annual expenditure phasing plan. This plan includes detailed monthly estimates of all of a project's obligations and costs for the fiscal year. An important consideration will be an estimate of the timing of funds expected to be received during the fiscal year (e.g., a continuing resolution could delay funding appropriation from Congress). The phasing plan will typically include carryover funds (funds from the previous fiscal year that were not obligated or costed) and forward funding (funds to be obligated in the present fiscal year and costed in the following fiscal year).

Develop and Update PPBE Submittals

Figure 3.3-3 depicts the overall flow for the Agency PPBE process. The PP&C team coordinates the PPBE data collection, analysis, and summarization, and the project manager reviews the data prior to release. The PPBE submission should be based on expected technical accomplishments and the associated schedule tasks for each FY. The project PPBE submission is coordinated with guidance provided through the project's programmatic chain of authority from its Agency, Mission Directorate, and Center policies. Center management reviews the proposed project PPBE submission for consistency and compliance with Center commitments and responsibilities. The PPBE submissions are integrated by Mission Directorate submissions to OCFO. PPBE submissions are expected to be consistent with the content and commitments that were approved at KDP C or as adjusted with new PPBE guidance including development of impacts that are then adjudicated by the Mission Directorate integration team and ultimately, if necessary, by the senior Agency programmatic leadership with integration provided by the OCFO.

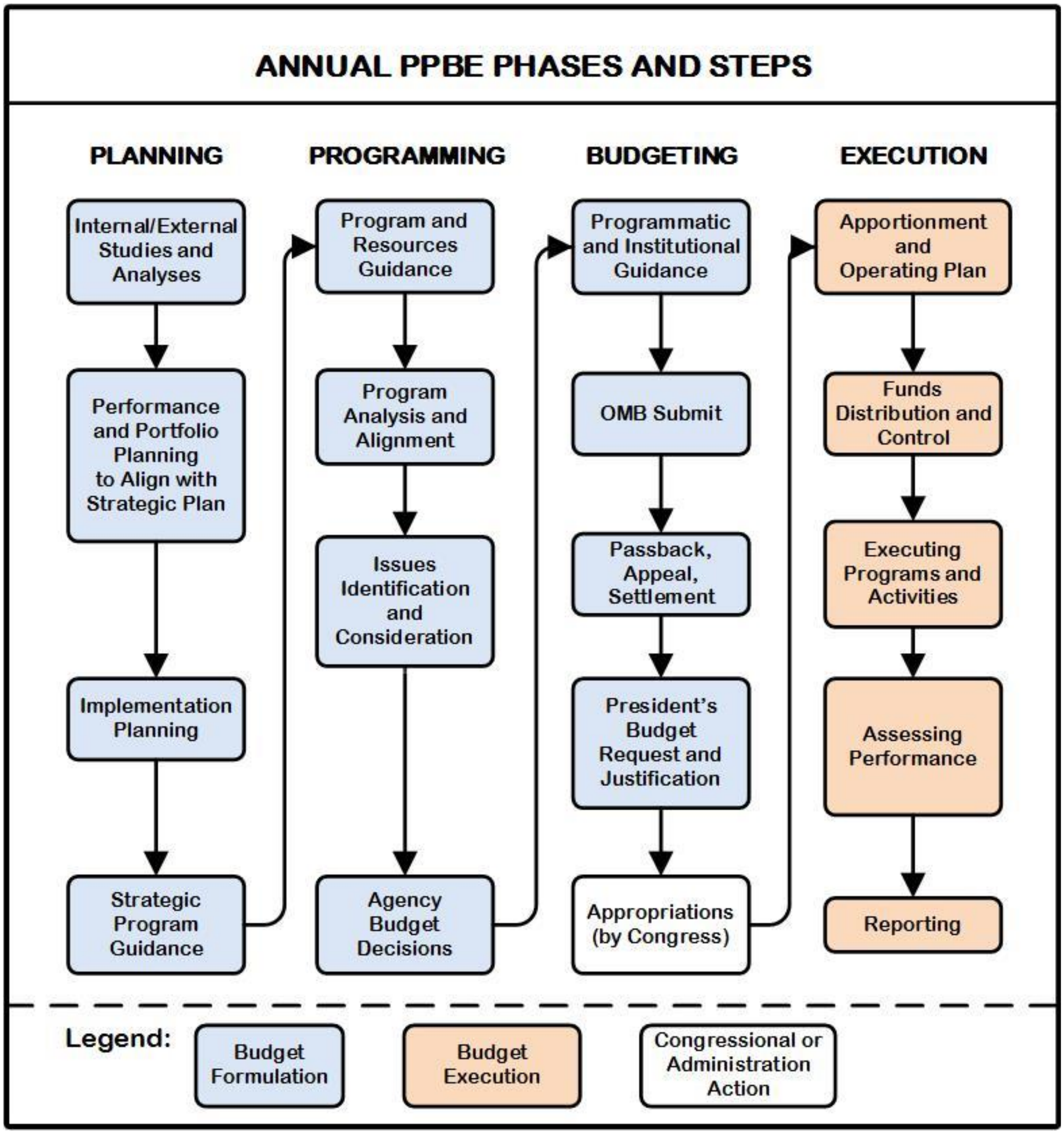


Figure 3.3-3 PPBE Phases and Steps (From *NPR 9470.1A, Budget Execution*)

The goal is to look beyond financial performance to assess a project's trend for achieving its commitments including the reaffirmation of budgets during the PPBE process. The Resource Management functional role may share or represent the perspectives of their PP&C lead and other stakeholders. Using tools for example, like EVM or assessments on RLSs, the Resource Management functional role includes assessment of progress on the technical scope and risk posture as well as the more traditional achievement milestones and financial performance.

Execute Budget by Managing Allocation of Funds, Workforce, and UFE

Budget execution is the process of making resources available and managing them to achieve the mission according to the approved plan. Funds represent the dollars available for expenditure in the accomplishment of the effort. Projects typically receive funds in increments during the course of each fiscal year, requiring careful allocation to cover labor, contracts, travel, and other expected expenditures as needed. Workforce management includes the tracking and analysis of work charged to the project and understanding and explaining any significant variances. In managing the UFE, the PP&C team should develop a log that tracks each UFE outlay, identifies the date and amount dispersed, identifies the purpose for the use, and includes the WBS to which it was applied.

3.3.3.2B Develop Integrated Project Status (Actuals)

It is important to assess and communicate project status through the following tasks.

Analyze and Assess Cost and Schedule Performance Impacts

Actual costs are accumulated on a regular monthly business cycle. This monthly cycle, also known as the "business rhythm," should be defined by the Resource Management function for all providers of the information required and described in the PP&C Management and Control Plan including required dates and content expected. Assessing cost performance is associated with the scope of work attendant to the WBS and includes but is not limited to accumulating the costs of the following:

- Contracts
- Any in-house (Government-Furnished Equipment (GFE)) development efforts for systems or subsystems
- Project management and support staff
- Center costs which the project must pay
- Any other suppliers that report costs separately
- NASA costs associated with partnerships

PP&C plays a primary role in supporting the management and administration of the contract. The Acquisition and Contract Management function of PP&C relies on this analysis. Analysis of the NF 533, contract invoices, Contract Data Requirements Lists (CDRLs)/ Data Requirements Descriptions (DRDs) such as an IMS, and various other contract reports are utilized. The NF 533 reports are the primary contract documents providing financial status on contracts. The NF 533M should be compared with the quarterly NF 533Q to ensure that the agreed upon contract value is accurate. In the case of Firm Fixed-Price (FFP) contracts, production and usage reports may be used by the analyst in lieu of NF533ss to gain an understanding of cost variance and impact to program activities. An analysis of the contractor's invoices and the contractor's financial management reports delivered to the Government on a monthly (533M) or quarterly (533Q) basis is required to ensure the contractors costs are in line with the project's budget. Contractor schedules are continually monitored, assessed, and managed to evaluate technical progress on the contract and are compared to the NF 533 reports. An analysis of the current actuals compared to plans, projected costs, and cost and schedule trends are necessary to manage the effort and to anticipate potential project overruns/underruns. The contract actuals and planned costs are used in conjunction with cost trends to predict a contract Independent Estimate at Completion (IEAC). For example, if a contractor shows that performance is one month behind plan, an average monthly burn rate from the NF 533 can be calculated and applied to the number of month(s) that the contract is behind schedule. If the contractor hasn't projected a variance in estimated cost from its planned cost, then an EAC including an additional month(s) of cost can be projected and incorporated into the IEAC. The contract EAC and the IEAC should be evaluated by the project team. Any material differences between the contractor's stated EAC and the IEAC, as well as any performance issues, should be addressed and coordinated and reconciled with the contractor through the CO and the Acquisition and Contracts Management function. See *NPD 9501.1, NASA Contractor Financial Management Reporting System*, and *NPR 9501.2, NASA Contractor Financial Management Reporting*, for more detailed information on 533 requirements. In addition, monthly analysis of the 533M should be done to determine how the contractor is performing to its planned rates for labor, overhead, General and Administrative (G&A) expense, etc. (Additional guidance is provided in *NPR 9420.1 Budget Formulation*.)

Integrate Cost and Schedule Updates

Integrate Schedule Updates

The Resource Management function depends on the Scheduling function to maintain an accurate schedule based on inputs from the P-CAM for each item on the schedule. The schedules are updated according to the business rhythm guidance, and the Resource Management function compares the latest schedules to confirm alignment with costs and ensure that any variances are characterized. Variance explanations should clearly identify the nature of the problem, significant reasons for the variance, effect on the immediate task, impact on the total contract and project, corrective action to be taken, and the timeframe for the corrective action. If the project is behind schedule, it is important to determine whether the critical path has been impacted and whether critical milestones are likely to slip.

Reflect Impacts Relative to Risks

For each discrete risk in the risk list, the Resource Management function accumulates the cost and schedule impacts and updates monthly, including the likelihood and the total expected value of the discrete risks. The integration of risk into the cost and schedule analyses assures that new technical, cost, or schedule risks are accumulated with mitigation plans, identified probability of occurrence, and impact. Resource Management tracks the value of risks over time, weighs their potential impact against availability of UFE, and potentially identifies performance trends as they appear.

Provide Reports and Recommend Actions

The project should prepare a monthly report of the progress compared to plans with an integrated summary of cost, schedule, and risk, where variances include a brief characterization of the scope involved. Periodically, the project should review the project-level EAC for updating.

(Note: This activity is performed by Resource Management in collaboration with PP&C Integration. A complementary description of this activity is provided in the PP&C Integration Function, Section 3.2.3.1. (See the activity Define Approach/Strategy for Executing Scope of Work.))

3.3.3.2C Implement Earned Value Management (as Applicable)

Though not required for all projects, the use of Performance Measurement Techniques (PMTs) can provide an objective measurement of how much work has been accomplished on a project. Using the earned value process, the management team can readily compare on a regular interval (usually monthly) how much work has actually been completed, the actual costs incurred to complete that work versus the amount of work planned to be accomplished. These comparisons can provide the project with metrics that can be used to project the schedule delivery dates and improve the fidelity of the EAC as discussed in the previous activity. The EAC can be used to modify the PPBE if required. All work is planned, budgeted, and scheduled in time-phased "planned value" increments constituting a PMB. When EVM processes are not required, there is still great value in utilizing EVM to evaluate project performance, including the discipline EVM imposes to address variance, scope changes, and deployment of UFE.

Maintain PMB, Gather EVM Data, Conduct Analyses,
and Conduct Surveillance

All changes to the PMB (scope, schedule, budget, EAC) need to be documented in some form to provide traceability as required for management control and reviews. A change in this type of data usually requires changes to other areas such as risk management information. As work is performed, the actual cost for accomplishing that work, known as Actual Cost of Work Performed (ACWP), is captured within the financial reporting system. The *value* of the work accomplished is the earned value of that work and is known as Budgeted Cost for Work Performed (BCWP). The Budgeted Cost for Work Scheduled (BCWS) represents the value of the time-phased work as it is planned. The integrated use of these three elements (BCWS, BCWP, and ACWP) provides the data needed to analyze schedule, cost, and technical performance.

Contractor EVM reporting thresholds are established during the acquisition process. The project specifies a variance threshold for reporting of variances, noting that these thresholds can differ by reportable WBS. Applicable contractors submit EVM data in an IPMR. The data should be consistent and reconcilable with both the Monthly Contractor Financial Management Report (NASA Form 533M) and the Quarterly Contractor Financial Management Report (NASA Form 533Q) if applicable. The IPMR should be reviewed for accuracy and adequacy.

After all the data is integrated into the EVM system, EVM analysis can be performed at any level and reported at the project level. The performance data is analyzed and an EAC is prepared as required. The adequacy of UFE is assessed. Input is provided at project risk meetings to ensure that risks are captured in the EAC and schedules.

Surveillance is the process of reviewing the health of the accepted EVMS process applied to projects. The purpose is to focus on using the Agency EVMS effectively to manage cost, schedule, and technical performance. An effective surveillance process ensures the key elements are maintained over time and on subsequent applications.

Provide Reports

EVM data should be included in all management reviews. Project status based on EVM data should be reported at the level appropriate for all levels of management. The project EVM reporting of cost and schedule performance measurement plays an integral part in providing information to support the decision-making process used by management to determine the appropriate actions.

A well-crafted reporting structure should provide the ability to quickly examine the performance data to determine the source of significant technical, cost, and schedule variances. Whereas the PMB is important to measure performance against a plan (budget), an EAC is necessary to understand the anticipated total funding requirements to complete the project. Real-time updates of EAC at individual control accounts to address issues occur during the monthly review and analysis of performance as appropriate. A comprehensive (e.g., bottoms-up) EAC is required annually as a minimum to better understand the project's EAC and total estimated funding requirements to ensure that the PPBE is updated appropriately.

Conduct/Participate in IBRs, Validation & Compliance Reviews, Surveillance, etc.

IBRs are required whenever EVM is required. The objective of an IBR is for all stakeholders to jointly assess the baseline to be used for performance measurement to ensure complete coverage of the SOW, logical scheduling of the work activities, adequate resourcing, and identification of inherent risks. (The *NASA Earned Value Management (EVM) Implementation Handbook*, *NASA/SP-2012-599*, provides detail on implementing EVM on a project and is found on both the external and internal websites at: http://evm.nasa.gov/ and (https://nen.nasa.gov/web/pm/evm). In addition, the *Integrated Baseline Review Handbook*, *NASA/SP-2016-3406* is at http://evm.nasa.gov/ and http://www.evm.nasa.gov/docs/Handbooks/NASA_IBR_Handbook_STI_13-058.pdf)

3.3.4. Function Activities by Life-Cycle Phase

Table 3.3-2 describes the Resource Management activities for each life-cycle phase:

Table 3.3-2 Resource Management Activities by Life-Cycle Phase

<table>
<tr><th>Pre-Phase A</th><th>Phase A</th><th>Phase B</th><th>Phase C</th><th>Phase D</th><th>Phase E</th><th>Phase F</th></tr>
<tr><td>Set up WBS to Level 2</td><td>Extend WBS to Level 3/4</td><td colspan="5">Update WBS as needed</td></tr>
<tr><td></td><td>Develop WBS Dictionary</td><td colspan="5">Update WBS Dictionary as needed</td></tr>
<tr><td colspan="2">Develop/refine budget planning information</td><td colspan="5">Update budget planning information as needed</td></tr>
<tr><td colspan="2">Develop/refine workforce planning information</td><td colspan="5">Update workforce planning information as needed</td></tr>
<tr><td colspan="2">Develop/refine infrastructure planning information</td><td colspan="5">Update infrastructure planning information as needed</td></tr>
<tr><td colspan="3">Develop Integrated Cost and Schedule Baseline</td><td colspan="4">Track Performance to the Baseline</td></tr>
<tr><td colspan="7">Develop PPBE submittals</td></tr>
<tr><td colspan="7">Formulate and execute annual phasing plans</td></tr>
<tr><td></td><td colspan="6">Tracking, analysis, and forecasting of project resources</td></tr>
<tr><td>Develop EVM schedule</td><td colspan="2">Develop EVM Implementation Plan</td><td colspan="3">Maintain EVM system: gather data, conduct analyses, provide reports, participate in reviews</td><td></td></tr>
</table>

3.4. Scheduling Function

3.4.1. Function Overview

The Scheduling function encompasses development and/or integration of lower level schedules, baseline, analysis, progress update, content change, reporting, and control of the IMS. The purpose of an IMS is to provide a time-phased plan for performing the project's approved total scope of work and achieving the project's goals and objectives within a determined timeframe. This includes contractor work. The project IMS provides a logical sequence of work activities from project start through completion based on all project work as defined/broken down by the established WBS. Estimates for all work tasks establish a logical hierarchy from the detailed activity level to intermediate and project summary levels and contain baseline, actual, and forecast dates for each activity. A properly prepared IMS provides a roadmap from which the project team can execute all authorized work and determine where deviations from the baseline plan have created a need for corrective action. The IMS is the backbone not only for managing the project successfully but also for communicating the overall work plan and the current progress made in completing the plan.

A credible IMS is also critical to successful implementation of EVM. The baselined IMS provides the time-phasing used as the baseline to measure EVM performance. (See Section 3.5, Resource Management Function for information on EVM.)

3.4.2. Integration with Other PP&C Functions, Inputs, and Outputs

The Scheduling function needs to effectively interact with other PP&C functions to:

- Develop the products, plans, and strategies that comprise an integrated, project-level executable plan during the planning phase; and
- Evaluate and control the entire project during the control phase.

The Scheduling function also needs to obtain information from and communicate information with entities external to PP&C.

Figure 3.4-1 is a flow diagram for the Scheduling function that depicts major inputs and outputs received from and provided to other PP&C functions as well as external entities. Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it. The flow diagram also summarizes key activities to consider during the planning and control phases when implementing this function**.** Section 3.4.3 discusses these key activities in detail and provides insight into the importance of the interactions with other PP&C functions.

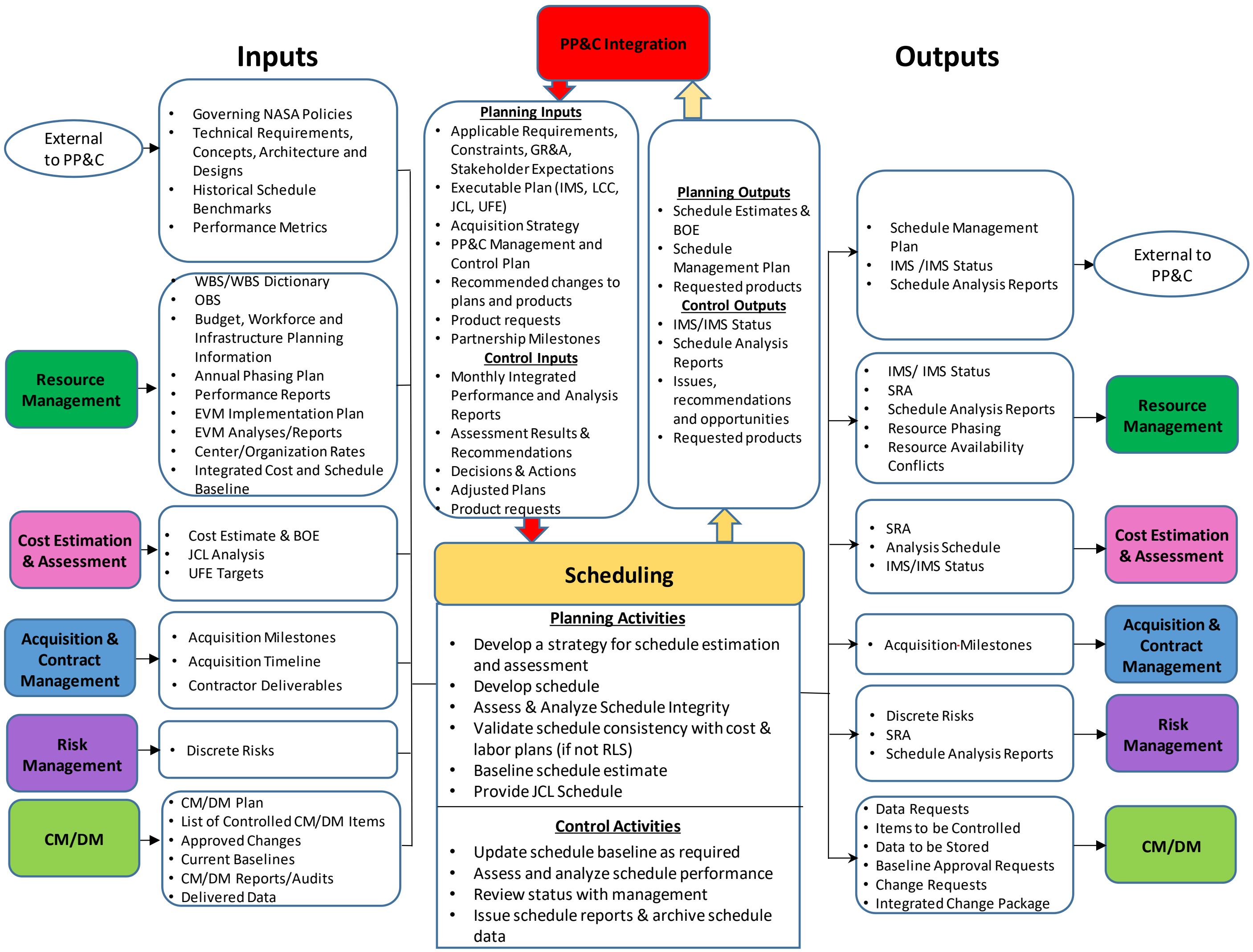


Figure 3.4-1 Typical Functional Flow Diagram for the Scheduling Function with Major Inputs and Outputs

Descriptive information is provided below for the inputs from external entities and for the outputs depicted in Figures 3.4-1. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.4.3.

Descriptions of all inputs and outputs can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.

3.4.2.1. Inputs

- **Governing NASA Policies:** Applicable Agency NPDs, NPRs, Center policies, lessons learned, and best practices including Agency handbooks. While NPR schedule requirements are generally high level, they establish the need for project schedules to exist and be sufficient for guiding project implementation and for identifying the critical path. Applicable Agency handbooks include *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, *NASA/SP-2012-599*, *NASA Earned Value Management (EVM) Implementation Handbook*, and the *Cost Estimating Handbook (CEH), Version 4.0 (February 2015).*

- **Technical Requirements, Concepts, Architecture, and Designs:** Examples that drive the schedule include the project work scope, mission concepts, trade studies, system requirements, test and verification requirements, safety requirements, hardware and software specifications, system design, interface design, tooling requirements/design, manufacturing standards, unique project assumptions, known risks, etc. These inputs should be clearly articulated by the project technical team and incorporated into the project IMS. The project work scope may be identified in the Project Plan or in a collection of other project documents (e.g., Acquisition Plan, verification plan, request for proposal, contracts, WBS/WBS Dictionary, etc.). A clear understanding of the work content is necessary before a valid schedule can be developed. Inputs include realistic task duration estimates, proper task sequencing, and valid constraints that impact work flow. Other project-specific inputs that may affect schedule development and control can be gleaned from the various project work scope documents. These inputs should be clearly articulated and vetted with the TPOC that is the closest possible to the work being performed.

- **Historical Schedule Benchmarks:** If available, the schedule development process should make use of historical schedule databases at each NASA Center. This data can be used to validate task duration estimates and analyze scheduling logic of similar types of projects and schedule activities.

- **Performance Metrics:** Performance metrics are project measurements that communicate vital information about the status or performance of a system, process, or activity for contractor and in-house efforts. Regular status updates for work performed in-house by

NASA organizations as well as for contracted work provides needed IMS activity progress for on-going work along with issues impacting work completion.

- **WBS/WBS Dictionary:** The WBS is a product-oriented family tree that decomposes the scope of work into manageable segments to facilitate planning and control of cost, schedule, and technical content. The WBS Dictionary is a document that describes the work content of each WBS element in product-oriented terms and relates each element to the respective, progressively higher levels of the structure. The WBS is used to develop and organize the schedule, directly tying tasks/events to their associated WBS element. If work is not included in the project WBS/WBS Dictionary that has been approved by project management, then it should not be included within the IMS. The structure of the project schedule should match the approved project WBS. It should be noted that while the Agency Core Financial System is currently limited to seven WBS levels for capturing actual project costs, a project's technical WBS and schedule can further extend to lower levels to ensure that work definition and progress insight is sufficient for proper management. NPR 7120.5 and NPR 7120.8 outline WBS structures for space flight programs and research and technology programs, respectively, and should be used as guidance on creating WBSs for these types of projects.

- **Organizational Breakdown Structure**: Generally, the Resource Management function uses the OBS to assign work to each WBS element, which can then be flowed down and assigned to each schedule task/milestone contained in the IMS.

- **Budget Planning Information:** Budget planning information (i.e., all estimated project costs and obligations including FTEs, WYEs, ODCs, procurements, travel, facilities, and other costs for each fiscal year during all phases of a project) is used by Scheduling in the initial IMS development and also further iterations of the schedule leading to an approved baseline project IMS. This information aids in determining IMS task durations, interdependencies, constraints, and calendars. It is imperative that the IMS baseline correlates to and is in agreement with all segments of the integrated cost and schedule baseline.

- **EVM Implementation Plan:** The EVM Implementation Plan, which may be part of the Project Plan, is a control plan that describes the project's implementation of EVM including methods the project will use to communicate changes for the schedule; the schedule information required of the suppliers to establish and maintain a baseline and to quantify schedule; how contractor performance reports will be required; how the schedule data from all partners/suppliers will be integrated to form a total project-level assessment of schedule performance; how the project plans to report schedule status to the program manager including the frequency; and a description of any tools necessary to implement the project's control process such as the scheduling system. This control plan will also include the process for establishing, monitoring, and controlling the IMS and the process for utilizing the project's technical and schedule margins and UFE to meet the management and commitment baselines.

- **Earned Value Analyses and Reports:** For contracts, a project-level IPMR is typically provided on a monthly basis to provide technical, schedule, and cost status information. The purpose of the IPMR is to provide early identification of problems that may have significant cost, schedule, and/or technical impacts and report the effects of management actions and project status information for use in making and validating management decisions. Projects integrate contract IPMR, in-house, and other data to produce a project level IPMR. Of particular importance to scheduling are WBS elements reflecting a poor Schedule Performance Index (SPI) or a significant schedule variance such as Earned Schedule (ES). ES is an EVM metric where the schedule variance is measured using time-based units rather than units of cost; ES measures project progress as it varies between zero time units and the baseline planned duration. The WBS areas that display performance concerns, per EVM data, should be addressed within the IMS to determine where they fall in relation to primary, secondary, and tertiary critical path data.

- **Center/Organization Rates:** When RLSs are used by a project, appropriate rates can be applied to resources assigned within the IMS to provide estimated costs for the project.

- **Integrated Cost and Schedule Baseline:** The integrated cost and schedule baseline is established based on the cost, schedule, and UFE for which the project manager has management control. This cost, schedule, and UFE is documented in the KDP C MA per the KDP DM. The integrated cost and schedule baseline needs to be consistent with the available funding plan. This baseline becomes the foundation against which the project's cost and schedule performance is assessed, adjustments are made, and EACs are developed. (This project-level integrated cost and schedule baseline is not to be confused with the PMB). (For additional detail, see Section 3.3.2.)

- **Cost Estimate & BOE:** A documented, risk-adjusted forecast of future cost representing a specific scope of work. The cost estimate includes the cost modeling framework (analogy-based, parametric, engineering build up) used in its development, and the BOE. The cost estimate is provided in the required format (range, LCC), and is phased (that is, spread over the time scope of the estimate). Parametric and/or detailed cost estimates for hardware and software content in a project can be used as an aid in determining various IMS definitions such as task content, resource assignment, task durations, etc. (For additional detail, see Section 3.5.2.)

- **JCL Analysis:** The JCL is a 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 Phase D. By being 'risk-informed," the characteristic of having mapped all discrete risks and classes of uncertainty within scope to JCL model elements, the JCL intends to ensure that adequate budgets and schedules are reflected in the Project Plan.

- **Unallocated Future Expenses (UFE) Targets:** 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 the scope of probabilistic risk and uncertainty, the full impact of which is not known.

- **Acquisition Milestones:** Acquisition milestones establish the dates when contracts are expected to complete key events or provide project deliverable(s). Acquisition milestones are key acquisition events that are identified within the baseline IMS. (When provided as an input from the Acquisition and Contract Management function, the acquisition milestones reflect the milestones established in contracts.)

- **Acquisition Timeline:** The planned dates when solicitations are expected to be released, proposals from offerors evaluated, and contracts awarded.

- **Contractor Deliverables:** The Acquisition and Contract Management function accepts and reviews deliverables to ensure they are consistent with contract requirements and provides the deliverables to the Resource Management and Scheduling functions for analysis and assessment of contract performance. Deliverables include the contractor's time-phased schedule plan for completing the total negotiated scope of work. The contractor baseline IMS should contain detailed tasks, key contract milestones, realistic durations, task interdependencies, project calendars, internal/external constraints, assigned resources, and task coding (e.g., WBS, responsibility, system, phasing, etc.). Contractor baseline IMS updates will reflect monthly task status and progress updates, changes, performance issues, workaround plans, narrative explanation for schedule variances, and forecast updates.

- **Discrete Risks:** Identified, documented potential events that each carry an estimated consequence and an associated likelihood (probability of occurrence). The Risk Management team frames the body of risks for project management decision making and programmatic analyses. Each discrete risk includes a risk statement and narrative description; a risk mitigation plan; cost and schedule consequences; likelihood and risk response. The Scheduling function should use discrete risks to perform a SRA and related analyses while ensuring risks are appropriately and completely characterized. The Scheduling function should also apply appropriate uncertainty ranges to the schedule durations as part of the SRA and JCL analyses based on project manager, CAM, SRB, or other appropriate stakeholder input. (For additional detail, see Section 3.7.2.)

- **List of Controlled CM/DM Items**: The Scheduling function needs to be aware of products that will be under either CM or DM.

- **Approved Changes:** Once the control board or other governing authority has made the decision to approve the requested changes, the decision is communicated to the Scheduling Function and the requested changes are made to the IMS.

- **Current Baselines**: Baselines of the current items that are on the CM/DM list are made available to all technical teams and stakeholders. These include the PMB, financial reporting, baselined IMS, budgets, and documentation.

- **CM/DM Reports and Audits:** Periodic reports on the status of the CM/DM items should be available to all stakeholders on an agreed-to frequency and at key LCRs. The Scheduling function should provide status input on CM/DM products that are produced by the Scheduling function. The Scheduling function should also be aware of the status of CM/DM items that are inputs to the Scheduling function.

- **Applicable Requirements, Constraints, GR&A, and Stakeholder Expectations:** These define and bound the scope of PP&C products developed by all PP&C functions. Identification helps to minimize or eliminate oversights that can result in PP&C products that fail to meet the needs of the project, its customers, and stakeholders. Constraints and GR&A include mission objectives, goals, and success criteria. They may be derived from stakeholder expectations and project and programmatic requirements including the project budget and project funding and technical requirements. Constraints and GR&A may be documented in the FAD, the FA, DMs, MAs, and Program and Project Plans. Project funding dictates the amount of work scope that can be accomplished in the time allotted. Caution should be exercised to ensure that project planning and schedule commitments never exceed the authorized funding. It is also important to understand that while project funding and project budget do have a relationship, they are not the same thing. (For additional detail including examples, see Section 3.2.2.)

- **Executable Plan (IMS, LCC, JCL, UFE):** The executable plan captures the integrated set of technical, science, cost, schedule, resource, and facility requirements of the project in the WBS, schedule, resource baseline, and budget. The baselined IMS, LCC estimate, JCL, and UFE are key elements of the executable plan. These products are also part of the project's ABC.

- **Acquisition Strategy:** The project's approved Acquisition Strategy for using NASA's acquisition authorities to achieve the project's mission within planned cost and schedule. (For additional detail, see Section 3.2.2.)

- **PP&C Management and Control Plan:** This Plan is an optional, project-level document intended to support an integrated, organized summary of a project's PP&C activities in one document. The plan provides an overview of the PP&C organization and describes the guidelines and processes to be used for the different PP&C activities. (For additional detail, see Section 3.2.2 and Appendix G: PP&C Management and Control Plan.)

- **Recommended Changes to Plans and Products**: Recommendations to this function for changes and/or adjustments to plans and products.

- **Partnership Milestones:** Partnership milestones establish the dates associated with partnerships such as when partnerships need to be executed, when partners are expected to complete events, or when international partners are expected to provide project deliverable(s). Partnership milestones may be identified within the baselined IMS.

- **Monthly Integrated Performance and Analysis Reports:** Current integrated cost and schedule performance, trends and variances, and the project's risk posture; analyses of cost and schedule variances and trends; identification of data correlations and causal relationships, key drivers, and sensitivities; and status of UFE, liens, and threats.

- **Assessment Results and Recommendations**: Forecast of integrated cost and schedule performance and EAC based on current performance, work remaining, and likely impacts of remaining risk and issues. Identification of key issues and decisions that need to be made by project management. Recommendations for controlling project performance. (For additional detail, see Section 3.2.2.)

- **Decisions & Actions:** Options and/or corrective actions approved for implementation by the project manager including associated decision packages. Plans for implementing, tracking, and reporting on the results of the options/corrective actions. (For additional detail, see Section 3.2.2.)

- **Adjusted Plans:** Updates to the project's plans based on approved options/corrective actions. May include updates to the baseline IMS, LCC, and EAC.

3.4.2.2. Outputs

- **Schedule Management Plan:** This plan may be established as a standalone document or as a specified section within the Project Plan. The key topics included are the scheduling approach, roles and responsibilities, tools to be used, IMS development processes, update and maintenance processes, analysis techniques, IMS baseline control, reporting formats, and data archival. (The Schedule Management Plan (SMP) is provided to PP&C Integration for review and comment prior to approval.)

- **IMS/IMS Status:** The IMS/IMS status and progress updates for work performed in-house, by contractors, and by other implementation entities. The baseline IMS is the end result of the IMS development process and is the project management-approved schedule to be used in guiding project implementation and measuring project performance. Management approved additions/deletions and revisions are captured in the IMS status update. Changes to the baseline IMS are configuration-controlled.

- **Schedule Analysis Reports:** Examples of typical analysis reporting include schedule health check, critical path analysis, schedule performance and work-off trend, Baseline Execution Index (BEI), Current Execution Index (CEI), Hit/Miss Index (HMI), total slack analysis, schedule milestone comparison, schedule margin tracking, etc. Additional descriptions and illustrations of the above formats are found in *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Chapter 7.

- **Schedule Risk Assessment (SRA):** An SRA is a forecast resulting from the stochastic simulation of the IMS or an analysis schedule whose tasks are loaded with duration uncertainty and discrete schedule risks. (For additional detail on risk versus uncertainty, see Appendix I: Uncertainty versus Risk: Functional Definitions from a Programmatic Analysis Perspective.) SRA results include but are not limited to the following reports:
    - Resultant distributions that measure variability of an ultimate project end date, such as a hardware delivery or launch date, or interim milestones or tasks.
    - Top schedule risks in terms of impact on milestones, criticality, or other metrics.

    - Other analyses including sensitivity of downstream schedule elements to the variability of tasks or milestones, correlation among tasks, and a characterization of schedule reserve relative to schedule targets.

- **Resource Phasing**: If the IMS is resource-loaded, it provides time-phased requirements for labor, material, and equipment. RLSs help to ensure cost and schedule integration and provide the resource requirements needed to ensure that project resources are available.

- **Resource Availability Conflicts:** RLSs provide the capability for over-allocation reporting, which can identify those tasks where resource conflicts exist. If manual processes are used to integrate resources and schedule, similar reporting is possible but can be much more difficult to produce.

- **Analysis Schedule:** An IMS or analysis schedule is used as the foundational framework for a JCL. It comprehensively includes well-defined tasks that are logically sequenced and justifiably interdependent. A project's analysis schedule is often a consolidation of its baseline IMS and other schedule data that preserves appropriate detail for elements that are more critical and summarizes those that are less important. Its structure ideally enables incorporation of risks, task uncertainty, and cost into a self-contained analysis.

- **Acquisition Milestones:** See Inputs. Initial acquisition milestones are provided to the Acquisition and Contract Management function for use in developing solicitations. As project work is accomplished and task/milestone forecast start/finish dates move earlier or later, it is important to monitor and keep the management team informed of changes to need dates for various hardware milestones/development efforts. Close communication of this information between project team members, the Acquisition and Contract Management function, and associated vendors will help ensure parts and material are available when needed.

- **Discrete Risks:** See Inputs. As an output these are:
    - Specific discrete risks identified by the Scheduling function, and/or
    - For each discrete risk in the RMS, authoritative schedule estimates for each risk's schedule consequence and mitigation plan along with the BOE. The Scheduling function reviews and may provide updates to this information provided by risk owners. Thus, this function is in part responsible for the schedule dimensions of risks, enabling transparent and traceable incorporation into schedule estimates.

- **Data Requests:** Requests to the CM/DM function for any of the PP&C or other data under data control.

- **Items to be Controlled:** Items developed by this function that need to be placed under configuration control including the baseline IMS and SMP.

- **Data to be Stored:** Data developed by the Scheduling function identified as needing to be stored.

- **Baseline Approval Requests**: Requests to place an item under baseline control.

- **Change Requests**: A request submitted to the CM/DM function to change an item under configuration control. (For additional detail, see Section 3.8.2.)

- **Integrated Change Package:** Evaluation of a requested change to an item under configuration control. Package includes a description of the change; project organizations that evaluated the change; impacts of the change on other project products, activities, and documentation; and impacts to the project's cost, schedule, and risk. The package is reviewed for approval or disapproval by the appropriate project control board/ decision maker. (For additional detail, see Section 3.8.2.)

- **Schedule Estimates & BOE:** The schedule estimates and schedule BOE are outputs of the schedule planning phase and a specific requirement stated in *NPR 7120.5, NASA Space Flight Program and Project Management Requirements*. During project Formulation, the schedule estimates are continually updated as the design matures. Assumptions in the development of the schedule are documented in the schedule BOE. Schedules are baselined prior to project Implementation. A one-dimensional schedule confidence level is provided with the preliminary schedule range estimate developed for KDP B.

- **Issues, Recommendations and Opportunities:** Issues include project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance. (For additional detail and examples, see Section 3.2.2.)

- **Requested Products**: Products requested from the other PP&C functions needed to support internal reviews, independent reviews such as LCRs and KDPs, audits, and external reports.

3.4.3. Function Planning and Control Activities and Tasks

Scheduling planning and control activities and tasks are outlined in Table 3.4-1 Scheduling Activities and Tasks. The activities and associated tasks are described in more detail in the text below the table.

Table 3.4-1 Scheduling Activities and Tasks

Scheduling	
Planning Activities and Tasks	**Control Activities and Tasks**
Activity: Develop a strategy for schedule estimation and assessment • Develop SMP • Review external and PP&C inputs • Select scheduling tool **Activity: Develop Schedule** • Define IMS tasks and milestones • Establish task/milestone sequence • Estimate task durations • Correlate budgeted cost to schedule plan • Assign valid schedule constraints • Define schedule calendars • Incorporate schedule margin • Define and document the schedule BOE **Activity: Assess and Analyze Schedule Integrity** • Perform schedule integrity health checks • Identify critical path(s) • Perform schedule risk assessment • Validate schedule estimate (i.e., peer reviews, historical data comparison, etc.) **Activity: Validate Schedule Consistency with Project WBS/WBS Dictionary and Budget/Labor Plans** • Validate consistency to WBS/WBS Dictionary • Validate consistency to budget/labor plans **Activity: Provide Analysis Schedule** • Prepare the analysis schedule **Activity: Baseline Schedule Estimate**	**Activity: Update Schedule Baseline as Required** • Gather and incorporate task progress and changes (per defined update cycle) • Evaluate schedule impacts of proposed changes and current status updates • Perform schedule integrity health checks **Activity: Assess and Analyze Schedule Performance** • Identify schedule performance and trends • Analyze changes to critical path(s) • Capture risk, assess and communicate threats against schedule performance **Activity: Review status with management** • Validate status update and impacts with discipline leads/managers • Obtain project manager approval of IMS update **Activity: Issue Schedule Reports and Archive Schedule Data** • Prepare and issue updated IMS • Prepare and issue analysis/performance reports • Archive schedule data

Scheduling	
Planning Activities and Tasks	**Control Activities and Tasks**
• Obtain project management approval and commitment to schedule • Obtain other participating stakeholder commitment to schedule	

3.4.3.1. Planning Activities

3.4.3.1A Develop a Strategy for Schedule Estimation and Assessment

Develop a Schedule Management Plan

A project SMP should be prepared during Phase A of project Formulation prior to KDP B for each project. While not explicitly required by NPR 7120.5 or NPRs 7120.7 and 7120.8, this document is a recommended best practice and may be required by the program/project manager. NPR 7120.5 does require a technical, schedule, and cost control plan, which is to be baselined at SDR/MDR. The SMP describes and defines the techniques and methods to be used in implementing the scheduling function. The SMP can be a standalone plan, or its pertinent information can be captured within the schedule control plan section of the Project Plan. Regardless of how it is structured within a project's documentation, the SMP/schedule control plan content should be subject to configuration control. The SMP is not intended as a detailed procedure for performing scheduling; rather, it should describe the project's processes for managing and controlling its schedule.

The content of the IMS and the overall SMP approach depends on the type of project and how it is organized. For example, there could be in-house, prime contractor, and/or external partnership activities that would influence the planning process. Additionally, scheduling should be in accordance and integrated with the Agency and institutional EVM processes and methodologies on projects that have a life-cycle cost of $20M or more. For small Category 3/Class D space flight projects with a life-cycle cost under $150M, scaling is accepted in EVM implementation as long as processes (including scheduling processes) satisfy the seven foundational principles of EVM as described by the NASA Associate Administrator in his formal management guidance and expectations for small Category 3/Class D space flight projects.

For additional information, see the Schedule Management Plan Outline in *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Appendix F, and *NASA/SP-2012-599, NASA Earned Value Management (EVM) Implementation Handbook*.

Review External and PP&C Inputs

The Planner/Scheduler's (P/S) first step in developing a project schedule includes understanding the project work scope, the WBS, the OBS, and the project funding/budget dynamics, and also involves reviewing pertinent studies, agreements, and project authorization documents that may be available.

Project schedules may include the work content of in-house efforts, international partner efforts, and contractor efforts. For work performed in-house, some type of a work authorization or work agreement process should be in place that identifies work scope, schedule requirements, and the approved budget. For international partner efforts, a partnership agreement should be in place. (The Partnership Milestones input identifies when international partners are expected to provide project deliverable(s)). For contractor efforts, the Scheduling function should coordinate with the responsible COR to develop the schedule management and reporting requirements for applicable procurements. These requirements may be contained in the contract SOW, CDRL, and/or DRD. The objective is to obtain the schedule information necessary to manage the IMS and enable informed decision making. SOW, CDRL, and DRD should be structured in order to take maximum advantage of contractors' existing scheduling systems, capabilities, and formats. Additional information and guidance on in-house and contractor schedule development activity can be found in *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Chapter 2.

3.4.3.1B Develop Schedule

The project IMS is developed by coordinating with the technical team and defining and sequencing tasks/milestones, estimating task/activity durations, incorporating project constraints, correlating to available resources, and organizing schedule content per established coding structures. IMS content includes the effort to be carried by all responsible entities involved in project implementation (e.g., NASA, other Government agencies, contractors, vendors, universities, national laboratories, international partners). The IMS should accurately reflect the planned project implementation. The IMS contains baseline schedule data as well as current schedule status and projections.

Use of "industry best practices" and "GAO best practices" for schedule development helps to ensure valid schedule data. Data credibility assumes that all authorized work has been included in the IMS as tasks and milestones, realistic task/activity durations have been utilized, logical interdependencies have been incorporated, and only valid constraints have been assigned. This time-phasing is critical in the implementation of EVM and should be used in the development of the project PMB. The following paragraphs outline the basics steps for developing a project schedule. Figure 3.4-2 shows the process of decomposing the project requirements to produce an executable IMS.

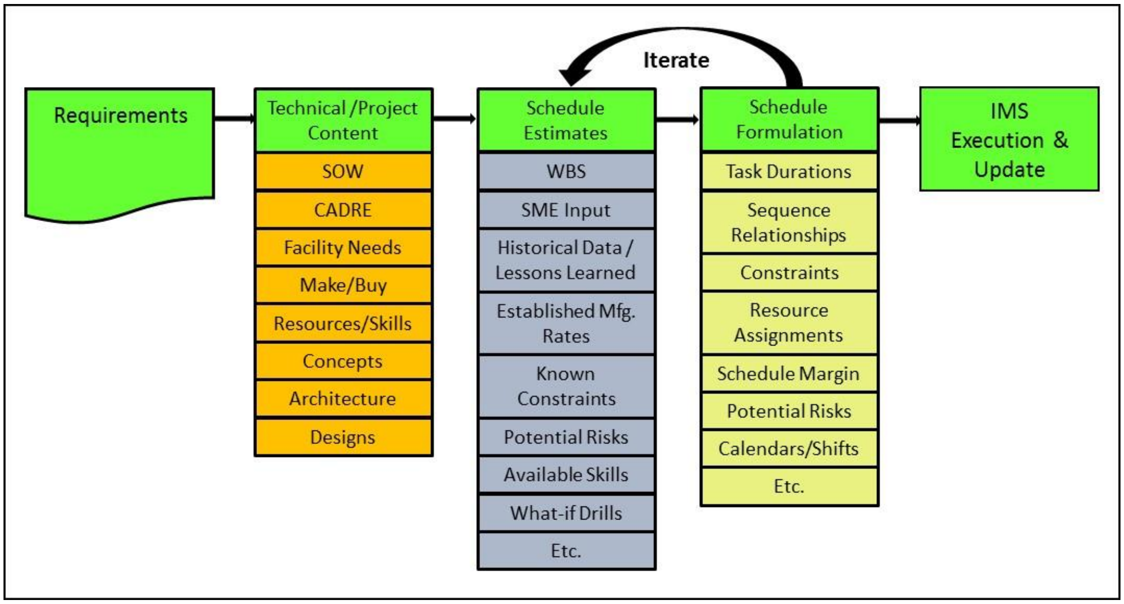


Figure 3.4-2 Schedule Development Process Flow

Define IMS Tasks and Milestones

Task definition begins with the product-oriented WBS. Technical and programmatic managers first decompose and extend the WBS elements for which they are responsible down to discrete and measurable tasks. Defining and integrating these components forms the beginning of the project schedule. The IMS should be structured by control account, work package, and planning package if applicable for EVM. Starting with the approved WBS not only helps ensure that the total scope of work is included in the schedule but also ensures consistency in the integration of cost and schedule data. The task/activity level of detail should be sufficient to allow for meaningful and accurate progress measurement and defined interface points to enable sequencing of tasks using the preferred “finish-to-start” interdependency logic relationship.

Establish Task/Milestone Sequence

The Scheduling function should work with the project manager, CAMs, and other stakeholders or Subject Matter Experts (SMEs) to define the logical relationships (interdependencies) between schedule tasks. This will help ensure accurate modeling of a project’s sequence of planned activities in the IMS. These relationships also provide the means for satisfying the requirement for vertical and horizontal traceability within the project schedule. For information and guidance on proper task relationships and the use of lag and lead values in relationships, see *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Section 5.4.1.

Establish Task Durations

Task duration is the length of calendar time a task is expected to take to complete consistent with the work time required and resources available. Durations should be realistic and where possible enable objective progress measurement. Some common methods and sources for deriving duration estimates are found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Section 5.5.1. The P/S should always seek valid sources and processes to assist in deriving the most accurate task durations possible for schedule development.

Task durations should be revisited periodically as work progresses and as new information becomes available for remaining work (no changes to completed work durations). It is important that durations should not be padded in order to keep a hidden contingency, reduced to be unrealistically optimistic, or arbitrarily cut by management.

Correlate Budgeted Cost to Schedule Plan

Projects not using RLSs still need to ensure that the budget plan and the schedule plan adequately correlate. This requires a joint effort and good communication between the Resource Management function and the scheduling team. It is a recommended practice that budget and schedule planning be done at a level of detail that provides sufficient management insight, control, and the ability to accurately measure and track progress. At this defined level of the WBS, budget and schedule development should be carried out by both organizations in a manner that accurately correlates the time phasing of both products. This collaborative approach aids in ensuring that the necessary consistency exists between the two plans. Because this is typically a manual effort, a disciplined process should be established and documented.

Assign Valid Schedule Constraints

A constraint is a fixed date assigned to a task or milestone that controls when it starts or finishes. Caution should be exercised when using constraints because they are a significant factor in how slack (float) is calculated throughout the project schedule. A constraint should only be assigned when a valid reason exists for its use. Example situations where the use of assigned schedule constraints is appropriate include facility availability, equipment availability, specific resource availability, vendor deliveries, other NASA Center deliveries, etc. See *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Section 5.4.3 for additional guidance in the use of schedule constraints.

Define Schedule Calendars

Project calendars specify valid time units in which a task or multiple tasks may be worked. Resource calendars specify valid time units in which assigned resources will be available to do work. Both resource and project calendars should be used appropriately and be a key consideration when estimating task durations. When tracking costs and/or earned value performance within the scheduling tool, it is recommended that the project calendar also be consistent with the accounting calendar to ensure accurate cost data. The Scheduling function should be cognizant of the impact on task scheduling and later schedule analysis when both types of calendars apply. Specific task and resource calendars should be established during initial schedule development.

Incorporate Schedule Margin

Schedule margin is the allowance carried in projected schedules to account for uncertainties and risks. Margins are allocated during the schedule formulation process based on assessments of risks and are typically consumed as the program/project proceeds through the life cycle.

It is a recommended practice that schedule margin based on risks, duration uncertainty, and historical norms is clearly identifiable when included within the IMS. Schedule margin may also be referred to as "schedule reserve" or "schedule contingency." Schedule margin is owned and controlled by the program or project manager. Factors that may contribute to determining the amount of schedule margin are: a) expert judgment, b) rules of thumb, c) percentage of overall project (or activity) duration, d) percentage of expected duration of risk impacts, or e) through insight gained from a probabilistic SRA.

For clarification, it should be understood that schedule slack (also known as float), which is a calculated value based on IMS network logic (e.g., task durations, lead/lag values, constraints, etc.), should not be considered the same as schedule margin. Schedule margin should be inserted into the IMS at strategic locations along the critical path of tasks so that it satisfies its intended purpose as overall schedule management margin for the project completion. Designated schedule margin should be closely monitored and not used unless approved by the project manager. It is also important that project funds adequately cover all schedule margin duration identified within the IMS. For additional guidance on incorporating schedule margin into the project IMS, see *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Section 5.7 and *NASA/SP-2012-599, NASA Earned Value Management (EVM) Implementation Handbook*.

Define and Document Schedule BOE

A schedule BOE is the documented foundation on which a plan for project implementation is conceived. The project schedule is created to depict the time frame required to accomplish the defined work. It is part of an enhanced management best practice to document key aspects (i.e., technical, cost, schedule, and risk) from which the project can be defined and planned. The schedule BOE is intended to be developed within the realistic parameters of the known and expected project requirements.

Beneath each process header are various data inputs that potentially provide basic information for determining duration estimates. The purpose of the schedule BOE is to produce definitive estimates that are easily defendable and traceable. Developing the schedule BOE should be a collaborative and iterative process within the PP&C community and executed in a reasonable manner at a practical level of the IMS. The Scheduling function should always seek valid sources and processes to assist in deriving the most accurate task durations possible for schedule development. The schedule BOE may be completed using various formats (e.g., separate spreadsheet, narrative paragraphs, IMS data field). A typical approach is to incorporate, at a reasonable level of the WBS, specific rationale, information, and other notes within an available data field contained within the scheduling tool. It should be remembered that the accuracy and credibility of a project schedule is only as good as the accuracy and credibility of the information that has been input and integrated within it. The schedule BOE will help to ensure credibility is maintained and also provide a critical source for schedule rationale during later project reviews.

3.4.3.1C Assess and Analyze Schedule Integrity

Perform Schedule Integrity Health Checks

One key method for assessing schedule validity is by monitoring key indicators within the IMS that reflect both good and poor characteristics of schedule structure and maintenance. These integrity indicators are based on standard rules of logic network development utilized in Critical Path Method (CPM) scheduling techniques. This type of evaluation, referred to as a "schedule health check," is typically accomplished using automated schedule assessment tools (e.g., the Schedule Test and Assessment Tool (STAT)) but can also be performed using manual data filtering processes within the IMS. An illustration of this type of assessment report is shown in Figure 3.4-3 below. A detailed explanation of these indicators along with other recommended schedule assessment techniques are provided in *NASA/SP-2010-3403, NASA Schedule Management Handbook*, Chapter 7.

Schedule Health Check

Caution: Color ratings should not be interpreted as "Pass/Fail", rather use as indicators for further analysis.

Project Name: Project XYZ

Using Baseline

Filter: All Tasks

Schedule Status

Description	Current
Current Start **(Note:** earliest activity Early Start Date)	10/8/2014
Current Finish **(Note:** latest activity Early Finish Date)	7/28/2017
Approximate Remaining Work Days	306
Number of Schedule Files Included in or Linked to this Project	1
Status Date	4/27/2016

Task and Milestone Count (Note: These counts exclude summary tasks)

Description	Count	% of Total
Total Tasks and Milestones	1782	
Completed Tasks and Milestones	975	55%
To Go Tasks and Milestones	758	43%
Inactive Tasks and Milestones	49	3%

Integrity Indicators *(Note: These counts exclude summary and started/completed tasks)*

Tasks and Milestones Without Predecessors or Inactive Predecessors	12	2%	G
Tasks and Milestones Without Successors or Inactive Successors	93	12%	R
To Go Tasks with No Finish Ties	49	6%	Y
To Go Tasks with No Start Ties	11	1%	G
Summaries with Logic Ties (see note below)	2	0%	G
Out of Sequence Relationships	5	1%	G
Tasks and Milestones Needing Updates	93	12%	R
Actuals after Status Date	0	0%	G
Tasks marked as Milestones (Note: having a duration of > 0)	1	0%	G
Tasks With Estimated Duration	0	0%	G
Manual Tasks (includes summary tasks - see note below)	0	0%	G

Note: *The summaries with logic ties and manual tasks numbers are calculated as a percentage of tasks and milestones.*

Constraints

Total Constraints (Note: other than ASAP including deadlines)	70	9%	
Start No Earlier Than	69	9%	G
Start No Later Than	0	0%	G
Finish No Earlier Than	0	0%	G
Finish No Later Than	0	0%	G
Must Start On	0	0%	G
Must Finish On	1	0%	G
As Late As Possible	0	0%	G
Deadlines	0	0%	G

Relationships

	Negative Lag		Positive Lag				
Total Relationships	0		56		1118		
Finish to Start (FS)	0	G	54	Y	949	85%	R
Finish to Finish (FF)	0	G	1		32	3%	
Start to Start (SS)	0	G	1		136	12%	
Start to Finish (SF)	0	G	0		1	0%	

Total Slack Analysis

Tasks Less than or equal to 10 days Total Slack	204	27%	Y
Tasks with Total Slack Greater than 25% of Remaining Duration	382	50%	R
Balance of Tasks	172	23%	
Minimum Total Slack	0		
Maximum Total Slack	686		

Remaining Duration Profile

Total Remaining Tasks	758	1%	G
Milestones	287	38%	
Greater than 0 to 2 weeks	422	56%	
2 Weeks to 1 Month	27	4%	
1 Month to 2 Months	11	1%	
2 Months to 3 Months	3	0%	
3 Months to 6 Months	7	1%	
6 Months to 1 Year	1	0%	
1 Year to 2 Years	0	0%	
Greater than 2 Years	0	0%	

Top 5 Critical Paths Analysis

	Total Slack			
Path 1	0	105	14%	Y
Path 2	1	19	3%	Y
Path 3	2	2	0%	Y
Path 4	3	14	2%	Y
Path 5	4	1	0%	Y

CAUTION: The Critical Path/Total Slack analysis reflected in the Table above are based solely on the project's IMS logic network (ie; predecessors, successors, durations, constraints, etc.). It should be noted that the credibility and value of this data should correlate directly to the quality reflected in the Schedule Formulation and Integrity Assessment shown above in this report..

Additional Schedule Information

Recurring Tasks	0	0%
Schedule traceable to WBS (Y/N)	TBD	
Realistic Critical Path(s) (Y/N)	TBD	
Remaining Tasks with Baselines Assigned	6	1%
Tasks With Resources	55	2%
Total Tasks (Including summary tasks)	2395	

Figure 3.4-3 Illustration - Schedule Health Check

Identify Critical Path(s)

The project critical path is typically defined as the sequential path of tasks in a network schedule that represents the longest overall duration from “time now” through project completion. Any slippage of the tasks on the critical path will increase the project duration and may require workaround planning. If workaround planning is not sufficient to keep the project duration intact, schedule margin may be utilized at the discretion of the project manager. During schedule development, it is imperative to always know what sequence of tasks is the real driver affecting project completion (i.e., the critical path). (See Figure 3.4-4 below.) Keep in mind that a new critical path may emerge if performance of a task that is not on the current critical path fails to meet the plan. It is also important to monitor the amount and consumption of schedule margin that may exist as part of the critical path. Management and PP&C insight into the critical path is essential in making accurate resource and manpower decisions to successfully achieve project completion.

Guidance and additional information to help in critical path identification and analysis within the IMS is found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Section 7.4.

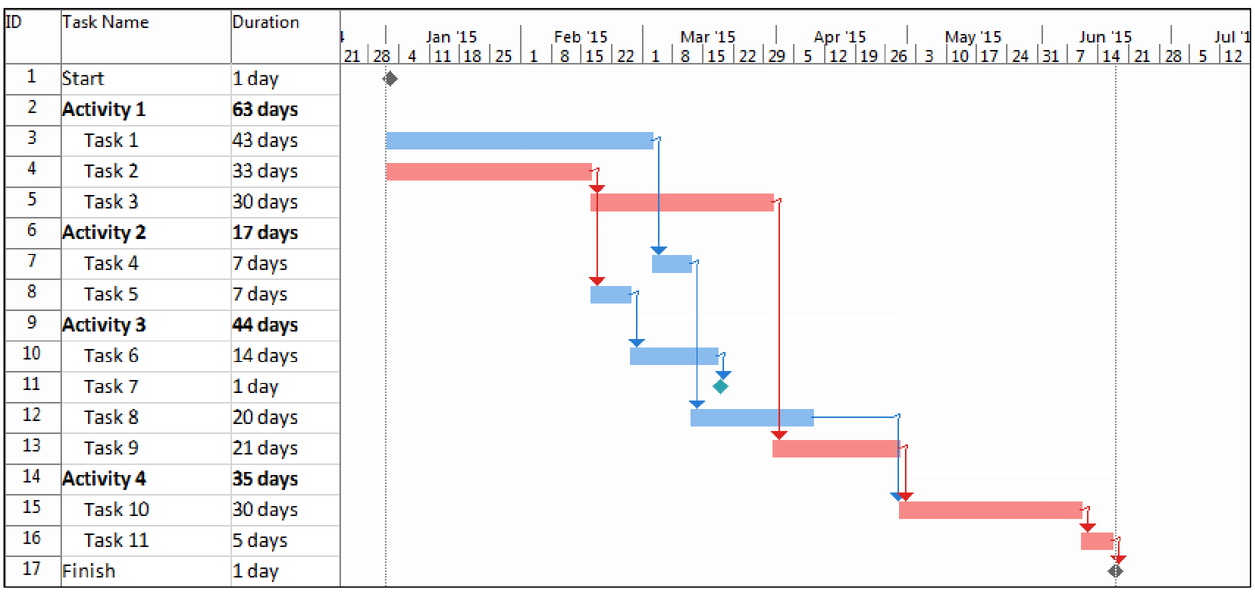


Figure 3.4-4 Illustration – Critical Path Identification

Perform Schedule Risk Assessment (SRA)[8]

Conducting a SRA is crucial during project Formulation and throughout the on-going Implementation life cycle of a project. Although there are various ways of evaluating cost and schedule risks and confidence levels, a recommended technique is to use a proven probabilistic risk assessment tool with random sampling functionality. The SRA is an important analysis

[8] The *NASA Cost Estimating Handbook*, *Version 4.0*, February 2015 (*Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis* (J.2.1.1)) refers to "SRA" as "Schedule Risk Analysis.”

process that provides the confidence level estimate of the likelihood that a Project Plan, reflected in the IMS, is achievable within the planned finish date constraints, given the schedule risks and uncertainties.

The SRA is the 'time equivalent' of the QRA in which discrete risks, each with a likelihood (probability of occurrence) and duration distribution of potential schedule impacts (consequences), are tied to tasks (which often have their own uncertainty distributions) in a schedule. (See Section 3.7.3.1 for a discussion of the QRA.) An SRA requires that the Scheduling function work with the Risk function as well as CAMs and the project manager to understand which risks on the project's risk list have schedule impacts. These risks should each be mapped to the appropriate task or tasks; discrete risks should be mapped at the lowest level possible (i.e., directly to the task that is impacted by the risk). Each risk is sampled based on the likelihood assigned in the SRA model. Each task's duration is also sampled, and the resulting schedule iteration's end date (or some other selected milestone) is recorded. Many such iterations result in a discrete distribution of a schedule's (or individual task's) end date (or total duration) from which confidence levels and other information can be extracted. (See Appendix I: Uncertainty versus Risk: Functional Definitions from a Programmatic Analysis Perspective for a discussion of total estimate variation, uncertainty, and discrete risk treatment within various programmatic analyses, including the SRA.)

Figure 3.4-5 is an illustration of how uncertainty and discrete risks may affect schedule. Here, each task has an associated uncertainty distribution. The discrete risk, denoted in purple, has a likelihood (probability of occurrence) and its own duration distribution (consequence). During a simulation, different iterations will allow selected uncertainties from each task's uncertainty distribution to be applied to their respective tasks. The applied uncertainties may be some percentage less than 100% that allows the task to "finish early," or some percentage greater than 100% that forces the task to "finish late." In addition, some iterations will turn "on" the risk, which will add a "risk task," essentially pushing out its parent task's end date.

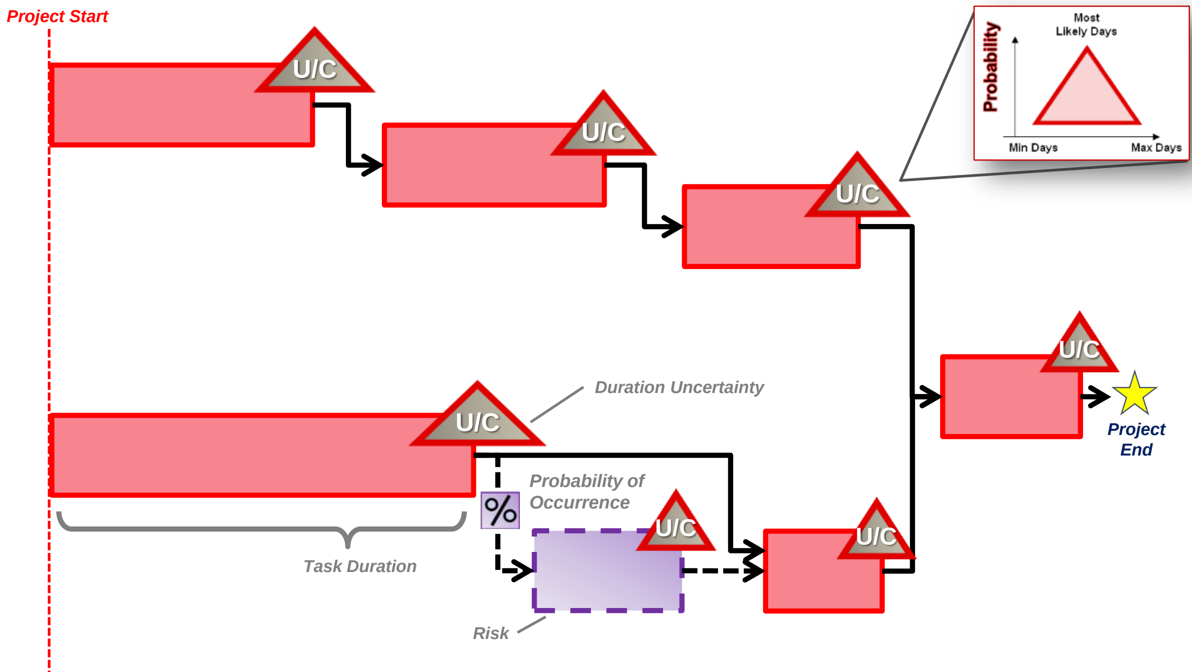


Figure 3.4-5 Schedule Risk and Uncertainty Schematic

SRA guidance and additional information can be found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Section 7.9.

Validate Schedule Estimate

A thorough schedule assessment should always be performed prior to management approval and formal establishment of the project baseline. The project IMS review should be a collaborative effort involving both technical and programmatic team leadership, facilitated by the Scheduling function to ensure that it is complete, accurate, and realistic. It is recommended that this evaluation include a comparison of the overall schedule estimate to actual schedule durations of past projects that were similar in scope. For example, NASA's Schedule Management and Relationship Tool (SMART) is an analogy-based tool for estimating spacecraft development durations from Phase A start to launch. In some instances, it may be helpful to compare durations of each phase of the schedule, or durations from one life-cycle milestone to the next. Where similar missions do not exist, analogies of particular subsystem schedules may be possible. A reliable schedule assessment checklist is also an important aid that can benefit a project team or outside review team in determining schedule validity. A thorough schedule assessment checklist example can be found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Appendix G.

3.4.3.1D Validate Schedule Consistency with Project WBS/WBS Dictionary and Budget/Labor Plans

Validate Consistency to WBS

The WBS is a management tool output from the Resource Management function that provides project structure and a framework for schedule development and financial planning. The structure and format of the IMS should closely correlate to the WBS to ensure traceability and consistency in reporting. This is accomplished by including within the IMS the correct WBS element code that associates with each schedule task. It is understood that to satisfy management insight and planning needs, the IMS will typically be broken down into lower detail than what is contained within the WBS. (See Section 3.4.3.1 for guidance on task detail.).) Therefore, it is acceptable and expected that multiple schedule tasks/milestones can be associated with the same WBS element. It should also be understood that no single IMS task/milestone should ever be assigned to more than one WBS element. In addition to providing a framework for planning, the WBS becomes very important to the Scheduling function by allowing various reporting data to be selected, sorted, and summarized to meet the analysis and forecasting needs of project management.

Prior to IMS baseline approval, the Scheduling function should validate that each schedule task/milestone has been assigned with the correct WBS element nomenclature and that accurate correlation exists between schedule, cost, and resource data. Unfortunately, due to the types of data being integrated, the validation of WBS assignment within the schedule typically has to be accomplished through manual efforts with coordination between the Scheduling function and the Resource Management function.

Validate Consistency to Budget/Labor Plans

When a RLS strategy is used, accurate correlation is automatically ensured as long as resources are correctly loaded within the IMS. If the schedule is not resource-loaded, then unfortunately, this part of the validation also results in a manual comparison effort. By comparing summarized data queries at appropriate WBS levels from the budget, labor, and schedule datasets, the consistency of time-phasing between each can be validated. The Scheduling function should work with the Resource Management function as well as the Cost Estimation/Cost Assessment function to ensure that the resources and costs are properly correlated to the planned work in the IMS. Additional information and detailed guidance for resource-loading the IMS and validating cost, schedule, and resource integration can be found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Sections 5.6.1 and 7.8.

3.4.3.1E Provide Analysis Schedule

For projects with a life-cycle cost over $250M, a requirement for receiving approval to proceed past KDP C is a successful conduct of the JCL analysis. The JCL analysis process, which is owned by the Cost Estimation/Cost Assessment function, is achieved using a probabilistic tool that typically functions with Monte Carlo simulations. This analysis may require the preparation of a project analysis schedule that has the all work scope identified in defined tasks and milestones that are accurately sequenced with realistic task durations, minimal task constraints, and zero schedule margin. The full project IMS may be used as the analysis schedule if it is adequately constructed as described above and is reasonably sized so that the probabilistic tool can run through the simulations in a timely manner. Typically, an analysis schedule reflects a summarized model of the project IMS with tasks defined and sequenced to an appropriate level to encompass discrete risk mappings. These summarized analysis schedules can be much simpler to work with and should be able to run the probabilistic simulations in a timely fashion.

Additional guidance on JCLs can be found in the *Cost Estimating Handbook*, Version 4.0, February 2015, *Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis*.

3.4.3.1F Baseline Schedule Estimate

Obtain Project Management Approval and Commitment to Schedule

Once the schedule validation process has completed and agreed upon adjustments/corrections are incorporated, the project schedule is ready for baseline approval by management. It is a best practice to ensure that the management and technical leadership team is fully informed and in general agreement on IMS content. This includes being aware of and agreeing with the overall duration estimate, critical path content, and the associated budget and labor plans. Areas of disagreement and content disconnects should be resolved between the appropriate PP&C functions and the CAMs to achieve total management approval and ownership. After this is accomplished, the schedule is placed under configuration control, which means that all future change requests must be documented and managed through a formal baseline change process (See Section 3.4.3.2). The Scheduling function should ensure that the IMS continues to reflect proper correlation with resources and budget as formal changes are made. The project baseline becomes the basis for the MA and, if applicable, the key component of the ABC commitment for tightly coupled and single-project programs.

Obtain Other Participating Stakeholder Commitment to Schedule

Gaining understanding and commitment to the schedule by key stakeholders is also highly recommended. The project schedule should also be presented and explained to key stakeholders that are not part of the internal technical and programmatic team. Stakeholders usually have a vested interest in a project's success and many times can have influence in decision making or activities that impact schedule success. For this reason, they should also have a good understanding of schedule content and agree with the plan for implementation before baseline approval is granted and formal control is started.

3.4.3.2. Control Activities

3.4.3.2A Update Schedule Baseline as Required

Gather and Incorporate Task Progress and Changes (Per Defined Update Cycle)

Status updates should be made as frequently as feasible. The frequency often depends on what phase the project is in and who is doing the work (in-house, contractor, or both) as well as the number of resources available to gather, input, and analyze the updates. Additional guidance for updating the project schedule can be found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Chapter 6.

As project work is executed, all tasks/milestones in the schedule should be updated to reflect their current status. This involves continued control and maintenance of the schedule, which includes making timely updates and approved changes to network logic, task additions/deletions, task percent completes, resource allocations, remaining durations, and actual start and finish dates. It is critical for the baselined IMS to accurately reflect the current plan to complete the remaining authorized scope as contained in the baseline. To ensure accurate project analyses and performance assessment, it is important that all incomplete tasks/milestones in the schedule be updated to a single "as of date" project status. Any tasks/milestones that have missed their start or completion date should be updated with new projected start/complete dates reflecting current status and changes against the baseline IMS. Schedule replanning consists of rescheduling the remaining project work; however, the overall baseline schedule objectives (e.g., delivery, launch, key reviews, etc.) remain the same. If a new ABC has to be established due to a project exceeding its cost and/or schedule commitments, the schedule will also need to be rebaselined. Rebaselining occurs when the existing baseline is no longer achievable and measuring performance against it is of little or no practical value. By properly maintaining the configuration of the schedule baseline, projects will have a plan against which to measure performance and understand variances that correspond to the work that is intended to be accomplished.

Task/milestone status may be gathered in various ways such as providing task owners with a printout containing the specific tasks that require update information; face-to-face meetings with task owners to discuss and redline the schedule copy; or weekly, biweekly, and/or monthly project schedule update meetings with all task owners participating by verbally providing their status. All task owners need to be aware of the "as of date" for project status when they are providing updates. Regardless of the strategy for gathering updates, the Scheduling function should ensure that the task/milestone progress is consistent with the pre-established task start/completion criteria and is adequate to update the schedule according to best practices.

Requested changes to the baseline IMS should only be implemented after formal change board approval has been received. These types of changes typically entail adding or deleting tasks/milestones and their associated sequence relationships, changes to contract or target milestone dates, and major cost/resource assignments. The Scheduling function should work with the Resource Management function and the Cost Estimation/Cost Assessment function when changes are made to ensure consistency across PP&C disciplines. For additional schedule baseline control guidance, see *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Chapter 8.

Evaluate Schedule Impacts of Proposed Changes and Current Status Updates

As current task/milestone progress and other update changes are incorporated into the IMS, the Scheduling function should be cognizant of the impacts caused by these updates. If there are impacts to the project critical path or any near critical path, then those issues should be examined further with the help of the responsible technical leads to ensure that all associated task durations, relationships, constraints, and lag values are accurate and producing valid schedule dates. Needed adjustments and corrections should be incorporated at this time.

Additionally, if task updates and changes result in resource conflicts, this should also be communicated to the appropriate technical and management leads and worked with the Resource Management function. These situations must be examined carefully using the same process as mentioned above to ensure that the conflicts are real and that necessary actions are initiated.

Perform Schedule Integrity Health Checks

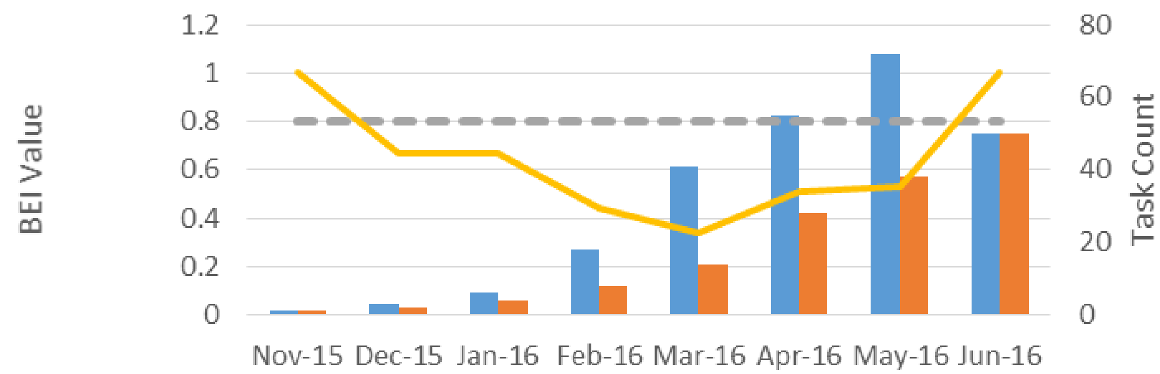
Performing IMS integrity health checks during the control phase should be the same process as described above (Section 3.4.3.1) in the planning phase.

3.4.3.2B Assess and Analyze Schedule Performance

Identify Schedule Performance and Trends

Performance assessment and analysis should be a routine process that is continuous during the later stages of project Formulation and especially during project Implementation. The techniques and metrics that follow are recommended examples of the types of performance assessment and analysis that should be continued routinely until project completion. See the *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Chapter 7 for more details on the schedule performance analysis techniques and guidance described below:

- **Baseline Execution Index:** The BEI is a cumulative measure of baseline schedule performance. It is the ratio of total number of IMS tasks (with a baseline) actually finished to date to the total number of tasks baselined to be finished to date. The BEI is an objective indicator of how efficiently the project in executing to its schedule baseline. In general, a BEI of 1.00 indicates the schedule is on plan, below 1.00 is behind, and above 1.00 is ahead. While the BEI score is important, the trend is particularly significant. For example, in Figure 3.4-6, the BEI was declining through March 2016. Even though some improvement occurred in April and May, the project chose to establish a new schedule baseline in June in which all unfinished tasks were replanned to future periods, hence the 1.00 BEI in June.



	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Baseline	1	3	6	18	41	55	72	50
Actual	1	2	4	8	14	28	38	50
Threshold	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Cum BEI	1.0000	0.6667	0.6667	0.4444	0.3415	0.5091	0.5278	1.0000

Figure 3.4-6 Illustration of Baseline Execution Index (BEI)

- **Current Execution Index:** CEI is a measure of the project's schedule performance against its month-to-month forecasts. It is the ratio of the actual number of tasks completed to the number of tasks forecast to complete during the month, based on the previous month's forecast; in other words, CEI answers the question, "Of the tasks we forecast to finish this month, what percentage of them did we finish?" The value of the CEI is that it gauges the quality of the project's near-term planning. If CEI is trending down significantly, it could mean a "bow wave" of unfinished work is building that could lead to a schedule delay. Additionally, monitoring the CEI along the project's critical path can provide important insight into the realism of on-time project completion. Figure 3.4-7 shows the CEI trend for an example project. While there does appear to be a slight downward trend in CEI, this project has remained above the target .60 threshold for the majority of the past year.

Figure 3.4-7 Illustration of Current Execution Index (CEI)

- **Hit or Miss Index (HMI):** HMI is a monthly measure of baseline schedule performance that answers the question, “Did a baseline task planned for completion get completed ("hit") or was it not accomplished ("miss")?” It is the ratio of the IMS tasks actually finished during the month to those baselined to complete in the month. The primary benefit of HMI is as an early indicator of the project's ability to execute to its schedule baseline. As indicated in Figure 3.4-8, this project's HMI performance trend has been declining for months, breaching the .50 threshold in December. While the unfavorable HMI performance does not necessarily mean the project will miss its baseline completion date, it may mean additional resources, workarounds, risk mitigations, or replans will be necessary.

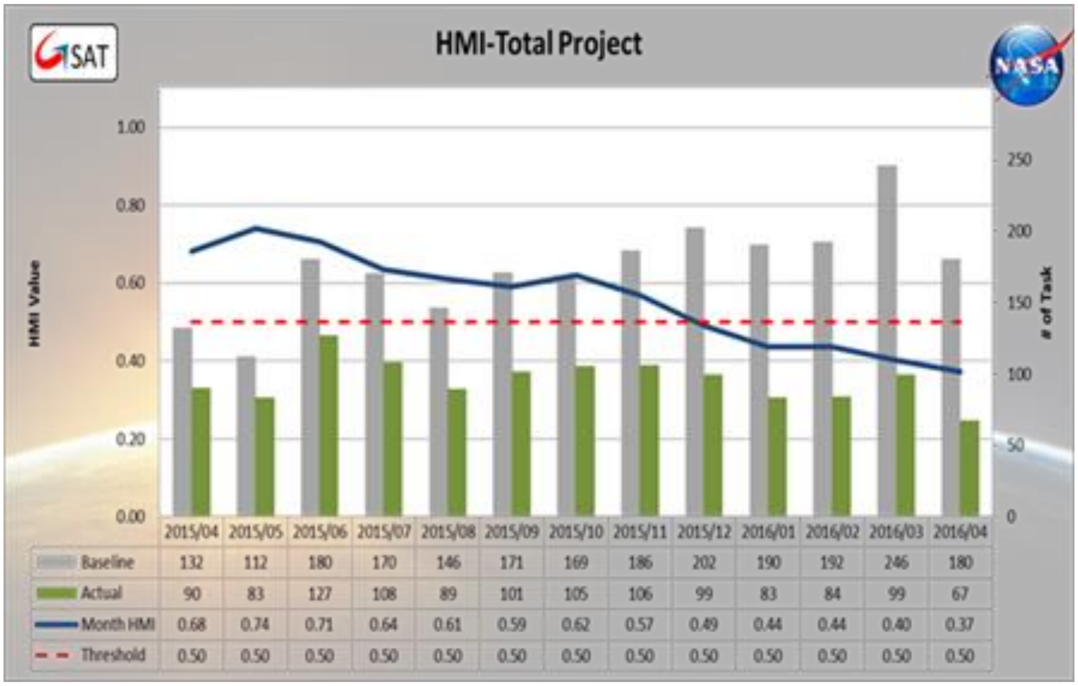


Figure 3.4-8 Illustration of Hit or Miss Index (HMI)

- **Milestone Comparison Metric**: This metric provides a baseline versus current forecast performance comparison metric for selected key milestones along with the associated amount of variance.

- **Schedule Margin Assessment**: Adequate schedule margin that is clearly identified and appropriately placed in a project schedule is critical to project success. Throughout the project life cycle, it is important to monitor and control the use of project schedule margin. The project manager owns schedule margin and should control its use in some documented manner.

- **EVM Schedule Performance Index**: For projects that implement EVM processes, there is standard reporting to reflect schedule performance that is based on how well the project is performing by measuring progress against its dollarized performance measurement baseline (see Figure 3.4-9). It is highly recommended that EVM schedule performance data be analyzed in conjunction with the typical IMS schedule analysis. Additional information and guidance for EVM reporting and analysis can be found in *NASA/SP-2012-599, NASA Earned Value Management (EVM) Implementation Handbook*.

Analyze by exception: EVM metrics enable the PM team to easily identify & prioritize those project elements that are not performing well

	WBS	Description	SV	CV	VAC	SPI	CPI	SV	CV	BAC	EAC	% SPENT
1	3200	COMMUNICATIONS	↑	↓	↔	0.777	0.844	-203.2	-130.8	2,043.0	2,130.0	41.03
2	3700	DATA DISPLAY	↑	↔	↔	0.585	1.000	-113.0	0.0	388.0	388.0	41.13
3	3300	AUX EQUIP	↓	↓	↓	0.877	1.133	-93.2	78.2	2,418.2	2,409.8	24.33
4	3100	SENSORS	↑	↓	↔	0.908	0.971	-36.6	-10.6	1,728.4	1,750.0	21.49
5	2100	PROJ MANAGEMENT	↑	↔	↔	0.959	0.942	-12.0	-17.4	618.4	621.6	48.51

Figure 3.4-9 EVM Schedule Performance Index

Numerous other schedule assessment and analysis techniques and metrics are also available to help in monitoring schedule performance and schedule impacts. See *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Chapter 7 for other schedule analysis techniques and guidance.

Analyze Changes to Critical Path(s)

The schedule may become very dynamic during the Implementation Phase, and because of this, it is necessary to always know the critical path or sequence of tasks that is driving project completion along with the near critical paths that could potentially overtake the primary critical path. Continued critical path analysis should include comparisons to the prior period's critical path content to identify changes and to understand the circumstances causing the changes. Critical path and near-critical analysis can provide meaningful insight to management about how resources should be allocated and managed. Therefore, the Scheduling function should work with the Resource Management and Cost Estimation/Cost Assessment function to ensure that changes in critical path are reflected in updates to resource and cost allocations. Additional information on critical path identification and analysis can be found in Section 3.4.3.1 of this handbook or in the *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Chapter 7.

When the schedule performance grows to be a concern, there are a number of options to try and bring it back into the box, each of which has added risk. (See Section 3.2.3.2 for more details about assessing performance and making recommendations). Some examples are:

1. Crash the schedule by increasing resources to the critical path activities to get the work done quicker. This will invariably result in increased project costs. To keep the cost down, carefully select the activities that will cost the least to crash but provide the most schedule acceleration.
2. Fast-track critical activities by carrying out activities in parallel on the critical path to accelerate the schedule. This option will likely increase project risk. It requires a greater level of control and coordination.
3. Redistribute the resources by moving resources from a lower-priority activity onto an activity in the critical path. Select the lower-priority tasks from the activities that are not on the critical path and which have adequate float to warrant this disruption.

4. Descope by removing tasks/activities or deliverables from the project or contract. This option will require a significant amount of discussion and coordination with the customer, program/project lead, and other key stakeholders. Documentation will need to be updated, contracts may need to be modified, and agreements may need to be reissued. (See Section 3.2.3.1 for more information on descoping.)
5. Allocate some of the schedule margin to cover the difference.

Capture Risks, Assess and Communicate
Threats against Schedule Performance

The Scheduling function should be aware of all risks that are identified by the project team along with those from outside the project. The Scheduling function should work with the Risk Management function to understand which discrete risks have schedule impacts. These risks should be mapped to appropriate tasks in the IMS. Using schedule risk analysis techniques, "what-if" impact scenarios can be run to better understand the potential risk impacts and formulate appropriate mitigation plans for use if needed. For this type of analysis, the Scheduling function will need to work with the Risk Management function as well as the CAMs and project manager to properly quantify the likelihood of the risk occurring as well as a realistic distribution of possible duration delays (consequences) should the risk occur. The Scheduling function should be involved in routine risk management meetings that address new risks, existing risk status, mitigation planning, and risk closures. This will help ensure that risks are clearly understood, affected IMS tasks are identified, and schedule performance impacts are analyzed.

3.4.3.2C Review Status with Management

Validate Status Update and Impacts

During each monthly IMS update cycle, the Scheduling function should ensure that the CAMs, management team, and other PP&C functions are involved and assist in validating task progress that has been incorporated into the baseline IMS. This assistance includes identifying/ determining performance issues, baseline change impacts, risk mitigation efforts, critical path changes, and any other schedule insight necessary to effectively manage the project. The Scheduling function should use all metrics necessary to help provide a clear picture to the management team so that appropriate and timely decisions are made that enhance the project's chances for accomplishing cost and schedule goals successfully.

Obtain Project Manager Approval of IMS Update

Agreement that task progress and changes have been accurately incorporated is reached after reviewing IMS status update information with the CAMs, management team, and other PP&C functions. At this point, project manager approval is obtained to proceed with issuing monthly IMS status update reports.

3.4.3.2D Issue Schedule Reports and Archive Schedule Data

Prepare and Issue Updated IMS

After performance updates are incorporated and impact analysis and resolution are complete, the Scheduling function provides updated schedule reporting to project management, customers, and other key stakeholders. It is especially important that updated versions of the baseline IMS are provided to the CM/DM function for control. The basic assumption that all WBS elements must report at the same level is not a valid assumption. Schedule reporting varies based on the level of management interest in the elements contained in the project. Higher volume (dollars or hours) or critical/risk items may require lower-level detailed reporting, while lower volume, non-critical/risk, or LOE tasks may require only summary-level reporting. In today's projects where resources are pushed to the limit, having flexibility in reporting requirements is a valid approach. Caution should be taken to ensure schedule reporting requirements are consistent with overall schedule management requirements. With WBS assignments being applied on all schedule content, the reporting levels can then be established appropriately within the IMS.

Prepare and Issue Analysis/Performance Reports

Schedule analysis conducted during the status update process should be documented and provided as part of the monthly issuance along with the baseline IMS update and other schedule performance reporting. Example analysis and performance reports include critical path reports, total slack reports, schedule margin reports, and performance trend reports. Formats for this type reporting should always be evolving to find techniques and formats that communicate the most accurate, clear, and effective project analysis and performance status.

- **Critical Path Report:** This is a report that identifies the primary critical path and near-critical path schedule driver(s) for the project. This report should be an extract from the baseline IMS and include all tasks and milestones with total slack (float) less than the project specified criteria. Typically, a waterfall format of the individual primary, secondary, and tertiary paths is most effective (see earlier Figure 3.4-4).

- **Total Slack Report:** This report should, at a minimum, show the previous reporting period history of slack for specified WBS elements, specified activities, or all tasks that exceed a specified total slack threshold. This report may be used to show trends by WBS element, by milestone, or by any other logical grouping. Rationale for significant total slack changes between reporting periods should be noted.

- **Schedule Margin Report:** This is a report showing the trend for schedule margin usage over the life of the project. Any change between reporting periods should also be clearly explained. This report should also show how the project is performing against its funded schedule margin requirement over the life of the project. Often times, projects also show their planned burn down of funded margin along with the current risk levels.

- **Performance Trend Report:** This is a report that shows the trends relating to schedule performance. Such reports should, at a minimum, include accomplishments (planned finishes versus actual finishes) and forecast credibility (planned starts/finishes compared to historical actual accomplishments), BEI, and CEI. Where applicable, performance data should be reflected both by month and cumulative.

Archive Schedule Data

Schedule data should be routinely archived in order to ensure important schedule information is not lost. Original baseline and as-built schedules along with the baseline IMS versions at major project milestones should be the minimum for project archives. This information is essential for estimating, forecasting, and analysis efforts on current and future programs/projects. Archived schedules should be provided to the Cost Estimating/Cost Assessment function for appropriate storage and accessibility of key data within CADRe. Individual NASA centers may also have their own established project data repositories for collection and storage of key historical project data from projects implemented at those specific locations and then made available for use in future project planning by their Center personnel. Electronically archived schedules can provide a wealth of information. Care should be taken to properly label and store these datasets.

3.4.4. Function Activities by Life-Cycle Phase

Table 3.4-2 Scheduling Activities by Life-Cycle Phase

<table>
<tr><th>Pre-Phase A</th><th>Phase A</th><th>Phase B</th><th>Phase C</th><th>Phase D</th><th>Phase E</th><th>Phase F</th></tr>
<tr><td colspan="2">Develop strategy for schedule estimation & assessment</td><td colspan="5"></td></tr>
<tr><td></td><td>Develop schedule</td><td>Baseline Schedule</td><td colspan="4">Update IMS & Assess and analyze schedule performance</td></tr>
<tr><td></td><td colspan="2">Validate schedule consistency with cost & labor plans (if not RLS)</td><td colspan="4"></td></tr>
<tr><td colspan="2"></td><td>Provide Analysis Schedule</td><td colspan="4"></td></tr>
<tr><td rowspan="2"></td><td colspan="6">Assess & Analyze Schedule Integrity</td></tr>
<tr><td colspan="6">Update schedule baseline as required</td></tr>
<tr><td rowspan="2"></td><td colspan="6">Review status with management</td></tr>
<tr><td colspan="6">Issue schedule reports & archive schedule data</td></tr>
</table>

3.5. Cost Estimation/Cost Assessment Function

3.5.1. Function Overview

Throughout a project's life cycle, PP&C will participate in a range of cost analysis activities. Diligent cost estimating and assessment is performed throughout project Formulation and Implementation phases, assuming many forms along the way: LCC estimates, non-advocate estimates, source selections, what-if exercises, affordability studies, joint confidence analyses, and many other manifestations that support numerous types of project and Agency decisions.

Robust cost analysis is critical to a project's health, though rendering credible cost estimates can be challenging for PP&C. The inability to properly capture technological nuances, task complexity, schedule details, changes in requirements, or risk scenarios reduces the predictive power and usefulness of estimates. However, according to a recent Inspector General report[9], the primary reason for unrealistic estimating at NASA has proven to be its culture of optimism. Historically, many Agency projects have overestimated their ability to predict and manage risk, a reality that has thwarted their intent to complete their missions on time and under budget. PP&C must address this optimism bias, in part, by constructing defendable cost estimates that maximize objectivity in data, presentation, and methods appropriate to the maturity of the project while adhering to best practice, the discussion of which comprises the majority of this section.

An important distinction must be noted here: the cost function as described in this section is focused on the development of estimates for planning purposes, which is a distinctly different thing (though related) from the project performance assessment and forecasting activities that are the purview of the Resource Management and PP&C Integration functions, the latter of which directs all analytical and assessment insight generation for project management consumption. While best practice entails assessment of the cost estimates and their underlying data, the monthly cadence of updating the EAC and similar activities that support regular project decisions is left to Resource Management and led by the PP&C Integration**.**

3.5.2. Integration with Other PP&C Functions, Inputs, and Outputs

The Cost Estimation/Cost Assessment function needs to collaborate with other PP&C functions to develop analysis products and strategies that support development of the integrated, project-level executable plan during the planning phase, and maintain cost analyses, tracking, and reporting throughout the control phase. The Cost Estimation/Cost Assessment function also interacts with entities external to PP&C to gather cost-related information and to communicate results of analyses. Figure 3.5-1 is a flow diagram for the Cost Estimation/Cost Assessment function that depicts major inputs and outputs received from and provided to other PP&C functions as well as external entities. Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it. The flow diagram also summarizes key activities to consider during the planning and control phases when implementing this function**.** Section 3.5.3 discusses these key

---

[9] NASA Office of the Inspector General (OIG), Report No. IG-12-021, September 2012.

activities in detail, and provides insight into the importance of the interactions with other PP&C functions.

Descriptive information is provided below for the inputs from external entities, and for the outputs depicted in Figure 3.5-1. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.5.3.

Descriptions of all inputs and outputs in can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.

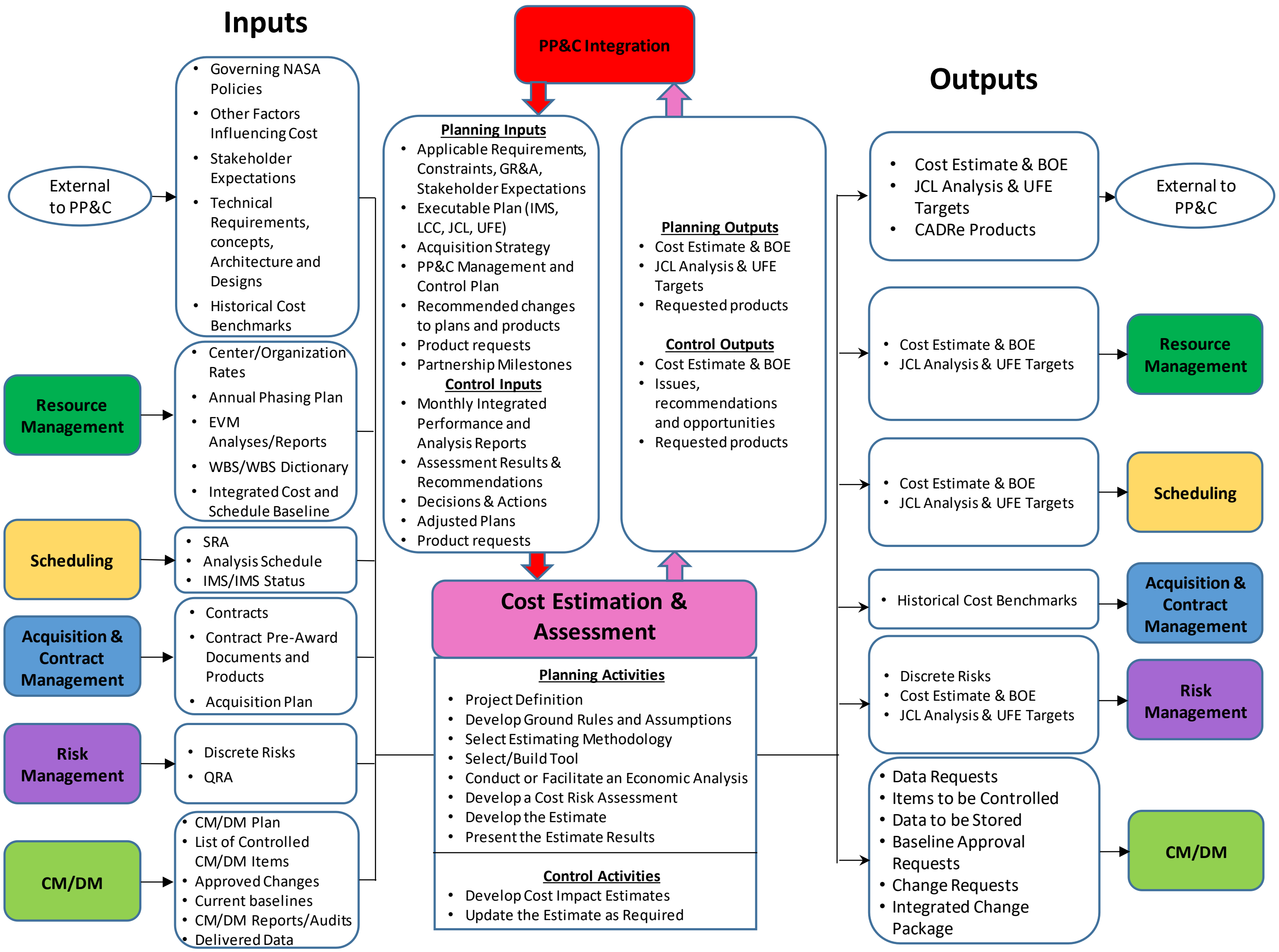


Figure 3.5-1 Typical Functional Flow Diagram for the Cost Estimation/Cost Assessment Function with Major Inputs and Outputs

3.5.2.1. Inputs

- **Governing NASA Policies:** Applicable Agency NPDs, NPRs, Center policies, lessons learned, and best practices, including Agency handbooks. Several governing documents place requirements on cost activities relative to project description and life cycle, most prominently *NPD 1000.5, Policy for NASA Acquisition*, *NPR 7120.5, NASA Space Flight Program and Project Management Requirements*, *NPD 7120.4, NASA Engineering and Program/Project Management Policy*, and *NPR 8000.4, Agency Risk Management Procedural Requirements*. There are also several "best practices" documents, such as *NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook*, *NASA/SP-2011-3422, NASA Risk Management Handbook*, and the *NASA Cost Estimating Handbook (CEH), Version 4.0, February 2015*.

- **Other Factors Influencing Cost:** There are many ancillary elements that should be factored into cost analyses as appropriate. These include but are not limited to the following items:
    - General economic conditions such as those that drive certain commodities and labor rates.
    - Local economic conditions such as the availability of a contractor's workforce and contract pricing.
    - Domestic and foreign political economic factors such as commodity prices, budget "austerity" efforts, and change of Presidential and Agency administrations.

- **Stakeholder Expectations:** The needs and objectives of the customer (project manager, program, Mission Directorate, and Agency) and other key stakeholders including anticipated products or support expected from the PP&C organization. The stakeholders' expectations need to be documented, and it is important to ensure a common understanding of the expectations between the customer, other key stakeholders, and the PP&C team. Requirements drawn from those expectations greatly influence the cost analysis framework.

- **Technical Requirements, Concepts, Architecture, and Designs:** Quantitative and qualitative descriptions of the project technical characteristics from which cost estimates will be derived. The nature of the input details required will likely vary based upon the cost modeling framework chosen. (See Section 3.5.3.1.) The project technical description should identify any area or issue that could have a major cost impact (e.g., risks) and therefore needs to be addressed by the Cost Estimation/Cost Assessment function. (See also Section 3.2.2.)

- **Historical Cost Benchmarks:** PP&C should equip itself with historical information on which it may base cost models and against which it may benchmark resultant cost estimates. Ideally, PP&C should gain access to a cost knowledge base, either formal (such as the ONCE or REDSTAR databases) or semi-formal, from which it may distill normalized cost and supporting data and draw conclusions. (A notional example: *History* *shows that avionics hardware and software complexity tends to drive cost more than simple structural components of spacecraft.*) Among the useful dimensions of comparison are technical, schedule, and risk information. Using history as a benchmark, PP&C can provide context for cost analyses.[10]

- **Annual Phasing Plan:** In major programmatic analyses where cost is a salient element, the phasing plan should be transparently reconciled with the cost-estimate phasing. This contributes to the elucidation of project health over time, UFE posture, the effects of shortfall (or surplus), productivity factors, select schedule issues (or opportunities), and other temporal elements.

- **Earned Value Management Analyses and Reports:** Cost estimates should justifiably and transparently incorporate EVM data when it appropriately enhances the forecasting quality.

- **Schedule Risk Assessment (SRA):** An SRA is a forecast resulting from the stochastic simulation of the IMS or an analysis schedule whose tasks are loaded with duration uncertainty and discrete schedule risks. (For additional detail on risk versus uncertainty, see Appendix I: Uncertainty versus Risk: Functional Definitions from a Programmatic Analysis Perspective.) SRA results include but are not limited to the following reports:
    - Resultant distributions that measure variability of an ultimate project end date, such as a hardware delivery or launch date, or interim milestones or tasks.
    - Top schedule risks in terms of impact on milestones, criticality, or other metrics.
    - Other analyses, including sensitivity of downstream schedule elements to the variability of tasks or milestones, correlation among tasks, and a characterization of schedule reserve relative to schedule targets.

- **Analysis Schedule:** An IMS or analysis schedule is used as the foundational framework for a JCL. It comprehensively includes well-defined tasks that are logically sequenced and justifiably interdependent. A project's analysis schedule is often a consolidation of its baseline IMS and other schedule data that preserves appropriate detail for elements that are more critical and summarizes those that are less important. Its structure ideally enables incorporation of risks, task uncertainty, and cost into a self-contained analysis.

- **IMS/IMS Status:** The detailed IMS should be linked to any integration/analysis/ summary-level schedule that is used to perform a JCL. Changes in the baseline IMS may reflect changes in uncertainty or risk in the JCL analysis.

- **Discrete Risks:** Identified, documented potential events that each carry an estimated consequence and an associated likelihood (probability of occurrence). The Risk Management team frames the body of risks for project management decision making and

[10] See *NASA Cost Estimating Handbook (CEH), Version 4.0*, February 2015, pg. 24 for a more detailed discussion of normalization.

programmatic analyses. Each discrete risk includes a risk statement and narrative description; a risk mitigation plan; cost and schedule consequences; likelihood, and risk response. The Cost Estimating/Cost Assessment function should incorporate risks into its cost models and analyses in ways that can be traced and defended including JCL analyses while ensuring risks are appropriately and completely characterized. (For additional detail, see Section 3.7.2.)

3.5.2.2. Outputs

- **Cost Estimate & BOE**: A documented, risk-adjusted forecast of future cost representing a specific scope of work. Features include (but are not limited to) the following:
    - **Cost Modeling Framework:** Every cost forecast is rendered by a data-driven algorithmic construct. There are three primary classes:
        - *Analogy-based*: Scaling, augmenting, or otherwise simply adjusting an appropriate analogue data point.
        - *Parametric*: Mining historical datasets to derive statistical relationships between cost and cost drivers (such as objectively measured complexity, mission characteristics, and level of realized heritage).
        - *Engineering Build Up*: "The computation of the cost of (each) WBS element by estimating at the lowest level of detail (often referred to as the "work package" level) wherein the resources to accomplish the work effort are readily distinguishable and discernable."[11]
    - **Total Variation in Forecasted Cost:**[12] The cost estimate probability distribution resulting from simulation or analytical methods. Point estimates do not contain the full range of effects induced by discrete risks and classes of uncertainty,[13] providing an incomplete picture of the universe of cost outcomes. Thus, it is codified Agency best practice to stochastically incorporate into the cost estimate's model all elements that contribute to total cost variation within a predetermined scope. Using a resultant cost distribution, a one-dimensional "confidence level" can be determined by assessing the cumulative probability of cost scenarios below a given budget figure.
    - **Milestones and Updates:** After the initial estimate is created, usually constructed using parametric or analogy methods, updates are made at milestones in the project's life cycle such as LCRs and rebaselining events (and in some cases, more often at the discretion of stakeholders). NPR 7120.5 requires the delivery of a cost estimate expressed as a range at KDP B and in the form of a LCC at KDP C (alongside the cost-loading inherent to the JCL product). Along the way, PP&C

[11] *NASA Cost Estimating Handbook (CEH)*, Version 4.0, February 2015, pg. 18.
[12] The CEH refers to this as the output of a "Cost Risk Assessment".
[13] For more on variation, risk, and uncertainty, see Appendix I: Uncertainty versus Risk: Functional Definitions from a Programmatic Analysis Perspective.

should monitor the maturity of project data, which will dictate the appropriate methods of estimating.

- **Basis of Estimate:** Generally, the BOE should provide "sufficient information (about) how the estimate was developed so that independent cost analysts—or other review team members—could reproduce the estimate"[14] and understand the logic of how the estimate was derived. Key BOE elements here include:

  - GR&A including content (e.g., performance period, work and major tangible elements, requirements, mission milestones), risk, and opportunity scope.

  - A dossier of project data being used as model inputs including (if possible) other types of BOEs (e.g., for schedule, technical parameters, and risks).

  - Detailed documentation of the cost estimating methods used including a traceable path between historical datasets and the models they drive.

- **Cost Phasing:** A characterization of how costs (including FTEs, WYEs, and ODCs) are spread over the time scope of the estimate; that is, calibrated to the appropriate granularity (e.g., weeks, months, quarters, or years). Budget plans, often expressed in years, are sometimes compared to the estimate's cost phasing as part of the larger programmatic assessment.

- **JCL Analysis:** According to NPR 7120.5, JCL is defined as a "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 Phase D." By being "risk-informed," the characteristic of having mapped all discrete risks and classes of uncertainty within scope to JCL model elements, the JCL intends to ensure that adequate budgets and schedules are reflected in the Project Plan. Only a certain subset of projects requires a JCL. According to NPR 7120.5, at KDP C, projects with an estimated LCC greater than $250 million are required to develop a RLS and perform a "risk-informed" probabilistic analysis that produces a JCL.

- **Unallocated Future Expenses (UFE) Targets:** 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 the scope of probabilistic risk and uncertainty. NASA policy closely ties project UFE determination to JCL analysis. According to policy, Mission Directorates are required to plan projects based on a 70 percent JCL to ensure funding (which is in no case less than the equivalent of a 50 percent JCL) for projects is consistent with the MA.[15] It is prudent for projects not subject to the JCL

---

[14] *NASA Cost Estimating Handbook (CEH)*, Version 4.0, February 2015, pg.29.

[15] According to NPR 7120.5, divergence from the JCL UFE policy must be approved by the Decision Authority employing compelling, documented justifications.

requirement to nevertheless justify their desired levels of UFE to the Decision Authority at life-cycle milestones.

- **CADRe Products:** A formal project document that describes the programmatic, technical, LCC, and cost/schedule risk information of a project. It describes a NASA project at specific milestones and provides a historical record of cost, schedule, and technical project attributes so that estimators can better estimate future analogous projects. The Cost Analysis Data Requirement (CADRe) is an integrated product owned by the project manager that results from the LCR process. In addition to cost estimates and BOEs, a CADRe contains detailed programmatic data and technical descriptions. The NASA cost community assists in the compilation of the CADRe and ensures that the project constructs and provides a submission when required.

- **Historical Cost Benchmarks:** See Inputs. Benchmarks and other useful cost-related information compiled by the Cost Estimation/Cost Assessment function may be provided to the Acquisition and Contract Management function to inform that function's processes and products.

- **Discrete Risks:** As an output, these are:
    - Specific discrete risks identified by the Cost Estimation/Cost Assessment function, and
    - For each discrete risk in the RMS, authoritative cost estimates for each risk's cost consequence and mitigation plan along with the BOE. The Cost Estimation/Cost Assessment function reviews and may render updates to the cost information provided by risk owners. In this way, this function is in part responsible for the cost dimensions of risks, enabling transparent and traceable incorporation into cost estimates.

- **Data Requests:** Requests to the CM/DM function for any of the PP&C or other data under data control. The cost estimator's effort may begin with scarce data. The estimator, as discussed, requires a thorough project definition, which may require results from several data requests to complete. In addition, updates will require data with respect to changes and developments in the project. As a project matures, there will be a greater opportunity for the project to provide pertinent data. The cost estimator should be aware of these opportunities and engender the requests. Many of the inputs to this PP&C function should be the result of data requests.

- **Items to be Controlled:** Items developed by this function that need to be placed under configuration control including the cost estimate and BOE.

- **Data to be Stored:** Data developed by this function and other project data (including data developed by external entities) identified as needing to be stored at any time during the life cycle. Data include the estimating models and data. The estimate and findings are documented and, along with the estimating models and data, are made available for subsequent estimating and analyses.

- **Baseline Approval Requests:** Requests to place an item under baseline control**.**

- **Issues, Recommendations and Opportunities:** Issues include project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance. (For additional detail and examples, see Section 3.2.2.)

3.5.3. Function Planning and Control Activities and Tasks

Cost Estimation/Cost Assessment planning and control activities and tasks are outlined in Table 3.5-1 Cost Estimation/Cost Assessment Activities and Tasks. The activities and associated tasks are described in more detail below the table.

The table below is a synthesis and summary of two very similar twelve-step estimating processes (one found in *NASA's Cost Estimating Handbook (CEH)*, which maps to another in *GAO's Cost Estimating and Assessment Guide*[16]) and avoids simple recitation of their source content herein; rather, this abstracted discussion references documented best practices while highlighting PP&C's treatment and construction of cost analyses.

These elements reflect NASA and GAO best practice but are not intended to be rigidly prescriptive. Depending on the size, structure, nature of its mission, and other defining characteristics, a project may find it appropriate to scale its cost estimating approach. However, this caveat is not intended as license to minimize the importance of sensible cost analysis.

---

[16] GAO guidance directly informs NASA's cost estimating best practices as reflected in the content of this chapter. This chapter also captures areas where NASA's best practices diverge from GAO guidance.

Table 3.5-1 Cost Estimation/Cost Assessment Activities and Tasks

Cost Estimation/Cost Assessment	
Planning Activities and Tasks	**Control Activities and Tasks**

Activity: Prepare Cost Analysis Strategy	Activity: Develop Cost Impact Estimates
Activity: Prepare Cost Analysis Strategy • Define estimates’ purpose in the context of stakeholder’s requests and policy requirements. • Characterize the analysis’ effort scope. • Formally document the cost analysis strategy. **Activity: Execute Cost Assessment Tasks** • Obtain and assess the project technical description. • Identify and update the estimate’s GR&A. • Gather, assess, and normalize data. **Activity: Execute Cost Estimating and Supplementary Analytical Tasks** • Prepare the structure of the BOE. • Select or refine estimating method. • Develop cost model, including stochastic elements. • Generate a resultant cost forecast distribution, whose total variation is driven by discrete risks and uncertainty. • Conduct related decision support analyses. **Activity: Conduct a Joint Confidence Level Analysis** • Develop the stochastic model that produces a JCL (or cost and schedule ranges) when directed by stakeholders and policy. • Generate a joint cost/schedule distribution and related analytical elements. • Establish project UFE target levels. **Activity: Present Analyses to Stakeholders** • Finalize analyses’ BOE. • Report estimate to stakeholders. • Create and deliver CADRe submissions (if applicable).*	**Activity: Develop Cost Impact Estimates** • Develop estimates of cost impacts of project and external events and risks **Activity: Update the Estimate as Required** • Gather and assess stakeholder feedback and lessons learned, incorporating them into the cost analysis strategy. • Update the estimate as the project evolves and to support milestone reviews.

*CADRe submissions are also created and delivered during the Control Phase.

3.5.3.1. Planning Activities

Cost estimating and assessment activities comprise the heart of cost analysis, which plays a critical role in the larger programmatic environment. Most of PP&C's cost estimating work (including constructs like JCL) reflects a high degree of nonlinearity, requiring sufficient iteration and interaction with the other functions. Like all robust programmatic analyses, cost estimates, JCLs, and related products are the result of intensive refinement and circumspection.

Figure 3.5-2 captures the three stages of the cost analysis cycle. First, it is necessary for a project to invest time in preparing an estimating strategy that will establish what cost analyses are being performed, why, and who will perform them. Once the groundwork has been laid, the core cost analysis activities are executed iteratively: cost assessment[17] of existing artifacts (primarily data) and cost estimating that leverages the assessed data to create a cost forecast. (A JCL level analysis may also be created during this stage[18].) After an appropriate amount of iteration during which data, methods, ground rules, and the estimates themselves evolve, the analyses are finalized and presented to stakeholders, thus completing the cycle.

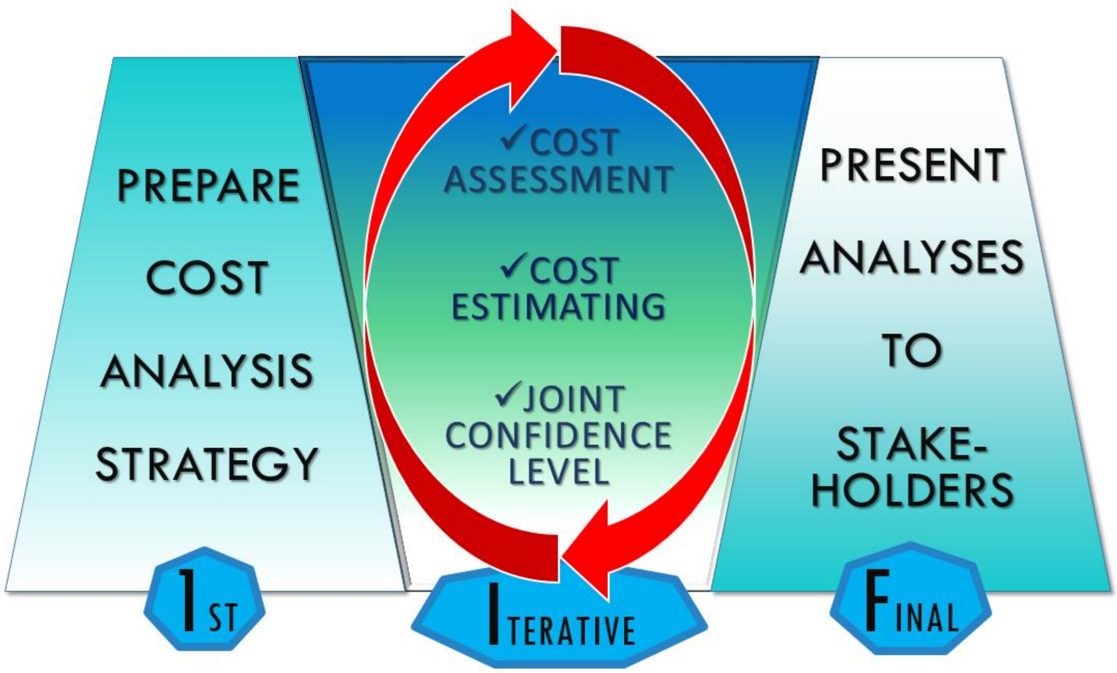


Figure 3.5-2: The Cost Analysis Cycle

---

[17] An initial round of cost assessment is necessary before cost estimating can begin. This activity does not include "independent assessment" conducted by parties outside the project.

[18] Per NPR 7120.5, at KDP C, projects with an estimated LCC greater than $250 million are required to develop JCL.

3.5.3.1A Prepare Cost Analysis Strategy

After receiving a request from the stakeholders it supports (or, in some cases, recommending the need for a cost analysis cycle to stakeholders), PP&C should establish a strategy from which it can iterate its core analysis activities in pursuit of a delivery-quality estimate package. These requests materialize as a routine consequence of policy dictates (from, for example, NPR 7120.5) or the need for analyses, either single-use or recurring, that support stakeholder decisions.

The seminal discussion in the estimate planning progression should capture stakeholders' preliminary requirements, which can and should be influenced by the project's PP&C leadership even if it is policy alone that is driving the request. It is incumbent upon PP&C at this early stage to educate stakeholders about past estimating methods and how they met or fell short of requirements originating from either policy or stakeholder-drawn specifications. PP&C should present to stakeholders consensus best practices and a "suite of solutions" that have met similar needs in various, nuanced ways with equally various data and resource demands; often there are many paths to fulfilling the letter of even hard policy (such as the requirement to provide a "range of cost" at KDP B as mandated by NPR 7120.5).

A pragmatic lens is indispensable when examining candidate cost approaches. The prudent cost estimator will select a method by exhaustively studying the contextual constraints. It is very important for PP&C and its stakeholders to carefully shape the effort scope, which addresses not the "How?" of estimate execution but rather the considerations wrapped in the question, "Are we capable?" (Specific methodology selection is undertaken later in the process.) An immature project, for example, should not purport to produce an estimate of great detail and precision; in another instance, political and other contextual factors may preclude certain avenues of analysis, datasets to be included, certain procedural precedents, and even select personnel from participating in the estimating process (as in the case of, for example, an independent assessor prevented from providing in-line support to a project that he or she had previously assessed). Further, stakeholders should be aware of their analyst team's experience and technical capability. It may simply be the case that talented analysts may not be well versed in a set of techniques entailed by a favored cost estimating method.

Key factors constraining an estimate's effort scope include data. The essential power of an estimate's results is inextricably tied to data quality and access. If data is known to be incomplete, costly to acquire, sequestered by contractors due to proprietary or competition-sensitive considerations, not well-circulated within the project's PP&C or technical organizations, or any other well-known reality that diminishes the data's utility, the stakeholder should be informed during requirements negotiation. (The Cost Estimation/Cost Assessment function will later perform detailed data assessment to determine its true utility after it is collected; see Section 3.5.3.1B.)

In some cases, existing datasets are readily available, like those contained within the One NASA Cost Engineering (ONCE) database, and the Resource Data Storage and Retrieval (REDSTAR) library. The data found in the ONCE database can be complemented by additional information such as the project's prior experience captured as lessons learned, previous project estimates, and other PP&C functions' analyses (e.g. schedule analyses). Led by PP&C, a project should take great care to grant the Cost Estimation/Cost Assessment function access to all appropriate datasets. Even before the analysis activities begin, it is essential that technical experts are made available for consultation to this and other programmatic functions, with PP&C itself setting a precedent through swift internal circulation of its own data and information. As these data-related priorities are disseminated throughout a project, the Cost Estimation/Cost Assessment function can strengthen its negotiation position with stakeholders.

A treasury of data is valuable only if sufficient estimating resources are available. Stakeholders and project leadership alike often underestimate the time, staffing, and other resource considerations required for a cost analysis, placing downward pressure on its effort scope. Honest discussions with stakeholders involving resource availability should be conducted with maximum transparency. PP&C should calibrate expectations early and take opportunities to right-size its team (if possible) to support the forecasted cadence of cost analysis support.

During these initial negotiations, throughout the strategy definition and beyond, PP&C should maintain keen awareness of predetermined biases and other detrimental influences that may skew realistic expectations. It should forge an agreement with stakeholders that is the truest representation of the option space of appropriate analytical frameworks that meet requirements and fall within the effort scope dictated by project constraints and capabilities.

3.5.3.1B Execute Cost Assessment Tasks

With stakeholder agreements in place, PP&C may begin its iterative cycle of cost analysis, which consists of three simultaneous, interrelated campaigns: cost assessment, cost estimating, and JCL analysis (if required). Cost assessment, which enables cost-related forecasting, is performed at the beginning and throughout the analysis cycle, heavily leveraging the cost analysis strategy and ensuring its fruition. Given stakeholder requirements and a well-defined effort scope, the cost assessment activities advance the estimating plan by persistently evaluating all project elements that drive effective cost estimating: stakeholder satisfaction, data integrity, data history and its underlying messages, assumption appropriateness, method and model integrity, and other all other contemporaneous items over which PP&C has direct or indirect control. Assessment is very strictly not a forecasting method; rather, it is the evolving stage upon which all cost-related analyses are performed.

It should be noted that, though the estimating process appears linear, GAO calls out a block of activities as iterative[19]. Here, this notion is taken a step further by insisting that the cost

---

[19] *GAO-16-89G, GAO Schedule Assessment Guide: Best Practices for Project Schedules*

assessment campaign is relentlessly continuous, ending only when the final estimate is delivered. Since estimating activities rely heavily on cost assessment, they are also iterative throughout.

Assessment concerns itself foremost with the collection and interrogation of existing data. (This includes, in many cases, existing estimates. For example, a project's schedule, by definition, is a temporal estimate that is necessary for many useful programmatic analyses.) PP&C's first obligation is to establish a permanent initiative to obtain and assess all data that is necessary to produce an estimate, beginning with the project's technical description and all salient programmatic information such as schedules, staffing, and budgetary documents. The objective of this task is to establish a knowledge base that exhaustively captures important project details for use in crafting estimates. It is the duty of PP&C leadership to ensure these data are made available to the cost and other functions.

Data quality and format is profoundly important to PP&C and its Cost Estimation/Cost Assessment function. Data is rarely delivered clean; it often exhibits omissions, errors, internal incongruities, disagreement with other datasets, intentional bias, and even occasional unintelligibility due to a lack of documentation. In its role as a data assessor, PP&C must influence healthy data transmission across the project, establishing standard formats, discipline in reporting, data integrity standards and strategies for repair. For this purpose, an essential tool is a WBS, which, according to the *NASA Cost Estimating Handbook*, "ensures that all work to be performed on the project is organized and aligned in accordance with the total scope of a program, using a hierarchical structure." A WBS not only establishes a common language between the technical and programmatic sides of a project but also serves as the basic structure of cost estimates. It is highly appropriate for PP&C to assist project leadership in creating a coherent WBS early in project life. (See Section 3.3 in this handbook, and *NASA Work Breakdown Structure (WBS) Handbook* for a deeper discussion.)

For proper cost estimating, PP&C needs more data than that which is sourced internally, though it is critical to vigilantly investigate its project's past performance for insights (such as examining EVM analyses). Historical datasets from similar projects should be continuously collected, assessed, and appropriately normalized. A project that views itself only through the lens of its own data lacks perspective; it is incumbent upon PP&C to gather historical and contemporaneous benchmarks. In general, benchmarking project elements against appropriate analogs lends considerable credibility to the programmatic story and, along with other useful cost- and programmatic-related information, can inform critical PP&C functions such as Acquisition and Contract Management.

As discussed in depth in the *NASA Cost Estimating Handbook* and *GAO Cost Estimating and Assessment Guide*, another critical ongoing task for PP&C is forging and updating GR&As that align all programmatic analyses in scope, common methodological philosophy, and treatment of key data. GR&As provide PP&C with the means to bound an estimate, focus attention on the most important items, and provide ad hoc resolution for undefined technical and programmatic questions. They are living guidelines that explicitly define what is excluded from the analysis scope and which special data items are leveraged such as labor rates, design heritage indicators, inflation schemes, and algorithmic specifications. (For a list of typical GR&A items including inflation assumptions, scope, and risk treatment, see the *NASA Cost Estimating Handbook (CEH), Version 4.0*, February 2015.)

Content scope is ideally well addressed by an estimate's GR&A documentation in terms of phase delineations (e.g., development versus operation) and technical content. Characterizations of the scope of uncertainty and risk,[20] however, often lack documented definition, triggering confusion and methodology reexamination with stakeholders as estimate results are being produced. In these cases, stakeholders may ask questions like, "What does the s-curve shape and range mean?" and "How much is risk X influencing the estimate?" Early in the cost analysis cycle, the Cost Estimation/Cost Assessment function, in close coordination with other PP&C functions that produce estimates and related analyses, should be proactive in broaching uncertainty and risk scope discussions with stakeholders, thus shaping agreements that precisely define what should influence the distributions included in a programmatic analysis model as well as how discrete risks should be treated.

GR&As are appropriately subject to recurring stakeholder negotiations, though PP&C should adjudicate which are the most salient candidates for continuing examination. Agreements with stakeholders, though sometimes painstakingly derived, should be revisited when necessary. To be clear: there is no substitute for analytical transparency.

Once PP&C has initiated cost assessment activities, the estimating campaign can begin. Cost assessment and estimating activities should coexist throughout the cost analysis cycle, a symbiosis that is necessary to affirm the integrity of an analysis package.

3.5.3.1C Execute Cost Estimating and Supplementary Analytical Tasks

The *NASA Cost Estimating Handbook* and *GAO Cost Estimating and Assessment Guide* describe cost estimating methods thoughtfully and comprehensively. For the purposes of this document, important factors in the process including learned lessons and synchronicity amongst PP&C analyses are emphasized, but the estimating process is not reproduced in detail.

An often neglected first step in the estimating cycle is preparing a strategy for documenting the estimate. PP&C needs to establish a cadence of capturing a comprehensible BOE or all the information necessary for a third party to reproduce an estimate and understand its constituent logic. It is much easier to document an estimate as it is created and revised than to wait until the cycle is over when even the vigilant cost analyst may not be able to recall all of the estimate's nuances. (The importance of documentation as part of the estimate's final activity is revisited in Section 3.5.3.1E.)

As the cost assessment activity collects data, PP&C needs to build (or choose) an appropriate modeling framework based upon data quality, project maturity, and the central tenants imbedded within the cost analysis strategy.[21] Models used to forecast cost generally fall into one (or more)

---

[20] See Appendix I: Uncertainty versus Risk: Functional Definition from a Programmatic Analysis Perspective for a discussion of total estimate variation, uncertainty, and discrete risk treatment within various programmatic analyses.

[21] A comprehensive discussion can be found in the *Cost Estimating Handbook* (pg. 14-19)

of four well-known classes: Analogy, Parametric, Engineering Build-Up, and Extrapolation from Actuals (which may leverage EVM metrics). Selecting a modeling approach is directly dependent on two ongoing activities: model validation (Are we building the right model?) and verification (Are we building the model correctly?) .[22] The "right" model is one that adheres to cost analysis requirements and is appropriately designed based upon the nature and maturity of the data. For example, the data elements needed for a component-level parametric model include the Master Equipment List (MEL) organized by indentured assembly level including component-level information (such as mass, power, quantity, Technology Readiness Level (TRL), composition, mass and power contingencies, etc.); schedules; identification of spares, test units and unique specialized Ground Support Equipment (GSE) and facilities; Software Lines of Code (SLOC) table(s); sensor/detector technology and related requirements; technical margins, and other design related documentation such as partnering and acquisition strategy.[23] In contrast, the primary data needed for an engineering build-up model include workforce, activity flows, precise phasing, and material buy quantities. The cost estimator needs to consult with the provider of technical data regarding the availability of the specific cost drivers leveraged by the chosen cost estimating model.

Figure 3.5-3 depicts the generally observed model class usage over a project's life cycle as data evolves; early, less detailed estimates generated from analogy-based and parametric models require less mature data and are eventually phased out as the advent of more detailed data enables engineering build-up and extrapolation-based estimates.

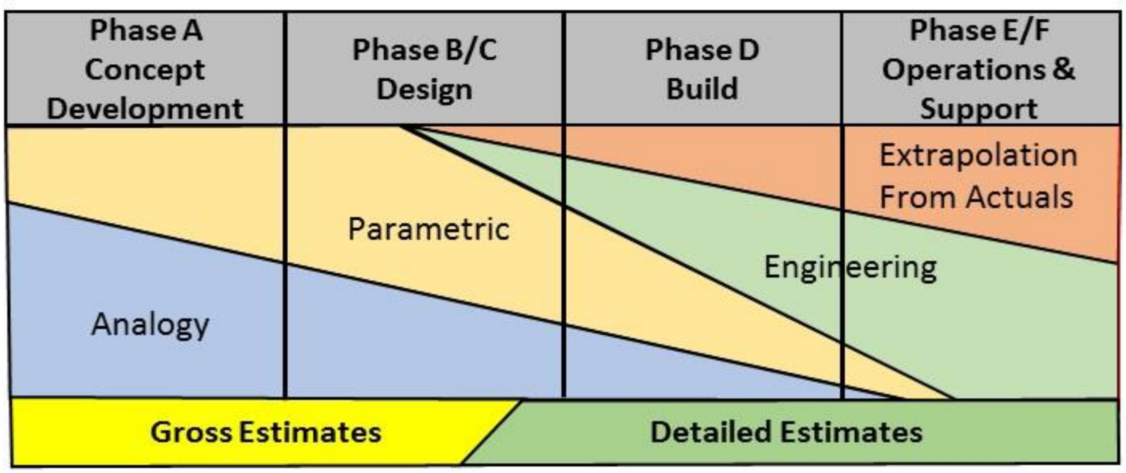


Figure 3.5-3 Use of Cost Estimating Methodologies by Phase[24]

[22] Concerning cases where validation exists without verification, George E. P. Box quips in *Empirical Model-Building and Response Surfaces*, "Essentially, all models are wrong, but some are useful."

[23] See also the *NASA Cost Estimating Handbook (CEH)*, Version 4.0, February 2015, Section 2.

[24] Source: Defense Acquisition University (DAU), "Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management Framework chart (v5.2)," 2008, as reproduced in the International Cost Estimating and Analysis Association's *Cost Estimating Body of Knowledge,* Module 2.

Thoughtful selection of a modeling approach has proven to be one of the most critical estimating decisions. Though largely valuable and heavily relied upon throughout the NASA and U.S. Government estimating communities, third-party commercially available estimating software packages such as PRICE or SEER suffer from a 'black box' condition, a profile of weaknesses involving historical data inaccessibility and calculation opaqueness. Many of these packages render estimates in ways that cannot be fully verified for accuracy, documented, or completely explained by their users. The PP&C Cost Estimation/Cost Assessment function should be very careful when building models in environments that are not completely transparent; well-documented models (such as the NASA Project Cost Estimating Capability (PCEC) and the NASA Instrument Cost Model (NICM) tools) and custom ("from scratch") models driven by technical baseline data, project past performance, and historical benchmarks should be earnestly considered for the role of primary estimating approach. The NASA CEH's Appendix E: Models and Tools provides guidance on the selection of appropriate tools once a cost estimating framework has been selected.

All cost models, especially those created early in a project's development, should necessarily entail the capability to produce not just a point estimate but a resultant distribution of cost forecasts. Single value estimates miss nuances of the cost scenario space and may imbue it with an inappropriate level of implied accuracy, especially since most point estimates with sufficient precision have no chance of occurring; common sense and NASA policy (i.e., NPR 7120.5) affirms this philosophy. Thus, cost models of any type and maturity (in addition to most types of programmatic analyses) should accommodate uncertainty around parameters[25], uncertainty associated with the chosen estimating method, discrete risks, and anything else that may drive total variation in the resultant estimate. (See Appendix I: Uncertainty versus Risk: Functional Definitions from a Programmatic Analysis Perspective for a discussion of total estimate variation.) The *NASA Cost Estimating Handbook* refers to the generation of these stochastic parameters and model elements as cost risk assessment although the activity is concerned as much with uncertainty as discrete project risks. Distributions are generally much more useful than point estimates and can be used to derive secondary metrics like confidence levels, measures of central tendency, and characterizations of estimate dispersion.

Among various aspects of the cost estimate, it is important that PP&C carefully time-phase its estimates according to the project's programmatic complexion; that is, the confluence of schedules, workforce, interdependencies, risks, and other project features. The Cost Estimation/Cost Assessment function should not time-phase its estimate without first consulting the integrated programmatic picture. The need to properly time-phase estimates, like other key programmatic analysis mechanisms, acts as an important forcing function in aligning information across PP&C.

The *NASA Cost Estimating Handbook* lists several analyses that support stakeholder decision making and strengthen the story surrounding the primary estimate construct.[26] These include sensitivity analysis, trade studies, and other techniques that could be requested by stakeholders.

---

[25] "Parameter" here equates to any input that is entered into a developed model to generate an estimate.

[26] See NASA *Cost Estimating Handbook*, Section 4.

Perhaps the most valuable supplementary analyses are those that can be used to benchmark (or cross-check) an estimate or otherwise enhance its explanatory potential. (Sensitivity analyses, for example, can demonstrate the influence of certain cost drivers and highlight those that are either counterintuitive or particularly concerning to stakeholders.) Of importance are secondary estimates or metrics constructed with methods that differ from the primary estimate. Conclusions supported by disparate cost estimating approaches (all adhering, of course, to the same set of GR&A) are exponentially more powerful that single-dimensioned inferences. Traces to cost trending, specific benchmarks' characteristics, and independent estimates also serve to triangulate the estimate and enrich the context. Ideally, a cost analysis should never just contain the estimate itself but rather a collection of informational pieces that advance a strong central message.

3.5.3.1D Conduct a Joint Confidence Level Analysis

JCL is a forecasting framework that melds the dynamics of cost, schedule, risk, and uncertainty together, as depicted in Figure 3.5-4.

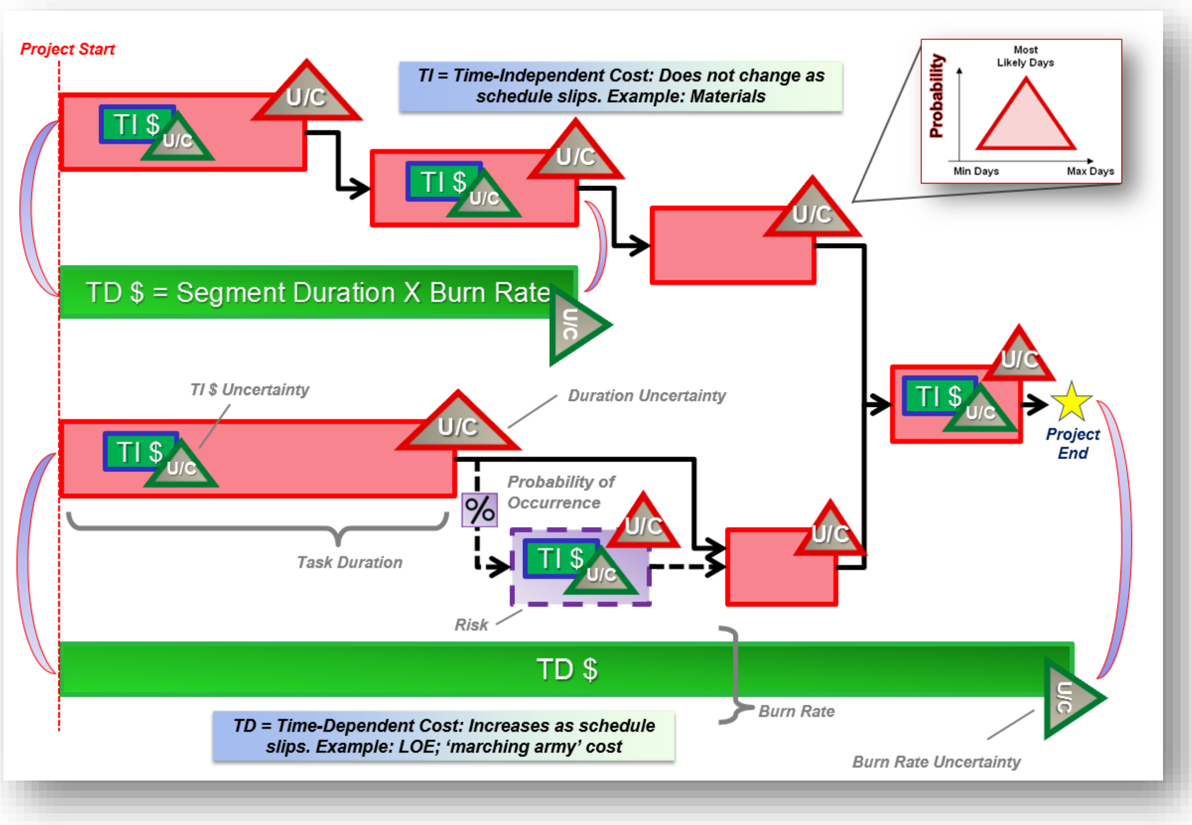


Figure 3.5-4. The JCL Framework

JCL analysis is simply another type of estimating and therefore depends on assessment activities as much as pure cost forecasting does. After cost, schedule, uncertainty, and risk data are properly collected, assessed, and integrated into the model, the simulation is run with certain time-dependent costs increasing as schedule tasks slip due to high draws of task uncertainty and the triggering of schedule risks. A JCL percentage, derived from the simulation's resultant joint cost and schedule distribution, equals the empirical probability that a project's cost will be equal to or less than a target cost and that the schedule will be equal to or less than a target finish date.

Many NASA projects are required to produce a JCL analysis at KDP C[27] according to requirements set forth in NPR 7120.5. A level of UFE needed to achieve a particular JCL is chosen by the appropriate NASA Decision Authority after the analysis is delivered. According to the *NASA Cost Estimating Handbook*, the level of UFE or UFE percentage should be selected based upon achieving a particular level of confidence from the cost or joint cost and schedule risk analysis.

Projects not subject to the JCL requirement should not fail to characterize appropriate levels of UFE using historical guides (including justified rules of thumb) and programmatic analyses that include a portrayal of total estimate variation.[28]

These are not trivial efforts. The process of constructing a JCL model[29] with its extensive programmatic data requirements needs to be facilitated by extensive prior planning and coordination early in a project. The question then arises, "Besides policy mandates, why should projects produce a JCL?" According to historical research, approximately 80% of major NASA projects have overrun their budgets while nearly 100% have surpassed their initial schedules.[30] One of the primary reasons for this dire record of chronic cost and schedule growth has been the absence of an integrated programmatic picture at the beginning and throughout a project's life cycle, which enables conflicting assessments of a programmatic health and allows optimism to nullify realism.

JCL analysis addresses these problems by merging the erstwhile "stovepipes" of cost, schedule, and risk, capturing the dynamics of their interrelationships. It facilitates programmatic transparency with stakeholders regarding the magnitude of realism associated with their expectations and the probabilities they will be met. Ultimately, JCL analysis provides a cohesive and holistic picture of a project's ability to achieve cost and schedule goals.

PP&C's challenges in creating defendable cost estimates are amplified with JCL due to its considerable dependence on diverse (and sometimes unruly) data. PP&C has an obligation to marry programmatic analyses and datasets together, a very tall order in practice. In recent years, JCL has been shown to overcome these challenges in a fruitful way.

---

[27] NPR 7120.5 also dictates that certain types of projects produce cost and schedule ranges at KDP B. These may be derived from a JCL, though it is not explicitly required at KDP C.

[28] See Appendix I: Uncertainty versus Risk: Functional Definition from a Programmatic Analysis Perspective.

[29] Models are often housed within standard platforms like Polaris and Joint Analysis of Cost and Schedule (JACS), both found on the One NASA Cost Engineering (ONCE database portal.

[30] Based upon historical data sourced from the ONCE database.

GAO has also recognized the value of JCL analysis:[31]

> "Over the past several years, NASA has made positive changes that have helped contribute to the improved performance of its projects… NASA instituted the joint cost and schedule confidence level (JCL) process, which is expected to quantify potential risks and calculates cost, schedule, and reserve estimates based on all available data."

See *Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis* of the *NASA Cost Estimating Handbook (CEH,)* Version 4.0, February 2015 for guidance on conducting a JCL analysis.

3.5.3.1E Present Analyses to Stakeholders

When finalizing analytical results, PP&C exploits its final opportunity to validate that GR&A are reflected throughout its analyses and assess all factors that have contributed to the estimates. The documentation package including a completed BOE is then finalized, and the material on which a report to stakeholders can be based is harvested. It is important to note that a BOE lives far beyond its role in influencing the cost analysis story presented to immediate stakeholders. It functions additionally as an explanatory tool for PP&C as estimate curation duties circulate among various personnel and as audits are initiated. Regardless of project expectations, PP&C should treat audits as inevitable and fortify, to the extent possible, its BOE to ensure that the project is fully prepared for the audits.

PP&C's primary aim in presenting its products to stakeholders should be to ensure the story is credible, supportable, defendable, and, most importantly, buttressed by intuitive, compelling arguments. To that end, key details such as salient supporting data, rationale, and assumptions should be made readily apparent while extraneous or distracting detail should be minimized.

It is vital that the Cost Estimation/Cost Assessment function prepare a solid presentation package that provides the context and rationale for the analyses in a way that is likely to be clearly understood and accepted by stakeholders. A large part of this context needs to align with other analyses and assessments rendered across PP&C and leverage GR&A as the "Rosetta Stone" that facilitates a common analytical language and presentation approach. Too often, PP&C functions produce a set of isolated, contradictory analyses; above all, PP&C should ensure that its cost analyses do not confound or invalidate other functions' results. This does not preclude the possibility that the functions' individual analyses, despite fundamental linkage through common data sources and project nuances, may lack perfect synchronicity. PP&C should individually verify each analysis product in its portfolio and artfully explain the differences among potentially conflicting messages to stakeholders in a self-consistent manner.

After presentation and delivery to primary stakeholders (such as project, Directorate, Center, or Agency management), the Cost Estimation/Cost Assessment function should turn its attention to documenting its cost analysis and supporting information for the benefit of the NASA

---

[31] GAO-13-276SP *Assessments of Selected Large-Scale Projects*, April 2013, p. 22

community. A programmatic record of the project can serve as a benchmark for development of future projects' cost estimating models.

Since 2005,[32] the Agency has required projects to package data in a standard format called the Cost Analysis Data Requirement (CADRe), a bundle of three documents of standard format that capture a project "snapshot" comprised of programmatic, technical, LCC, schedule, risk, and uncertainty information at major life-cycle milestones. The CADRe is a project-owned document released under the signature of project manager; it simply records the known configuration of the project and not independent assessments, evaluations, audits, and opinions. It enables programmatic tracking, illuminating changes that occurred between milestones and helping project management communicate all external and internal project events of consequence. The CADRe is NASA's unique response to the need for improving cost and schedule estimates during project Formulation, providing a common description of a project at a given point in time, and thereby satisfying a foundational cost estimating need.

Collecting data across all major flight projects at NASA into a single repository for use in performing estimates for future missions, the One NASA Cost Engineering (ONCE)[33] database is a web-based, controlled-access interface for automated CADRe development. The ONCE interface mimics manual CADRe templates: Parts A, B, and C (see below for descriptions). ONCE allows for source document upload and retrieval and electronic submittal of CADRes. The CADRes contained in ONCE describe a NASA project at six milestones (see below) and provide a historical record of cost, schedule, and technical project attributes so that estimators can better estimate future analogous projects.

Six CADRes are prepared from existing project data generated during milestone reviews that are conducted over the life cycle:

- System Requirements Review (SRR)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Systems Integration Review (SIR)
- Launch
- End-of-Mission (EOM)

At each milestone, three components are provided:

- **Part A**: Describes the project at each milestone and includes significant changes that have occurred, essential subsystem descriptions, block diagrams, and heritage assumptions.

---

[32] NPR 7120.5C was the first Agency policy document to require CADRe delivery.

[33] For access, visit https://oncedata.msfc.nasa.gov/ and follow the Access Instructions link.

- **Part B**: Contains standard templates that capture key technical parameters that drive cost, such as mass, power, data rates, and software metrics.
- **Part C**: Captures the cost estimate and actual LCCs according the project's WBS. This section also captures the project schedule, risks, and GR&As.

3.5.3.2. Control Activities

3.5.3.2A Develop Cost Impact Estimates

The Cost Estimation/Cost Assessment function supports the PP&C Integration function in developing cost impact estimates of project and external events including proposed changes to technical and programmatic baselines. See the affordability blue box in Section 3.2.1 and Section 3.2.3.2C. Support is also provided to the Risk Management function for development of estimates of cost consequences and risk mitigation plans for discrete risks. (See Section 3.7.)

3.5.3.2B Update the Estimate as Required

It is vitally important for PP&C to prepare for estimate updates. Stakeholders' feedback needs to be formally adjudicated, which may warrant adjustments to the cost analysis strategy. Weaknesses in the analyses need to be resolved and lessons learned collected and properly addressed. In the interest of transparency, PP&C will again need to meet with stakeholders, documenting new agreements and expectations as appropriate.

As a project proceeds through its life cycle, information will both change and multiply; analytical methods are expected to adapt, necessitating a reexamination of all estimate aspects. PP&C must be prepared to formally revise estimates as required by project events such as milestone reviews and when significant new data is revealed. This evolution necessitates as well a reexamination of the cost analysis strategy and stakeholder review.

3.5.4. Function Activities by Life-Cycle Phase

Table 3.5-3 depicts cost analysis activities for each life-cycle phase. This representation is an example of a common sequence of activities and is not strictly prescriptive. For instance, it is sometimes appropriate to forgo updating a cost estimate if it is likely that the results will not change. Similarly, policy does not require all projects to produce a JCL. In other cases, large perturbations in project progress may elicit a need to revisit activities from early phases.

Table 3.5-3 Cost Estimating Activities by Life-Cycle Phase

Pre-Phase A	Phase A	Phase B	Phase C	Phase D	Phase E	Phase F
Prepare Cost Analysis Strategy		Update as needed				
Execute Cost Assessment Tasks						
Execute Cost Estimating and Supplementary Analytical Tasks						
		Conduct a JCL Analysis				
		Present Analyses to Stakeholders				
			Develop Cost Impact Estimates			
Update the Estimate as Required						

3.6. Acquisition and Contract Management Function

This section provides guidance for projects that involve the Acquisition and Contract Management function. This section is fully consistent with relevant parts of the FAR and NFS for procurements. The project will depend on the NASA CO for procurements to ensure compliance with Federal regulations and NASA and Center policies.

3.6.1. Function Overview

Many NASA projects acquire supplies and/or services performed by contractors, whether through a prime contractor for the purpose of handling major acquisitions directed at and critical to fulfilling the Agency's mission and entailing the allocation of relatively large resources, or through smaller support contractors. The Acquisition and Contract Management function provides the activities needed to assure that project objectives are accomplished through the procurement process including participation in acquisition planning.

Activities associated with establishing contracts include the following:

- Developing solicitations and SOW and ensuring proper clauses and Data Requirements Descriptions (DRDs) are included to enable contract monitoring;
- Determining approaches for incentivizing contractors to achieve desired performance;
- Providing the in-house cost estimate;
- Supporting proposal evaluations including cost/price analysis and past performance evaluations; and
- Supporting contract award.

Contract management[34] begins immediately after the contract is awarded (and continues through contract closeout) and includes actively monitoring contractor performance including quality of work, cost and schedule performance, contributing to contractor performance evaluation and/or fee determinations, and contract administration (e.g., supporting the assessment of changes or modifications in the contract and evaluation of cost and schedule impacts associated with contractor proposals in response to contract change requests, etc.). Multiple PP&C functions support contract management.

It should be noted that the overall administration of the contract, issuance and approval of contract modifications, exercise of options, and evaluation of contractor's performance is the direct responsibility of the CO with assistance from the COR in accordance with FAR Part 1 and NFS 1801. However, the PP&C organization needs to provide the financial, budgetary, or resource information necessary to support the CO and COR in performing contract administration activities. The PP&C roles and responsibilities associated with procurements are

[34] The term "Contract Management" in this handbook is equivalent to the term "Contract Administration" in the FAR and NFS.

not intended to address the functions of a CO or COR but to provide support to the CO and COR in procurements by providing the expertise in financial, budgetary, and resource matters, and to understand the terms and conditions and work to be performed by the contractor outlined in a solicitation and resulting contract as it affects the management of a project.

3.6.2. Integration with Other PP&C Functions, Inputs, and Outputs

The Acquisition and Contract Management function needs to effectively interact with other PP&C functions to develop the products, plans, and strategies that comprise an integrated, project-level executable plan during the planning phase and to evaluate and control the entire project during the control phase. The Acquisition and Contract Management function also interacts with entities external to PP&C to obtain information and to communicate results and provide products. Figure 3.6-1 is a flow diagram for the Acquisition and Contract Management function that depicts major inputs and outputs received from and provided to other PP&C functions as well as external entities. Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it. The flow diagram also summarizes key activities to consider during the planning and control phases when implementing this function**.** Section 3.6.3 discusses these key activities in detail and provides insight into the importance of the interactions with other PP&C functions.

For the Acquisition and Contract Management function, the planning phase corresponds to the period prior to award of contracts, and the control phase begins at contract award and continues until contract completion.

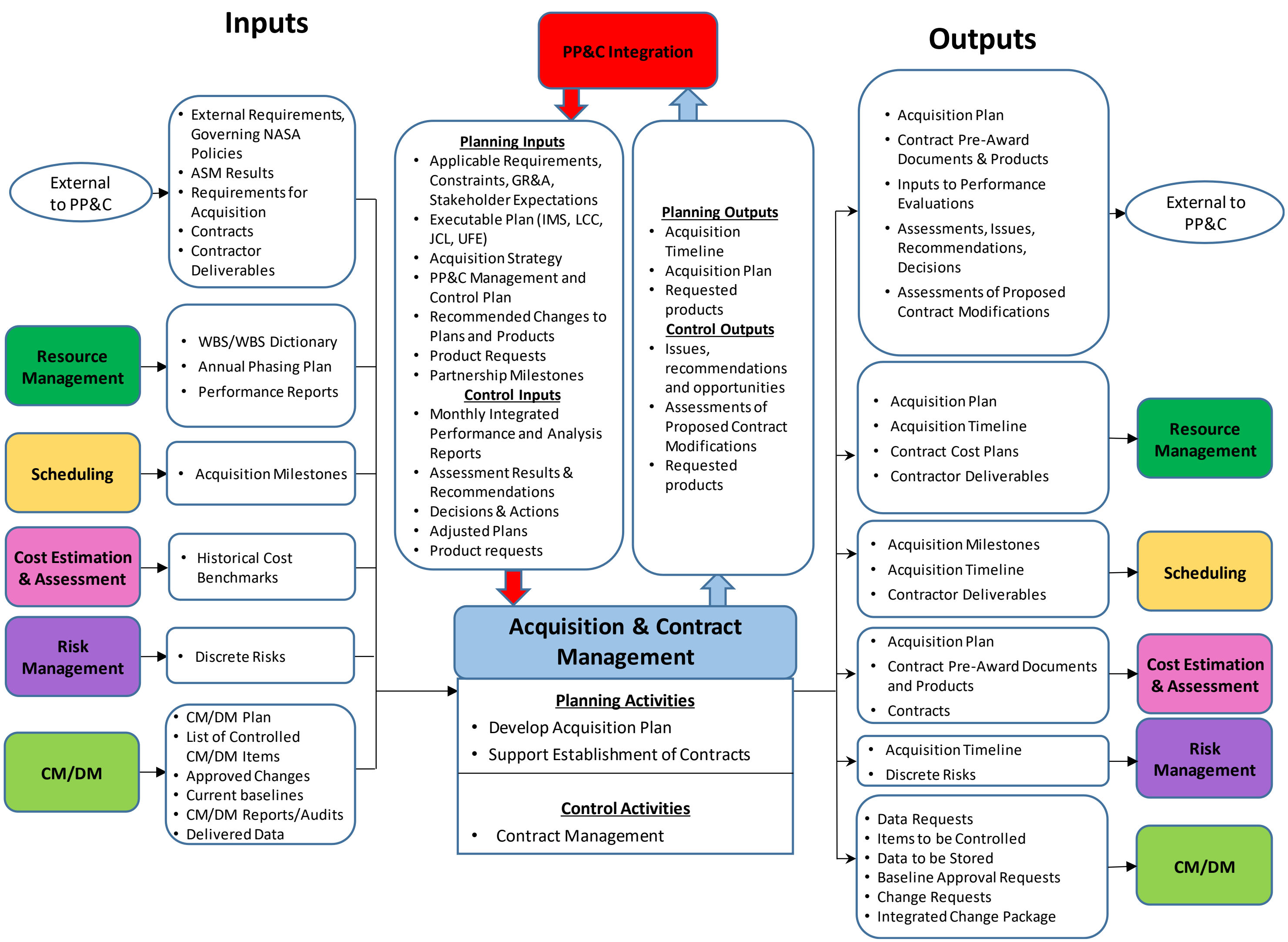


Figure 3.6-1 Typical Functional Flow Diagram for the Acquisition and Contract Management Function with Major Inputs and Outputs

Descriptive information is provided below for the inputs from external entities, and for the outputs depicted in Figure 3.6-1. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.6.3.

Descriptions of all inputs and outputs in can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.

3.6.2.1. Inputs

- **External Requirements, Governing NASA Policies:** Applicable NPDs, NPRs, NASA Center policies, Federal regulations, lessons learned, and best practices including Agency handbooks. Acquisition regulations and requirements applicable to procurements including pre-solicitation activities, solicitation, evaluation of offerors' proposals, contract award, contract management (or administration), and contract closeout/retirement. Includes the Federal Acquisition Regulation (FAR) and NASA FAR Supplement (NFS) and Agency and Center policies including NPRs and NPDs (*NODIS* library) that are required to be identified to enable contractor's performance under a contract. *(Planning input)*

- **Acquisition Strategy Meeting (ASM) Results:** The ASM is a review by senior Agency management of the project's proposed acquisition strategy and results in either its approval or modification. Results of the ASM are also used to develop and finalize the Acquisition Plan. (For additional detail, see Section 3.2.2.)

- **Requirements for Acquisition:** Requirements for procurements to facilitate the identification of the appropriate FAR and NFS regulations, Agency policies, requirements, directives, and procedures for inclusion in the solicitation and resulting contract. Requirements include technical, safety mission assurance, EVM, environmental, quality assurance, risk management, IT, IT security, physical security, health security, property, export control, etc. *(Planning input)*

- **Contracts:** The project's contracts as awarded and/or as modified.

- **Contractor Deliverables:** These include contractor financial management reports and contractor invoices, the WBS, WBS Dictionary, and baseline IMS, EVM deliverables when applicable, and other deliverables required by the contract. The financial management reports are the monthly and quarterly NF 533s or the contractor's invoices. See *NPD 9501.1*, *NASA Contractor Financial Management Reporting System* and *NPR 9501.2*, *NASA Contractor Financial Management Reporting* for more detailed information on NF 533 requirements. EVM deliverables include the IPMR. Other deliverables may include monthly progress reports. The Acquisition and Contract Management function accepts and reviews deliverables to ensure they are consistent with contract requirements and provides the deliverables to the Resource Management and

Scheduling functions for analysis and assessment of contract performance. (For more detailed descriptions of contract deliverables, see Data Requirements Descriptions (DRDs) in Section 3.6.3.1B.) *(Control input)*

- **Annual Phasing Plan:** The Annual Phasing Plan will integrate specific contract cost plans when available. *(Planning input and Control input)*

- **Performance Reports:** When performance issues appear in the data, the performance report should include specific identification of the troubled contract or activity. *(Control input)*

- **Acquisition Milestones:** Acquisition milestones establish the dates when contracts are expected to complete key events or to provide project deliverable(s). Acquisition milestones are key acquisition events that are identified within the baseline IMS. (Initial acquisition milestones are provided as an input to this function for use in developing solicitations for contracts.) *(Planning input)*

- **Discrete Risks:** Identified, documented potential events that each carry an estimated consequence and an associated likelihood (probability of occurrence). The Risk Management team frames the body of risks for project management decision making and programmatic analyses. Each discrete risk includes a risk statement and narrative description; a risk mitigation plan; cost and schedule consequences; likelihood; and risk response. Discrete risks include any identified during development of the acquisition strategy.

- **Acquisition Strategy:** The acquisition strategy is a key input for development of the Acquisition Plan. *(Planning input)*

- **Recommended Changes to Plans and Products:** Recommendations to this function for changes and/or adjustments to plans and products such as the Acquisition Plan. *(Planning input)*

- **Adjusted Plans:** Updates to the project's plans based on approved options/corrective actions. These may include updates to the project's acquisition plans including modification of existing contracts or establishing new contracts. *(Control input)*

3.6.2.2. Outputs

- **Acquisition Plan:** Documents the project's approved acquisition strategy that enables the project to meet its mission objectives and provides the best value to NASA. It identifies all major acquisitions and provides summary information on each acquisition. It describes completed or planned studies supporting make-buy decisions and describes the supply chain and procedures used to identify, monitor, and mitigate supply chain risks. It identifies all agreements, Memoranda of Understanding (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. The Acquisition Plan is provided to PP&C Integration for review and comment prior to approval. *(Planning output)*

- **Contract Pre-Award Documents and Products:** This includes documented results of market research, Purchase Requisition (PR) packages and other inputs to solicitations including Requests for Proposal (RFPs) and Requests for Quotation (RFQs). PP&C contributes to the following components of PR packages: financial requirements on contracts; SOW; identification of deliverables and delivery schedule; contract reporting requirements (CDRLs/DRDs); Government in-house cost estimate; WBS of the Government in-house cost estimate and cost charts; EVM requirements if applicable; evaluation criteria factors, instructions, and numerical weights; and identification of applicable NPDs and NPRs, etc. This information is provided to the Center Procurement Office and, upon request, to other PP&C functions, including the Cost Estimation/Cost Assessment function to facilitate development of the project's cost estimate. *(Planning output)*

- **Inputs to Performance Evaluations:** Periodic evaluations are conducted by the CO, COR, and project to assess contractor performance. PP&C provides inputs to these performance evaluations that include but are not limited to quality of work, cost performance, timely performance, effectiveness of management, compliance with labor standards, and compliance with safety standards. *(Control output)*

- **Assessments, Issues, Recommendations, Decisions:** These are assessments of cost and schedule performance at the individual contract level (taken from the performance reports input); issues and opportunities pertaining to individual contracts (taken from the issues, recommendations, and opportunities output); and recommendations and decisions pertaining to individual contracts (taken from the assessment results and recommendations input and the decisions and actions input). This information is provided to the CO and COR for each contract. *(Control output)*

- **Acquisition Timeline**: The planned dates when solicitations are expected to be released, proposals from offerors evaluated, and contracts awarded. *(Planning output)*

- **Contract Cost Plans**: An estimate of when funds will be obligated to each of a project's applicable contracts and when work is expected to be completed for contractual costing purposes. For cost-reimbursable contracts, the contractor is required to submit a time-phased baseline cost plan. Proper funding of termination liability should be taken into consideration. *(Control output)*

- **Contractor Deliverables:** See Inputs. The Acquisition and Contract Management function accepts and reviews deliverables to ensure they are consistent with contract requirements and provides the deliverables to the Resource Management and Scheduling functions for analysis and assessment of contract performance. *(Control output)*

- **Acquisition Milestones:** See Inputs. When provided as an output from the Acquisition and Contract Management function, the acquisition milestones reflect the milestones established in contracts that have been awarded. *(Control output)*

- **Contracts:** See Inputs. Contracts are provided to other PP&C functions upon request, including the Cost Estimation/Cost Assessment function to facilitate development of the project's cost estimate.

- **Items to be Controlled:** Items developed by the Acquisition and Contract Management function that need to be placed under configuration control such as the Acquisition Plan. *(Planning output and Control output)*

- **Data to be Stored:** Data developed by the Acquisition and Contract Management function and other project data (including data developed by external entities such as contractors) identified as needing to be stored at any time during the life cycle. *(Planning output and Control output)*

- **Issues, Recommendations and Opportunities:** Issues include project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues, and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance. Issues, recommendations, and opportunities may pertain to individual contracts or to industry in general. (For additional detail and examples, see Section 3.2.2.) *(Control output)*

- **Assessments of Proposed Contract Modifications:** Assessments of the cost and schedule impacts submitted by contracts for proposed modifications. The Acquisition and Contract Management function ensures and coordinates these assessments that are conducted by the Resource Management and Scheduling functions and reviewed by the PP&C Integration function. (*Control output)*

3.6.3. Function Planning and Control Activities and Tasks

Acquisition and Contract Management planning and control activities and tasks are outlined in Table 3.6-1 Acquisition and Contract Management Activities and Tasks. The activities and associated tasks are described in more detail below the table.

Table 3.6-1 Acquisition and Contract Management Activities and Tasks

Acquisition and Contract Management	
Planning Activities and Tasks	**Control Activities and Tasks**
Activity: Develop Acquisition Plan **Activity: Support Establishment of Contracts*** • Conduct procurement planning • Support development of statement of need and market research • Support determination of contract type • Support preparation of PR package; includes solicitation requirements, Government in-house cost estimate and cost charts to enable evaluation of offeror's cost/price, provisions and clauses, and contract reporting deliverables necessary to execute control tasks. • Support solicitation; includes inputs to evaluation criteria, other activities required by CO, contract award, etc.	**Activity: Contract Management *** • Host post-award orientation • Accept contractor deliverables (contractor financial management reports, contractor invoices, EVM, and other deliverables) • Evaluate contractor performance • Support contract modifications • Participate in contract termination (if applicable) • Participate in contract closeout

*These activities may occur during both the Formulation and Implementation life-cycle phases of a project.

3.6.3.1. Planning Activities

3.6.3.1A Develop Acquisition Plan Activity

PP&C typically has responsibility for developing the project's Acquisition Plan with support from the project's technical team, project management, and the host Center's Procurement Office. (All references to the Acquisition Plan in this document are references to the project's Acquisition Plan required by NPR 7120.5, not the acquisition plans required by FAR 7.105 and NFS 1807.105 developed by the Center's Procurement Office to contract for a specific requirement.)

The project's Acquisition Plan documents the project's approved, integrated acquisition strategy that enables the project to meet its mission objectives and provides the best value to NASA. The acquisition strategy is developed by the PP&C Integration function (see Section 3.2.3.1B) and describes the approach for using NASA's acquisition authorities to achieve the project's mission within planned cost and schedule. The acquisition strategy addresses plans for obtaining the systems, research, services, construction, and supplies needed to fulfill the mission including in-house work plans, any known procurement(s), plans for partners and their roles and anticipated contributions, and plans for obtaining commitments for these contributions.

The Acquisition Plan:

- 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.
- Describes the process for reporting supply chain risks to the project.
- Describes the internal and external mechanisms and procedures used to identify, monitor, and mitigate supply chain risks and includes data reporting relationships to allow continuous surveillance of the supply chain that provides for timely notification and mitigation of potential risks.
- Promotes sufficient project stability to encourage industry to invest in, plan for, and bear their share of risk.
- Identifies the project's approach to strengthening SMA in contracts and describes how the project will establish and implement a risk management process per *NPR 8000.4, Agency Risk Management Procedural Requirements* and *NASA/SP-2011-3422, NASA Risk Management Handbook*.
- Describes all agreements, MOUs, barters, in-kind contributions, and other arrangements for collaborative and/or cooperative relationships including partnerships created through mechanisms authorized under transaction authorities other than the FAR and NFS. It lists all such agreements 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 may include partnerships and NASA agreements. (See Section 3.2 of this handbook for information on establishing partnerships and NASA agreements.)
- Lists long-lead procurements that will need to be procured in Phase B, which will need to be approved by the program manager.
- Describes the IBRs and schedules required for contracts requiring EVM (refer to the NFS), how the project needs to conduct any required IBRs, and how to maintain the contract documentation.

See NPR 7120.5, Appendix H, Section 3.4, and Table I-5; and *NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook*, Section 4.3.4.2.2 for detailed information on the Acquisition Plan. See Section 3.2.3.1B of this handbook for information on development of the project's acquisition strategy.

Once the project Acquisition Plan is approved, the Acquisition and Contract Management function supports the project in initiating approved acquisitions in accordance with identified schedules including establishing contracts.

3.6.3.1B Support Establishment of Contracts Activity

Conduct Procurement Planning

The key to a successful procurement is organization, planning, estimating and budgeting resources, and executing the plan. PP&C provides essential and key support to the CO for conducting the tasks necessary to accomplish the procurement including conducting the market research, developing the requirements to be included in the solicitation, selecting the contract type, preparing the PR package, and supporting the solicitation. The procurement process results in a contract between the Government (NASA) and the contractor. All of the activities described in this section are guided by the CO assigned by a Center's Procurement Office and supported by the project being responsive to the CO.

The CO has the authority to enter into, administer, or terminate contracts and make related determinations and findings. COs may bind the Government only to the extent of the authority delegated to them. Only COs have the authority to bind the Government. No contract is entered into unless the CO ensures that all requirements of law, executive orders, regulations, and all other applicable procedures including clearances and approvals have been met. COs are responsible for ensuring performance of all necessary actions for effective contracting, ensuring compliance with the terms of the contract, and safeguarding the interests of the United States in its contractual relationships.

Procurement actions vary in scope and complexity and should be tailored to the specific requirement. The specific components of the PR package and the PP&C contributions depend on the nature of the work, whether the contract is to be awarded competitively or non-competitively, and risk. Commercial items and services are placed on Purchase Orders (POs) or contracts. Contracts are appropriate for both Research and Development (R&D) and non-R&D items and services. Items and services that are not commercially available and consequently need specification typically require a contract to be awarded. POs may not be appropriate for noncommercial items and services. For example, if the procurement requires the development or manufacture of a prototype or engineering model or support for analysis or application of plasma physics or quantum mechanics, it probably is not a commercial service. This type of support would require a contract to be awarded or a task or delivery order to be placed on a contract. (See FAR 13.302 for additional information on POs.)

When thinking about establishing contracts, the project should consider the following:

- Chains of responsibility in the management structure, given the limits of the candidate organizations. What organizational and contract structure will result in the strongest project team? How will the project be integrated across all elements of the acquisition strategy? How will risk be identified, integrated, and managed with the acquisition strategy?
- Utilizing the WBS and OBS to ensure all project elements including contracts and their relationships to one another have been considered. The WBS is included in solicitations and contracts for contractor reporting (e.g., DRDs, NF 533 reports, and invoices).
- Common cost, schedule, and risk tools for the project and other products that may be rolled up and/or integrated at the project level. Contract requirements may include use of specific tools and generation of specific products consistent with the project's approach.
- The depth of penetration/insight/oversight NASA expects to apply and what dilution of contractor responsibility would result.
- How firm the project operation/mission concepts and requirements are. Is contractor support required to perform alternatives analysis (including technical, schedule, cost, and risk) to better refine project requirements? If so, will multiple contractors be utilized to conduct these trades and concepts? And, if so, are cost-plus, fixed price, or Indefinite Delivery, Indefinite Quantity (IDIQ) contract vehicles the most beneficial for this support?
- The likely project strategy for UFE; i.e., where the UFE is held and guidelines for how UFE will be used.
- The skills required to successfully execute the effort and where are they located.
- The most important elements of the project that would drive incentives and contract structures.
- The level of cost risk to be borne by the contractor or Government. During the development phase of a project, NASA may take on the cost risk due to the challenges associated with first-time developments. However, once a project is in the production and operations phases or if acquisition of continuing services is required, industry should assume some of the cost risk of performance. Award fee, incentive fee, and Firm-Fixed Price (FFP) are some of the contract types that may be used. Negotiated fee should be commensurate with the technical complexity and level of cost risk assumed by the contractor. (See additional information on contract types in the subsection Support Determination of Contract Type below and in Appendix J: Contract Types.)
- Contractor cash flow is an important consideration in negotiating a contractor's fee. Favorable changes in payment to the contractor can often be more beneficial to the contractor than higher fee rates.
- Development of contract workload projections. (Project and procurement offices work together to develop workload projections for their requirements.)

- Whether project planning needs to comply with the Construction of Facilities (CoF) program mandated by Congress. For additional information on the CoF program, see *NPR 8820.2*, *Facility Project Requirements (FPR)*, *NPD 8820.2*, *Design and Construction of Facilities*, and *NPD 7330.1*, *Approval Authority for Facility Projects*.
- Whether EVM is required on the contracts(s).

In some cases, NASA may solicit sole source (non-competitive) proposals. A sole source acquisition is a contract for the purchase of supplies or services that is solicited and negotiated with only one source. Statutory authorities (including applications and limitations) permit contracting without providing for full and open competitions as outlined in FAR 6.3. Sole source or acquisitions that provide for other than full and open competitions require justifications and approvals to support the use of the specific authorities outlined in the FAR. The Office of Procurement should be consulted prior to initiation of any discussion with a prospective sole source contractor.

Depending on the type and dollar amount of the procurement, PP&C may be involved in supporting the following tasks:

- Conduct market research for the service or supply to be acquired. This includes identifying potential sources and determining if commercial sources are available to satisfy the government's requirements.
- Develop a statement or description of the Agency's needs, project's objectives, goals, and requirements.
- Issue Requests For Information (RFIs) from industry, if required.
- Identify potential offerors and evaluate potential supplier past performance and potential risks.
- Develop a "supplier's list" for the service or supply to be acquired, to include each subsystem or component.
- Obtain industry feedback on the draft SOW, draft specifications, and draft solicitation.
- Develop a procurement cycle schedule for the contract or critical PO.
- Conduct a PSM, if needed.
- Develop a PR package.
- Select the contract type (FAR Part 16 Types of Contracts).
- Develop requirements for inclusion in the SOW, specifications, and DRDs.
- Develop pre-award products and documentation: government in-house cost estimates (labor and non-labor resources), a WBS, solicitation cost charts, CDRLs/DRDs, and financial management reporting requirements.

Support Development of Statement of Need and Market Research

Each project determines its goals and objectives and how to best capture industry capabilities and progress to meet the project's needs. An acquisition begins with a description of the project's needs stated in terms sufficient for conducting market research. Typically, it is a narrative description of items or services, expressed as general statements of the intended use in terms of function to be performed, performance requirements, essential physical characteristics, and, if necessary, operational environments. Some requirements are critical and essential; others may be desirable and expressible as targets or objectives. Contracting personnel will not normally have a major role in the preparation of the statement of need. However, contracting personnel should participate in the initial industry contact in support of developing the requirements for the acquisition solicitation.[35]

FAR Part 10 Market Research requires that Federal agencies state requirements in terms that enable and encourage companies to provide commercial and non-developmental items/supplies and services. It specifically requires Federal agencies to conduct market research prior to developing new specifications for procurements and before soliciting bids or proposals for a contract that exceeds the simplified acquisition threshold. Market research is a tool used to determine what is available on the marketplace to meet a specific need that supports project goals and objectives. It is important to document the market research. The level of market research and documentation will vary depending on the nature of the item or services and the complexity and dollar magnitude of the acquisition being contemplated. PP&C participation in and/or cognizance of the market research effort inform the support and products that PP&C provides to the acquisition process.

Plans for an acquisition must address the extent and results of market research. When planning an acquisition, it is important to maximize the use of competitive market forces. Through market research, the level of market competition and the number of potential sources capable of satisfying requirements can be identified.

Support Determination of Contract Type

One of the most critical decisions associated with contracts is the determination of what contract type to use. A wide selection of contract types is available to the Government to provide flexibility in acquiring the large variety and volume of supplies and services. Contract types are grouped into two broad categories: fixed-price type contracts and cost-reimbursement type contracts. (Outside of this general categorization are Indefinite Delivery Contracts (IDCs), Time-and-Materials (T&M), labor-hour, and letter contracts.)

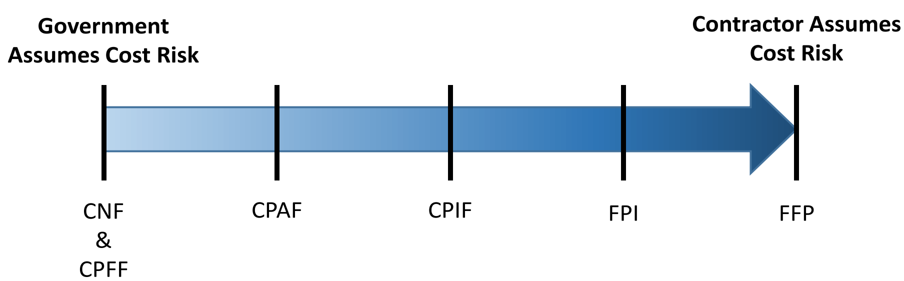
---

[35] The CO is responsible for posting any necessary source-sought notices, RFIs, draft and final solicitations and amendments, notices of industry briefings, and any other necessary notices in the publically accessible Governmentwide Point of Entry (GPE), which is FedBizOpps. (The GPE is the single point where Government business opportunities greater than $25,000 including synopses of proposed contract actions, solicitations, and associated information can be accessed electronically.)

The most commonly used contract types are depicted in Figure 3.6-2 ordered in accordance with the degree of risk assumed by the contractor with each type. These range from Cost-No-Fee (CNF) and Cost-Plus-Fixed-Fee (CPFF) where the contractor has minimal risk or responsibility for performance costs and the fee amount (if any) is fixed and is not adjusted in response to actual costs or performance, to FFP representing contractor assumption of all cost risk (contractor has full responsibility for the performance costs and resulting profit (or loss). In between are the various incentive contracts in which the contractor's responsibility for the performance costs and the profit or fee incentives offered is based on the uncertainties involved in contract performance. Incentive contracts are designed to obtain specific acquisition objectives by:

- Establishing reasonable and attainable targets that are clearly communicated to the contractor; and
- Including appropriate incentive arrangements to motivate contractor efforts that might not otherwise be emphasized and to discourage contractor inefficiency and waste.

If the contract requires EVM, the contract type is affected. Generally, any of the incentive type contracts can be used. EVM on FFP type contracts is discouraged. For more details on contract types, see FAR Part 16 Types of Contracts including FAR 16.103 Negotiating contract type, FAR 16.104 Factors in selecting contract types; and NFS Part 1816 Types of Contracts.



Legend

CNF = Cost-No-Fee
CPAF = Cost-Plus-Award-Fee
CPFF = Cost-Plus-Fixed-Fee
CPIF = Cost-Plus-Incentive-Fee
FFP = Firm-Fixed-Price
FPAF = Fixed Price with Award Fee
FPI = Fixed-Price Incentive

Figure 3.6-2 Cost Risk to Contractor

In the spectrum of contract types, the various fee/profit structures provide for varying degrees of contractor responsibility depending upon the degree of uncertainty involved in contract performance. Selection of contract type is the principal method of allocating cost and performance risk between the Government and the contractor. When performance risk to the contractor is minimal or can be predicted with an acceptable degree of certainty allowing for a reasonable cost estimate, a FFP contract is the preferred contract type. As uncertainties increase, other types of fixed-price or cost-reimbursement contracts can be used to mitigate the uncertainties and avoid placing too much risk on the contractors. It is important to select the proper contract type to be able to properly motivate and incentivize the contractor to perform. In cost-reimbursement type contracts, the contractor is only required to make its "best effort" to complete the work. Once contract funds run out, the contractor is not obligated to continue performance under the contract or otherwise incur costs in excess of the amount allotted by the Government to the contract. Selecting the proper contract type requires the exercise of sound judgment. The objective is to negotiate a contract type that fairly allocates performance risk between the contractor and the Government and incentivizes the contractor to perform effectively, efficiently, and economically.

The CO is responsible for selecting the appropriate contract type. However, in most instances, the project including the PP&C organization is responsible for drafting the SOW, specifications, and other technical/performance requirements. A project that is familiar with the technical requirements and degree of uncertainties in the SOW is in an important position to provide the CO with information that is critical to the contract type selection. The project's responsibilities are an integral part of the procurement process. The SOW is the key element in deciding the selection of a contract type. The level of detail, clarity, and identification of performance objectives and expectations in the SOW drive all other conditions of the contract from pricing structure to the contractor's entitlement to payment and to the level of contract management (or administration). That said, the greater the degree to which the Government can articulate its needs accurately and clearly, the greater the likelihood that the contractor will accept greater performance and cost risk associated with a particular type of contract.

Considerations when selecting contract type based on the SOW include the following:

- What is the risk associated with contract performance?
- What is the degree of development required in the work to be performed?
- Are the requirements clearly defined or are there a lot of unknowns?
- What are the technical, environmental, schedule, and financial risks?
- Are market conditions stable?
- Can the work-years and type of labor/labor mix required for performance be estimated with any degree of certainty?
- Can the required equipment, facilities, ODCs, and material be estimated with any degree of certainty?
- Are there any issues with the place of performance or any unknown site conditions?
- What is the quality of Government-Furnished Property (GFP)?

A description of the types of contracts is provided in Appendix J: Contract Types.

Support Preparation of PR Package

Once all of the required market research data have been obtained, PP&C supports the project and the CO in the development of a PR package and the draft and/or final solicitation including RFPs and RFQs. The PR package documents all technical and financial requirements for the contract including the SOW, specifications, other technical requirements; identification of deliverables and delivery schedule; contract reporting requirements (CDRLs/DRDs); Government in-house cost estimate with an estimate of the labor and non-labor resources required to meet the Government's requirement; WBS of the Government in-house cost estimate and cost charts to help the offerors understand the requirements when developing their proposals and for contract reporting; evaluation criteria factors, instructions, and numerical weights; and identification of applicable NPDs and NPRs per the NODIS library, etc. Contracts requiring EVM reporting will include the requirement for the contractor to use an EVMS that meets the guidelines in EIA-748 to monitor contract performance. An EVMS is normally used on cost-reimbursement contracts. See NSF Part 1834 Major System Acquisition and NASA's external and internal websites at http://evm.nasa.gov/ or https://nen.nasa.gov/web/pm/evm for more information on the requirements for application of EVM on contracts.

Projects should develop their requirements and SOWs clearly and unambiguously and be mindful that it is best to try to minimize contract changes. They should also anticipate that some contract change will be needed. Some project managers are overly optimistic about stable requirements and the absence of contract changes. A plan with few or no assumed changes is not realistic.

These requirements are included in the PR package along with NF 1707 (Special Approvals and Affirmations of Requisitions) so that a solicitation can be developed and issued by the procurement organization. The procurement office will use the contents of the PR package and the NF 1707 to develop the solicitation to include the applicable provisions and clauses based on the type of contract contemplated.

Technical Requirements

The project manager, systems engineer, and/or the discipline engineer representing the project's interests to obtain the contract work with the CO to develop technical requirements for goods and services that will be procured and negotiate with the applicable project elements to resolve any lack of congruence between what is to be procured and the resources available.

Financially-based Requirements

PP&C provides the financially-based requirements of the PR package (e.g., cost/price charts for solicitations, Government in-house cost estimate, applicable cost/price CDRLs/DRDs, etc.) and ensures that funding needed for the contract is adequate for contractor performance and consistent with the project's funding profile or budget. PP&C should work with the project to determine and develop the contract WBS, which provides structure for technical planning and management of the work to be performed including scheduling, cost estimating and budgeting, contract scope definition, work authorization, product development, status reporting, and contract reporting. Financially-based requirements must be compliant and consistent with all applicable Anti-Deficiency Act (ADA) funding and appropriation and budgeting requirements and regulations.

- **Anti-Deficiency Act:** The ADA prohibits obligation or expenditure of Government funds in excess of the amount appropriated by Congress or in excess of amounts permitted by regulations; forbids the obligation of any funds in advance of the official appropriation of funds; and requires the head of each Government agency to establish an administrative control system for the purposes of keeping obligations within the amount of apportionment and enabling the agency to detect and report violations of the ADA through the Executive Branch to Congress.

- **Funding and Appropriation:** Funding lies at the core of all Government functions. To ensure that expenditures are charged to the proper accounts, the project should ensure that appropriate and adequate funding is available for the acquisition and ensure that any constraints or limitations are known for various types of funds. The project is responsible for the appropriate use of the funds. The consequence of using NASA funds inappropriately could lead to an employee being held personally responsible for commitments and purchases made. The project should seek the advice of its CFO or the OGC or the Office of the Chief Counsel (OCC) to ensure that actions are consistent with GAO's *Principles of Federal Appropriations Law (The Red Book)*. Early in the process, the project should verify that funds are available or have been reserved in the budget and specifically identified in the NASA Program Operating Plan for the acquisition or that a plan to obtain funding has been developed. Appropriated funds are subject to three basic fiscal controls: purpose, time, and amount. These are described as follows:

    - **Purpose**: Appropriations shall be applied only to the objects for which the appropriations were made except as otherwise provided by law. For example, salary and benefits funding should not be used to purchase new aircraft.

    - **Time**: An appropriation is available only for payment of expenses properly incurred during the period of availability or to complete contracts properly made during the period of availability. This is also referred to as the "bona fide needs" rule or law. (See legal reference at 31 U.S. Code § 1502 - Balances available. See also *NPR 9470.1Budget Execution*.)

    - **Amount**: The Anti-Deficiency Act (ADA) prohibits an officer or employee of the United States Government from making or authorizing an expenditure or obligation exceeding an amount available in an appropriation or fund for the expenditure or obligation. The ADA prohibits an officer or employee of the Government from involving the Government in a contract or obligation for the payment of money before an appropriation is made unless authorized by law. The extended duration of Continuing Resolutions (CRs) in recent years requires the Government to devote particular attention to ensure compliance with this Act and to avoid major disruptions to essential Government services. Absent specific authority, funding under a CR is generally available only to fund ongoing projects and activities, not new initiatives or projects, and provides only partial funding until appropriations have been received.

- **Budgeting:** The project is responsible for proper budgeting, which is an important step in ensuring compliance with the ADA. The CO has ultimate responsibility for ensuring that the appropriate funding is available for obligation at contract award. Project budgeting must also account for the limitations on incremental funding of contracts and orders as prescribed in NFS Subpart 1832.7 Contract Funding.

Government's In-House Cost Estimate

The Government itself estimates the costs that a contractor/offeror may incur in performing services and/or providing supplies to achieve the Government's objectives. The development of a detailed Government in-house cost estimate should be accomplished early in the acquisition planning process and, at a minimum, before the solicitation is issued.

The Government in-house cost estimate serves as the basis for reserving funds during acquisition planning and it provides the basis for comparing costs or prices proposed by offerors in response to a solicitation. In general, the Government in-house cost estimate should contain an estimate of the labor and non-labor resources required to meet the Government's requirement and typically includes direct costs such as labor, fringe benefits, Federal Insurance Contributions Act (FICA) tax, other direct costs/materials/equipment, contracts, and indirect costs such as labor overhead, material overhead, G&A expenses, facilities capital cost of money, and profit or fee. The Government in-house cost estimate should also describe the types of estimates and methodologies used to develop the estimate. A WBS can facilitate development of the Government in-house cost estimate.

Generally, the project has the clearest understanding of the resources that will likely be needed to satisfy the requirements. For example, for a service contract, the requiring organization would most likely know the skill mix and staffing levels that may be required as well as the amount of travel or other direct cost items. The project must include the basis of its estimates for the Government in-house cost estimate; e.g., benchmark information provided by the Cost Estimation/Cost Assessment function including historical costs and escalation factors for multiple-year contracts. The project may need assistance from a procurement representative to obtain information about prevailing industry/locality wage rates, industry overhead or burden rates, and typical contractor accounting systems. The project must thoroughly review, challenge, refine, and ultimately adopt the cost estimate as the Government's best estimate of what the requirement might cost using what the Government believes to be a reasonable approach to accomplishing the work. A well-developed Government in-house cost estimate will provide a useful reference point during the evaluation and analysis of cost proposals.

Data Requirements Descriptions (DRDs)

PP&C involvement is very important in ensuring that the correct requirements for management and data reporting are included in the solicitation. These requirements are defined through clear narrative direction within the SOW and also within specific DRDs included in the solicitation document. Significant PP&C participation in supplying input, guidance, and review of requirements is recommended to ensure that management processes and all data received satisfy the project's need for measuring the contractor's ongoing performance during implementation.

A well-crafted reporting structure provides the ability to examine the contractor reported data to determine the source of any significant technical, cost, and schedule variances. Reporting and analysis is most efficient when levels and thresholds are carefully crafted and the primary focus is on elements that exceed these thresholds. Therefore, it is important to develop the appropriate Contract Data Requirements List (CDRL) and DRDs for reporting data that support project-level planning and analysis and are included in the solicitation and contract. The CDRL is the basic contractual document that governs the data required by and for the contract. The DRD defines the specific data, format, maintenance instructions, and submittal requirements for reporting.

NPD 9501.1, NASA Contractor Financial Management Reporting System and *NPR 9501.2, NASA Contractor Financial Management Reporting*, require that all acquisitions that will result in cost-reimbursement, price redetermination, and fixed-price incentive type contracts include NF 533 as a deliverable and that reporting criteria (WBS) be developed for inclusion in the solicitation. The NASA Contractor Financial Management Reports, NF 533M and NF 533Q, are the primary source for contractor reporting on cost planning, performance, and control for cost-reimbursement, price redetermination, and fixed-price incentive type contracts. All cost and incentive type contracts require NF 533M. NF 533Q is optional on solicitations between $500K to $999K that are one (1) year or more in duration and solicitations of $1 million or more that are less than one (1) year in duration. Both 533M and 533Q are required on solicitations of $1 million or more that are one (1) year or more in duration.[36]

The project WBS provides the structure for technical planning, scheduling, cost estimating and budgeting, contract scope definition, work authorization, product development, contract status reporting, and assessment. In other words, the WBS provides the framework for implementing EVM. The WBS should be a product-oriented hierarchical division of the hardware, software, services, and data required to produce the required deliverables. The WBS should also be consistent with current NASA requirements in NPR 7120.5, NPR 7120.7, and *NPR 7120.8*. An example of a contract DRD for the WBS and WBS Dictionary is provided in the *NASA Work Breakdown Structure (WBS) Handbook (NASA/SP-2010-3404)*. Normally during the solicitation stage, the solicitation provides a contract WBS down to level three. The contractor uses this contract WBS and extends it to the appropriate management level. The contractor may also propose changes to the contract WBS. The *NASA Work Breakdown Structure (WBS) Handbook* provides recommended methods and best practices for developing the project and contract WBS.

The solicitation should include language that requires a logic network schedule and defines the logic network schedule requirements. These requirements should be consistent with NPR 7120.5 and satisfy the scheduling best practices included in the *NASA Schedule Management Handbook (NASA/SP-2010-3403)*. Requirements should ensure the establishment, management, and control of the baseline master schedule and its derivative schedules. These requirements help ensure establishment of a valid framework for time-phasing budgets and coordination of efforts into a

[36] In accordance with NPR 9501.2, NF 533Q reporting may be waived by the CO with concurrence by the Center CFO and cognizant project manager for support service or task order contracts when NF 533M reports and other data are sufficient to ensure accurate monthly cost accruals, track the contractors' actual cost against plans, and forecast resource requirements.

master plan that also enables the measurement of accomplishments. A sample IPMR DRD defining schedule content and format is also included in the *NASA Schedule Management Handbook*, which provides recommended methods and best practices for the development and maintenance of the baseline IMS.

The project needs to ensure that the solicitation and resulting contract include all the requisite EVM contract provisions and clauses. Each NASA Center has an Earned Value Management Focal Point (EVMFP) who will help ensure the appropriate EVM DRDs are included and scaled as necessitated by the complexity of the contract and project management reporting requirements. The contract IPMR DRD provides guidance for the preparation and submission of each of the IPMR required formats, variance analysis thresholds, reporting frequency, reporting levels, distribution, and specific project instructions if required.

EVM reporting thresholds are established that specify when a detailed analysis of cost and schedule variances is required in the monthly IPMR deliverables. Establishment of variance analysis reporting thresholds is important to ensure that EVM variance reporting is meaningful to NASA and provides valuable project status but at the same time is not onerous to the contractor. Contract provisions and clauses NFS 1852.234-1 Notice of Earned Value Management System and NFS 1852.234-2 Earned Value Management System are required for all contracts exceeding the dollar threshold as established in NFS 1834.203. The solicitation needs to include provisions from NSF Part 1834 and NFS Part 1852. Contracts should include *DI-MGMT-81861A, Department of Defense (DOD) Data Item Description: Integrated Program Management Report (IPMR)*, which has superseded DI-MGMT-81466A (Contract Performance Report (CPR)) and DI-MGMT-81650 (IMS). See NPR 7120.5, the *NASA Earned Value Management (EVM) Implementation Handbook (NASA/SP-2012-599)*, the *NASA Schedule Management Handbook (NASA/SP-2010-3403)*, and the *NASA Work Breakdown Structure (WBS) Handbook (NASA/SP-2010-3404)* for more information on DRDs.

Support Solicitation

The Acquisition and Contract Management function supports the CO in integrating the refined version of the SOW, data requirements, and other documents provided by the PR package with FAR and NFS clauses and provisions in the solicitation. In addition to the standard clauses, the unique performance situations that might be encountered need to be considered and clauses that protect NASA’s interests need to be included.

PP&C support may include inputs to the development of the evaluation factors and subfactors to be established in the solicitation as well as their relative importance. These evaluation criteria will be used to evaluate proposals and to provide information needed by the source selection authority for the selection decision. NASA typically uses three evaluation factors: mission suitability, cost/price, and past performance.

Mission Suitability Evaluation Factor

The “mission suitability” section in the solicitation states the criteria NASA will use to evaluate the offerors’ technical proposals. The solicitation should request very specific information correlating with each of the evaluation subfactors that are important to the specific acquisition. The solicitation should include a requirement for offerors to deliver a risk mitigation plan as a part of their proposal or identify risk areas inherent in the requirement and/or their proposals and should include their proposed approaches to minimize the impact of risks identified. PP&C may be involved in developing and defining the mission suitability subfactors and determining their relative importance. Some common mission suitability subfactors of potential interest to PP&C include management approach, corporate resources, representative task orders, risk management approach, and project management plan.

Cost/Price Evaluation Factor

The solicitation will provide detailed instruction on how offeror's cost information is to be presented in the offeror's proposals and will include electronic spreadsheet cost formats and describes how the cost or price analysis will be conducted. For fixed-price contracts, the solicitation should explain how proposed prices will be analyzed. For cost-reimbursable contracts, the solicitation should define how the cost evaluation will be conducted. At a minimum, a cost evaluation should produce findings that include the following:

- The costs or prices proposed by all offerors including a comparison with the Government in-house cost estimate;
- For cost-reimbursable acquisitions, the probable cost to the Government of each proposal including any recommended additions or reductions such as quantity and/or level of personnel, equipment, materials; and
- The differences noted in each proposal regarding business methods, operating procedures, and practices as they impact cost.

A determination that a proposal does not adequately demonstrate that the offeror will be able to perform the work with the resources proposed may indicate a mission suitability weakness. In such cases, an adjustment for probable cost may be required. This integration between mission suitability findings and probable cost adjustments is critical to accomplishing cost realism.

Past Performance Evaluation Factor

The solicitation describes how an offeror's past performance will be evaluated. Past performance reflects the accomplishment of work by an offeror that is comparable to or related to the work/effort being procured. The solicitation should specifically solicit from offerors relevant programs and/or projects of similar size, content scope, and complexity to those expected to be encountered in the work being procured and should include past performance in these types of areas: technical performance, cost performance, schedule, safety and health and environmental compliance, and contract management. The past performance evaluation assesses the contractor's performance under previously awarded contracts. The past performance evaluation is an assessment of the Government's level of confidence in the offeror's ability to perform the solicitation requirements.

3.6.3.2. Control Activities

3.6.3.2A Contract Management

FAR Part 42 Contract Administration and Audit Services outlines the policies and procedures for assigning and performing contract management; i.e., contract administration and contract audit services. FAR 42.302 outlines over 70 contract administration functions. The CO may delegate some of these functions to the Defense Contract Management Agency (DCMA) and may obtain contract audit support from the Defense Contract Audit Agency (DCAA) or a contractor (see NFS 1815.404-2). (Functions that may be delegated or obtained include negotiating forward pricing rate agreements; establishing final indirect cost rates and billing rates; compliance with cost accounting standards; adequacy determinations of contractor's disclosure statements, adequacy determinations of contractor's accounting systems.) The CO may retain many of the 70 functions outlined in the FAR as deemed appropriate. These functions include negotiating and definitizing contract modifications or supplemental agreements under the changes clause of the contract; reviewing, approving or disapproving contractor's request for payments; identifying contractor overrun or underruns of estimated costs under cost-reimbursement contracts; performing property administration (screening of Government property before allowing a contractor to purchase property, etc.); monitoring contractor industrial labor relations; ensuring compliance with safety requirements; ensuring compliance with Quality Assurance (QA) requirements; performing surveillance of the contractor's engineering systems and processes; approving subcontracts; accomplishing administrative closeout of a contract; etc. The prime contractor has the responsibility for administering any subcontracts. The PP&C team supports the CO in conducting some of these functions as described below.

The CO may designate other Government personnel to act as his/her representative for inspection, approval, and other administrative functions. The designation may be called the Contracting Officer's Representative (COR). The COR assists with technical requirements for contract administration and provides a liaison among the contracting office, the project office, and the contractor. Delegated responsibilities may include monitoring contract performance, establishing and providing the CO with a surveillance plan, performing surveillance as specified in the plan, assuring technical proficiency, ensuring contractor compliance with contract requirements, reviewing contractor invoices and recommending payment approval, recommending in writing to the CO any desired changes to scope or technical provisions, performing inspections for completed work, keeping the CO informed of any actual or perceived problems, and other duties delegated by the CO.

There are different examples for interaction between the project and the contractor. One example is where the COR is the prime point of contact for all technical systems, and the contractor's prime interface is also one person. All of the information, direction, and management of the contract flow through those two people. This is generally more effective with smaller, homogeneous contracts such as a single scientific sensor or instrument. Another example has a Government system manager assigned to each major system of the contract, and there is a lot of interaction between the Government system manager and the corresponding contractor system manager. In this case, the CO and COR still manage and direct the contract, but the Government system managers have plenty of interface with their counterparts. Strict rules on avoiding verbal direction must be understood by all parties. In both examples, PP&C supports the COR in monitoring contract performance, ensuring contractor compliance with contract requirements, reviewing contractor invoices and recommending payment approval, developing recommendations to the CO for any desired changes to scope, and keeping the CO informed of any actual or perceived problems.

Post Award Orientation

FAR 42.5 Postaward Orientation outlines the policies and procedures for post-award orientation of contractors through a conference or a letter or other form of written communication. Post-award orientation is helpful to both parties to ensure a clear and mutual understanding of the contractual requirements, and to identify any potential problems. Post-award orientations are encouraged for small business concerns, but the decision to have one is up to the CO. If a post-award orientation will be conducted, it should be done promptly following the contract award. This meeting is a good time to introduce the project's representatives and set the stage for good working relationships under the contract. The CO chairs the conference or designates a chairperson, and the PP&C team participates along with the COR, project manager, and cognizant technical representatives. PP&C discussions with contractor counterparts should include a review of business and financial reporting requirements and DRDs, monthly reviews, and when EVM is required, establishment of the PMB and the expectation for the initial IBR outlined in the contract.

Accept Contractor Deliverables

The Acquisition and Contract Management function reviews contractor deliverables when they are received to ensure that the deliverables are consistent and compliant with contract DRD requirements. If deliverables are deemed to be unacceptable, any issues need to be addressed through coordination with the CO and COR.

Evaluate Contractor Performance

At least annually, agencies are required to include evaluation of contractors' performance under a contract or order by using the Contractor Performance Assessment Reporting System (CPARS), a Governmentwide reporting tool. These evaluations include an assessment and rating of the contractor's performance in areas including technical, cost control, schedule/timeliness, business/management relations, and small business subcontracting.[37] Cost control is one evaluation factor in evaluating contractor's performance that is addressed in the annual past performance evaluations. Cost is also one factor in award fee evaluations, which are conducted periodically in accordance with the contract's specific Performance Evaluation Plan (PEP) on contractors in CPAF or FPAF contracts. Typically, these evaluations are conducted semi-annually or annually. The Acquisition and Contract Management Function coordinates with the Resource Management Function to evaluate the performance of the contractor's PP&C efforts noting both strengths and weaknesses. These reports are provided to the CO for integration and

[37] The use of CPARS is required for each contract and order that exceeds the simplified acquisition threshold. FAR 42.15 outlines the specific requirements and any exceptions.

used in the evaluation of overall contract performance and any associated award fees determined by the Fee Determination Official (FDO). PP&C personnel may be asked to be part of the Performance Evaluation Boards (PEBs). Per FAR 16.401, Government agencies are required to collect relevant data on award and incentive fees paid to contractors and measure the effectiveness of award fee incentives. The Award Fee Evaluation System (AFES) is NASA's software application that collects salient award fee data on all NASA award fee contracts. COs, with the assistance of the CORs, are required to input contractor performance data relative to award fee incentives into AFES for each award fee evaluation period (see NFS 1842.1503).

Throughout the contract, any significant variances in the contractor's performance with the approved plans are noted, documented, and reported to the CO and COR. This information is also used to determine the overall health of the project.

Support Contract Modifications

Only the CO may modify the contract terms or enter into or change a contractual commitment on behalf of the Government. Active coordination between technical, engineering, contracting, PP&C, field inspection, auditing, legal, and other personnel is necessary in the post-award period to administer the contract effectively and to protect Government rights and best interest.

Contract modifications may be necessary for changes within the general scope of the contract in accordance with the specific changes clause included in the contract. Changes in contract drawings, design or specification; method of shipment/packing; or place of inspection, delivery or acceptance may be acceptable depending upon the specific FAR changes clause in the contract. Requests for a contract modification may come from the contractor or the project. In addition, PP&C personnel may identify the need to request a contract modification. All proposed contract modifications should be coordinated with PP&C to assess the impact to cost and schedule. The Acquisition and Contract Management function ensures and coordinates these assessments that are conducted by the Resource Management and Scheduling functions. It can take considerable time and resources to modify contracts in response to project technical, schedule, and budget changes, so early and frequent communication with the project team is essential.

An Undefinitized Contract Action (UCA) is used to change the scope or terms of a contract for the Government's convenience, often to enable contract activities to continue while the more formal process of negotiating and updating the contract changes commences. Any desired contract changes and any scope changes must be carefully coordinated and endorsed by the CO as it puts the Government at risk, and any scope changes to a contract are generally not legal without proper CO approval. It is critical to seek guidance from the CO regarding discussion of scope changes before discussing changes with the contractor and reinforce this guidance to the CAMs and technical monitors who regularly engage the contractor.

Participate in Contract Termination (If Applicable)

Terminations fall into one of two categories: terminations for default and terminations for the convenience of the Government. Terminations for default are based on the contractor failing to fulfill its obligations. The need to terminate a contract is determined by project management. (See policies and procedures in FAR 49.5 on contract termination clauses and the termination clauses specifically included in the project's contract(s).)

A variety of situations can lead to a contractor being considered in default. Under a cost reimbursement-type contract, the contractor is entitled to all normally allowable and allocable costs incurred up to termination and, if fee was included in the contract, to a pro rata portion of the fee based on work accepted by the Government. Under fixed-price type contracts, the contractor is not reimbursed for work performed prior to the termination that has not yet been accepted by the Government, and the Government is entitled to repayment of any unliquidated advance or progress payments applicable to such work. PP&C supports determination of the amount of reimbursement to the contractor.

All terminations not made for default are by definition for the convenience of the Government. Terminations for convenience involve no wrongful acts on the part of the contractor. Accordingly, for terminations for convenience, the terms of the contract settlement are more favorable to the contractor.

Participate in Contract Closeout

Ideally, a contract runs its normal course without being terminated. The closeout of cost reimbursement-type contracts can take considerably longer than fixed-price type contracts since the Government usually conducts an audit of the contractor's records to ensure that all costs incurred in performance of the contract were allowable and allocable. This audit takes place after the settlement of all final annual indirect cost rates for all contract years, which can sometimes take several years after the contract's period of performance ends. The COR may be called upon to comment on the reasonableness of or the necessity for certain items of cost. Part of contract administration is the responsibility of administratively closing out the contract after receiving evidence of physical completion. FAR 4.804 outlines the requirements and procedures for closeout of contracts to include obtaining evidence of its physical completion, reviewing the contract funds status and notifying the CO of any excess funds that might need to be deobligated, settlement of direct and indirect costs to include indirect rates for the contract, obtaining property and plant clearance, obtaining contractors' final invoices, etc. PP&C may be involved in supporting the financial aspects of the closeout processes.

3.6.4. Function Activities by Life-Cycle Phase

Table 3.6-2 depicts Acquisition and Contract Management activities by life-cycle phase.

Table 3.6-2 Acquisition and Contract Management Activities by Life-Cycle Phase

Pre-Phase A	Phase A	Phase B	Phase C	Phase D	Phase E	Phase F
Develop Acquisition Plan		Update, if needed				
Support Establishment of Contracts*			Support Contract Management/Administration**			

*This activity may also occur in later life-cycle phases.
**This activity begins following contract award, which may occur in earlier life-cycle phases.

3.7. Risk Management Function

3.7.1. Function Overview

According to *NPR 8000.4 Agency Risk Management Procedural Requirements*:

> "Risk management is a set of activities aimed at achieving success by proactively risk-informing the selection of decision alternatives and then managing the implementation risks associated with the selected alternative…. risk management is defined in terms of Risk Informed Decision Making (RIDM) and Continuous Risk Management (CRM)."

The PP&C Risk Management function adds to NASA risk guidance and policy by describing the role of the PP&C team in executing the two risk management process cycles (RIDM and CRM). This function is performed in collaboration with the larger Risk Management team, which includes other disciplines within the project such as SE and SMA. (See the *NASA Risk Management Handbook (NASA/SP-2011-3422)* for more information about RIDM and CRM and how they interact.)

3.7.2. Integration with Other PP&C Functions, Inputs, and Outputs

The PP&C Risk Management function needs to effectively collaborate with other PP&C functions to develop analysis products and strategies that support development of an integrated, project-level executable plan during the planning phase, and maintain risk-intensive analyses, tracking, and reporting throughout the control phase. This function also interacts with entities external to PP&C to gather risk-related information and communicate results of analyses.

Figure 3.7-1 is a flow diagram for the PP&C Risk Management function that depicts major inputs and outputs received from and provided to other PP&C functions, as well as external entities. Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it. The flow diagram also summarizes key activities to consider during the planning and control phases when implementing this function**.** Section 3.7.3 discusses these key activities in detail, and provides insight into the importance of the interactions with other PP&C functions.

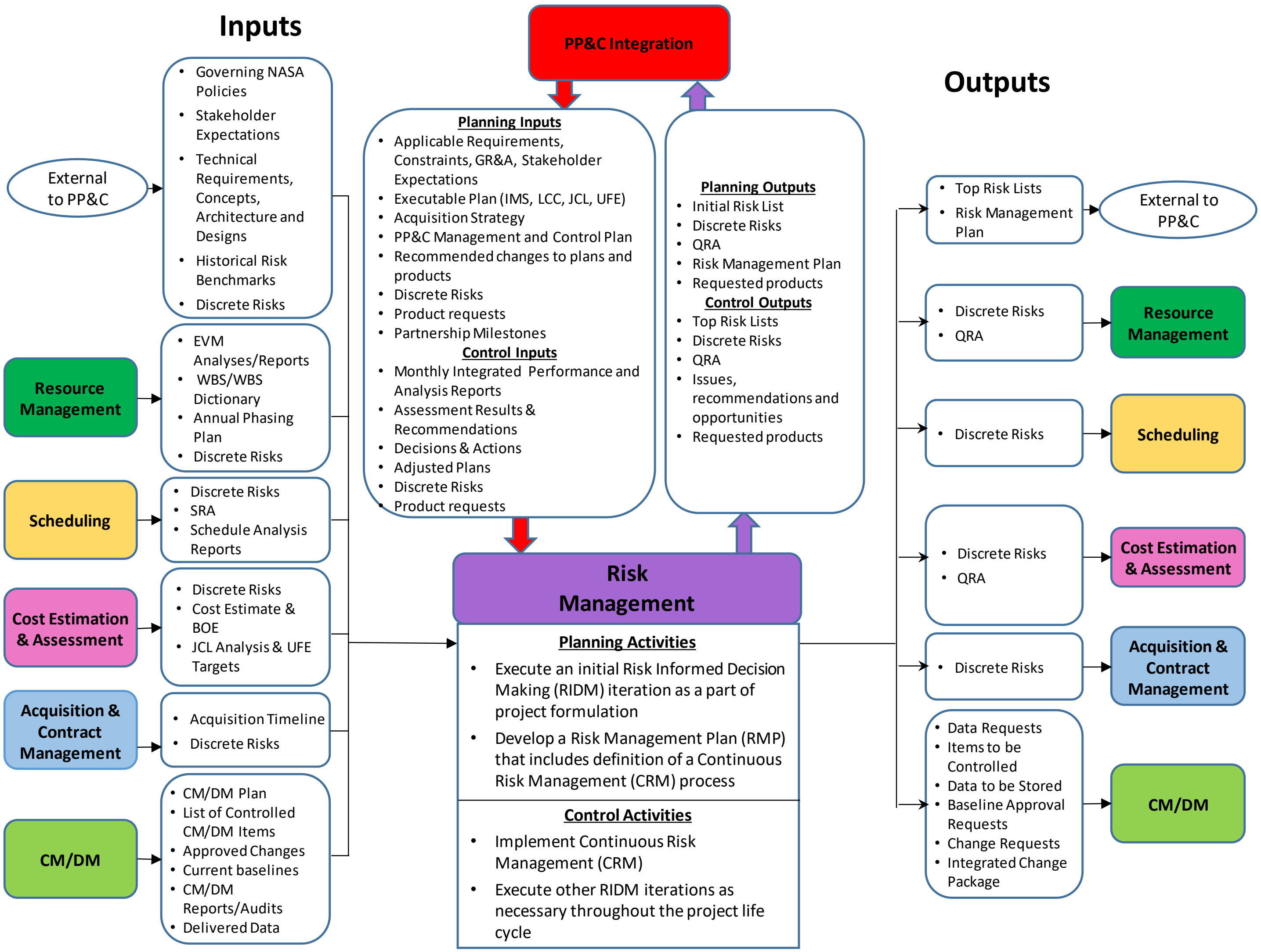


Figure 3.7-1 Typical Functional Flow Diagram for the Risk Management Function with Major Inputs and Outputs

Descriptive information is provided below for the inputs from external entities and for the outputs depicted in Figure 3.7-1. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. (In addition, the description for one input that is provided by all other PP&C functions to this function, "Discrete Risks," is provided below.) Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.7.3.

Descriptions of all inputs and outputs in can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F N-Squared Diagram of Inputs and Outputs.

3.7.2.1. Inputs

- **Governing NASA Policies:** Applicable Agency NPDs, NPRs, Center policies, lessons learned, and best practices including Agency handbooks. Applicable NPRs include *NPR 8000.4, Agency Risk Management Procedural Requirements*, and *NPR 7120.5, NASA Space Flight Program and Project Management Requirements*. Applicable Agency handbooks include *NASA/SP-2011-3422, NASA Risk Management Handbook*.

- **Stakeholder Expectations:** The needs and objectives of the customer (project manager, program, Mission Directorate, and Agency) and other key stakeholders including anticipated products or support expected from the PP&C Risk Management function. The stakeholders' expectations need to be documented, and it is important to ensure a common understanding of the expectations between the customer, other key stakeholders, and this function. As needed, the PP&C Risk Management function should educate stakeholders regarding past risk analyses, their nuances and caveats, and historical risk behavior in general.

- **Technical Requirements, Concepts, Architecture, and Designs:** PP&C practitioners translate these inputs into acquisition, cost, resources, and time-phasing requirements, which in turn provide the basis for the acquisition strategy, budget requests, the project schedule, and resource needs. The realism of the business approach and requirements is dependent on the interrelationship of the project management, technical, and business aspects of project planning. Salient risks associated with the potential inability of the designs and architecture to adhere to requirements and other programmatic constraints should be the centerpiece of continuing discussion.

- **Historical Risk Benchmarks:** The PP&C Risk Management function should equip itself with historical risk information against which it can benchmark a project's identified risks. Ideally, access should be gained to a risk knowledge base, either formal or semi-formal, from which normalized risk treatment guidance can be distilled and conclusions drawn. (A notional example: *Avionics hardware and software tend to have more identified risks than simple structural components of spacecraft*.) Among the useful dimensions of comparison are risks' cost consequence, schedule consequence, likelihood, and mitigations plans. The use of history as a benchmark provides context for risk management and risk-intensive analyses.

- **Discrete Risks:** Identified, documented potential events that each carry an estimated consequence and an associated likelihood (probability of occurrence). A discrete risk's information profile should contain the following characteristics:

    - **Risk Statement and Narrative Description**: According to the *NASA [Risk Management Handbook](#)*, each risk should contain the following:

        - **Risk Statement**: "A concise description of an individual risk that can be understood and acted upon. Risk statements have the following structure: 'Given that [CONDITION], there is a possibility of [DEPARTURE] adversely impacting [ASSET], which can result in [CONSEQUENCE].' "

        - **Narrative Description**: "Additional detail regarding the events, circumstances, and interrelationships within the activity that may affect the individual risk. This description is more detailed than can be captured in the risk statement."

    - **Risk Mitigation Plan**: As part of the initial risk identification, the risk owner may provide a plan for reducing the risk's consequences and likelihood to acceptable levels. This plan usually involves significant effort (e.g., cost, people, and time) outside the baseline project plan, although it may align with previously planned work in special cases.

    - **Cost and Schedule Consequences**: Among other types of consequences, these equate to the risk's impacts on the cost and schedule dimensions of a project's baseline plan. The severity of these impacts is usually expressed as scores calibrated to a project's risk matrix. In the ideal case, a risk owner, with potential involvement from the PP&C Risk Management, Cost Estimation/Cost Assessment, and Scheduling functions, should provide justified cost and schedule impact estimates (and their associated uncertainties[38]) in addition to the matrix scores. Note that a newly "accepted" risk's cost consequences should be incorporated into project cost estimates and budget plans; likewise, the accepted schedule consequences should augment the baseline IMS and related schedules.

    - **Probability of Occurrence**: The probability ($0\% < p < 100\%$) that the consequences associated with the risk will be realized given the current state of risk mitigation (or lack thereof). Ideally, a properly crafted and executed mitigation plan will reduce the probability of occurrence to levels acceptable to

[38] For discussion on the distinction between "risk" and "uncertainty," see Appendix I: Uncertainty versus Risk: Functional Definition from a Programmatic Analysis Perspective.

the project. The risk owner (or the Risk Management team itself) may choose to apply a degree of uncertainty to the probability of occurrence.

  - **Risk Response**: The preliminary or formal planned action associated with a risk. If the risk is already being addressed in some way before a formal response is adjudicated, the risk owner may provide a risk response to the Risk Management team for consideration. For example, if a risk's mitigation plan is already part of baseline work being executed, the risk owner may recommend "mitigate" as an appropriate initial response. Ideally, a risk response's status and related progress is tracked and reported on a regular basis.

- **Annual Phasing Plan:** A plan of obligations, costs, FTEs, WYEs, and ODCs for each fiscal year in the project's life cycle provided at the WBS level deemed appropriate by project management. The plan is typically broken out by month for the current fiscal year and actuals are reported against the plan on a monthly basis. Carry-in of prior year funds should be of special note and treatment in phasing due to expiration of those funds' obligation and costing authority. The Annual Phasing Plan should be compared to the cost phasing, which is part of the cost estimate and UFE target outputs of the Cost Estimation/Cost Assessment function. The alignment of UFE, as indicated in the cost phasing, should be aligned with budget availability as indicated in the Annual Phasing Plan. This alignment is integral to many types of UFE characterizations that result from select genres of risk analyses. In the Quantitative Risk Analysis (QRA) framework, for example, UFE amounts are compared to stochastically weighted risk totals to determine reserve adequacy.

- **Schedule Risk Assessment (SRA):** A SRA is a forecast resulting from the stochastic simulation of the IMS or an analysis schedule whose tasks are loaded with duration uncertainty and discrete schedule risks. SRA reports include but are not limited to resultant distributions that measure the variability in the project end date, top schedule risks in terms of impact on milestones and criticality, and other analyses such as sensitivities, correlation among tasks, and characterization of schedule reserve relative to schedule targets. (For additional detail, see Section 3.4.2.)

- **JCL Analysis:** According to NPR 7120.5, JCL is defined as a "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 Phase D." By being "risk-informed," the characteristic of having mapped all discrete risks and classes of uncertainty within scope to JCL model elements, the JCL intends to ensure that adequate budgets and schedules are reflected in the project's plan. Only a certain subset of projects requires a JCL. According to NPR 7120.5, at KDP C, projects with an estimated LCC greater than $250 million are required to develop a RLS and perform a "risk-informed" probabilistic analysis that produces a JCL.

- **UFE Targets:** 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 the scope of probabilistic risk and uncertainty. NASA policy closely ties project

UFE determination to JCL analysis. According to policy, Mission Directorates are required to plan projects based on a 70 percent JCL to ensure that funding (which is in no case less than the equivalent of a 50 percent JCL) for projects is consistent with the MA. It is prudent for projects not subject to the JCL requirement to nevertheless justify their desired levels of UFE to the Decision Authority at life-cycle milestones.

- **Executable Plan (IMS, LCC, JCL, UFE):** The executable plan captures the integrated set of technical, science, cost, schedule, resource, and facility requirements of the project in the WBS, schedule, resource baseline, and budget. The baseline IMS, LCC estimate, JCL, and UFE are key elements of the executable plan. These products are also part of the project's ABC. It is essential to understand the constraints of the executable plan to properly identify and assess risks to the plan.

- **Recommended Changes to Plans and Products:** Recommendations to this function for changes and/or adjustments to plans and products such as the RMP.

- **Monthly Integrated Performance and Analysis Reports:** Current integrated cost and schedule performance, trends and variances, and the project's risk posture; analyses of cost and schedule variances and trends; identification of data correlations and causal relationships, key drivers, and sensitivities; and status of UFE, liens, and threats.

- **Assessment Results & Recommendations:** Forecast of integrated cost and schedule performance and EAC based on current performance, work remaining, and likely impacts of remaining risk and issues. Identification of key issues and decisions that need to be made by project management. Recommendations for controlling project performance. It is essential to be fully aware of key project issues and proactively engaged in developing recommendations and understanding how issues and recommendations impact risk. (For additional detail on this subject, see Section 3.2.3.2.)

- **Decisions & Actions:** Options and/or corrective actions approved for implementation by the project manager, including associated decision packages. Plans for implementing, tracking, and reporting on the results of the options/corrective actions. It is essential to be fully aware of project decisions and actions and how they may impact risk. (For additional detail on this subject, see Section 3.2.3.2.)

- **Adjusted Plans:** Updates to the project's plans based on approved options/corrective actions. These may include updates to the baseline IMS, LCC, and EAC.

3.7.2.2. Outputs

- **Top Risk Lists:** Top risk lists are key among the various risk analysis products. In some sense, these call out drivers that are the greatest contributors to select dimensions of a project's performance risk including cost and schedule. These lists can be generated using several methods including SRA.

- **Risk Management Plan (RMP):** A project-level control document detailing how each risk management process step will be carried out in accordance with technical provisions and intra-project coordination guidelines. An RMP includes but is not limited to the following elements:[39]
    - Identification and analysis of stakeholders (e.g., Agency management, project management, Mission Directorate personnel, SRBs, etc.) as well as a detailed characterization of risk information needs.
    - Identification of risk-intensive analyses to be performed during each CRM cycle.
    - Development of a Risk Management System (RMS) that adheres to the CRM process.
    - Establishment of risk tolerance criteria, thresholds, and elevation protocols (the specific conditions under which a risk management decision must be elevated through management to the next higher level).
    - Delineation of the processes for coordination of risk management activities and sharing of risk information with other affected organizational units.
    - Establishment of risk communication protocols between management levels including the frequency and content of reporting as well as identification of entities that will receive risk tracking data from the unit's risk management activity.

  The Risk Management team develops the RMP with support from the PP&C Risk Management function. A preliminary RMP is developed before the first RIDM iteration is executed to help guide the project's nascent risk evaluation process. The RMP is provided to PP&C Integration for review and comment prior to approval.

- **Discrete Risks:** The Risk Management team supported by the PP&C Risk Management function frames the body of risks for project management decision making and programmatic analyses. Each risk has the following characteristics, many of which may have been authored, examined, or modified by the Risk Management team after receipt from risk owners as inputs (see Section 3.7.2.1) through the RMS:
    - **Risk Statement and Narrative Description**: These passages may be updated by the Risk Management team in the interest of clarity, technical accuracy, messaging salience, brevity, or some other justifiable end.
    - **Risk Mitigation Plan**: The official mitigation plan including the necessary resource and time allocations by project management may augment or replace that which may have been originally provided by the risk owner. Schedulers, resource

[39] See the *NASA Risk Management Handbook* for more information on RMP elements.

managers, and cost estimators should include the scope of project-approved mitigation efforts into their analysis products.

   - **Cost and Schedule Consequences**: Scoring provided by risk owners may be updated by the Risk Management team in consultation with the Scheduling and Cost Estimation/Cost Assessment functions as a result of the risk analysis and review process wherein benchmarking, subject matter consultation, or other insight-driven techniques could illuminate the most appropriate score values. The detailed cost and schedule consequence estimates should be incorporated into probabilistic frameworks maintained by several PP&C functions.

   - **Probability of Occurrence**: This may also be updated and used as above.

   - **Risk Response**: The Risk Management team will officially adjudicate the appropriate response and/or control action for each risk.

- **QRA:** Quantitative Risk Analysis (QRA) is a risk-intensive method for probabilistically summarizing risks for use in UFE assessment, resource management, cost estimating, and other PP&C-related activities. (See Section 3.7.3.1B for more information.)

- **Initial Risk List:** The initial risk list is based on the RIDM risk analysis and likely to contain only the major, top-level, and initially evident risks; it may therefore be incomplete, especially with respect to the non-discriminator performance measures. As soon as feasible, the CRM process will need to complete the RIDM risk analysis for the non-discriminator performance measures as well as expand and update the initial risk list to include any new risks from the completed risk analysis. The risks on the initial risk list need to be accounted for in the PP&C analyses including integrated cost and schedule estimates that characterize the executable plan.

- **Issues, Recommendations and Opportunities:** Issues include project and external events and situations that may affect the project's cost and schedule performance. For example, analyses of trends can indicate whether risks are being retired as planned or if threats are increasing. Depending on the life-cycle phase of the project, one might expect new discrete risks to be identified during RIDM, but when the portfolio of risk increases after implementation, these observations are important to report. Recommendations include proposed approaches for addressing identified issues, and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance. (For additional detail and examples, see Section 3.2.2.)

3.7.3. Function Planning and Control Activities and Tasks

The PP&C Risk Management function's planning and control activities and tasks are outlined in Table 3.7-1 Risk Management Activities and Tasks. The activities and associated tasks are described in more detail below the table.

This section is based upon the Agency's existing risk management policy and guidance (NPR 8000.4 and the *NASA* Risk Management Handbook) but avoids repetition of its content herein; rather, this section echoes various documented best practices while highlighting the PP&C Risk Management function's treatment and usage of risks to gain programmatic insight. This section follows the five cyclical risk management functions (identify, analyze, plan, track, and control) with a focus on the PP&C role.

The following elements reflect NASA best practice but are not intended to be rigidly prescriptive. Depending on the size, structure, nature of its mission, and other defining characteristics, a project may find that scaling its risk management approach may be appropriate. However, this caveat in not intended as a license to minimize the importance of solid risk management. (See the *NASA* Risk Management Handbook for more information.)

Table 3.7-1 Risk Management Activities and Tasks

<table>
<tr><th colspan="2">Risk Management</th></tr>
<tr><th>Planning Activities and Tasks</th><th>Control Activity and Tasks</th></tr>
<tr><td>Activity: Execute an initial Risk Informed Decision Making (RIDM) iteration as a part of project Formulation
• Interrogate the risk characterization of each decision alternative as it is created
• Identify an initial risk list for each decision alternative
• Conduct initial risk analyses for each decision alternative and benchmark identified risks against historical data (i.e., perform a sanity check and calibration)
• Support comparison of decision alternatives' performance measures and capture risk information for CRM
Activity: Facilitate the development of a Risk Management Plan (RMP) that includes a definition of a Continuous Risk Management (CRM) process
• Analyze stakeholders' risk information needs
• Identify risk-intensive analyses to be performed during each CRM cycle
• Develop a RMS that adheres to the CRM process</td><td>Activity: Implement Continuous Risk Management (CRM)
• Initialize the RMS and populate it with risks.
• Perform risk-intensive analyses (any analysis that requires risk as an input), update project risk posture, and provide analyses to the CRM planning activity.
• Track risk trend information over time, capturing the "story" of each risk as it evolves.
• Provide continuous support throughout and beyond the risk control stage of CRM
Activity: Execute other RIDM iterations as necessary throughout the project life cycle
• Perform other RIDM iterations as needed, feeding information back to the existing CRM system (triggers include over budget and catastrophic events)</td></tr>
</table>

3.7.3.1. Planning Activities

3.7.3.1A Execute an Initial RIDM Iteration as a Part of Project Formulation

As a new project of any size and scope proceeds through the Formulation (pre-PDR) stage of development outlined in Chapter 2 of NPR 7120.5, it must identify high-level project objectives and, accordingly from among a set of alternatives, choose an initial design architecture that best meets those objectives before proceeding to more detailed design stages. (Both NPR 7120.5 and the *NASA Systems Engineering (SE) Handbook)* discuss this process comprehensively.)

A key part of this planning phase (and others throughout the project life cycle) is a subprocess called RIDM, which uses risk information to help decide among major design alternatives. The project's PP&C functions are essential in ensuring that cost, budgetary, schedule, and other non-technical domains are represented earnestly and comprehensively during the initial RIDM cycle.

Prior to formal risk identification, the PP&C Risk Management function, in collaboration with the Risk Management team and the project's technical organization, plays a key role in the initial RIDM iteration by first capturing the most basic information about risks as project technical leads begin to craft various system scenarios. In large part, a decision alternative's essence is comprised of its risk characterization, which will begin to reveal itself during seminal development discussions. At this juncture, it is likely that the risks will not yet be fully identified; the project team will identify risks during the risk analysis stage. The PP&C Risk Management function should be granted full license to provide historically-informed consultation that addresses risk characteristics such as cost and schedule consequences. It is therefore the role of the PP&C Risk Management function to assist in risk discovery as soon in the RIDM process as possible to support risk formalization. It is essential to work with the Cost Estimation/Cost Assessment function, the Scheduling function, and the technical organization to capture the risk descriptions and general risk information as each issue is uncovered by interviewing SMEs or otherwise synthesizing primary sources of information including study results, technical documents, technical meetings notes, and other data. The information gathered by the collective PP&C functions should be continuously and openly shared with the technical investigators as they determine the preliminary risk list for each alternative.

Before mathematical treatment is applied to any risk item in eventual support of comparison among design alternatives, the analyst should gain *profound* familiarity with each alternative's risk list (formal or informal) and the nuances contained therein. (See the *NASA Risk Management Handbook* for information on risk attributes.) If possible, the PP&C Risk Management function should work to understand the preliminary values of performance measures, the quantifiable metrics associated with the fulfillment of project-chosen performance objectives. (Examples relevant to PP&C are performance measures such as "total cost" or "project duration" that correspond to the performance objectives "meet budget target" and "meet plan schedule," respectively. Additionally, an uncertainty-adjusted cost performance measure known as the "confidence level" is associated with the "meet budget target" objective. For more information on performance measures, see the *NASA Risk Management Handbook* and the *NASA Cost Estimating Handbook (CEH)*.) The analyst should not, however, assign formal values (and accompanying stochastic attributes such as distributions associated with cost and schedule impacts) to the performance measures of preliminary risks until the project's technical authorities have fully defined the decision alternative spectrum.

Once project management has identified performance objectives and formally defined each decision alternative and its preliminary risk list, the analysis stage of RIDM is ready to begin. Risk analysis includes the process by which risks (defined at the macro level or potentially more specifically) and their accompanying performance measures are discretely defined through interrogation of each decision alternative's ability to meet performance objectives such as cost and schedule targets. (The *NASA* *Risk Management Handbook* refers to this as "risk analysis of alternatives.") In parallel with the risk identification work performed by their technical counterparts, the PP&C Risk Management function, having secured project management endorsement to do so, should be diligent in influencing the risks as they are authored, benchmarking risks relative to similar projects, and focusing on PP&C domains (e.g., cost, schedule, workforce, budgets, etc.). In working closely with technical counterparts to understand risk parameters such as likelihoods and consequences, PP&C functions supplement technical risk exploration and add value by bringing their own expertise (along with a traceable dataset) to risk discovery discussions. It is important that all parties understand that no risk is ever purely technical or purely unique; most risks of any type have happened before in analogous projects and are therefore subject to forensic analysis that can be used in benchmarking current risks against history.

In preparation for deliberation and determination of a single alternative as the new design architecture, the project can choose whether to "score" each decision alternative with respect to performance objectives as a synthesis of all qualitatively defined risks or to parse out all risks separately by carefully assigning performance measures to each and rolling them up to a top-level performance rubric. (An example scoring method is summing the probability of all cost cases below or equal to a given target cost value. The resulting cumulative probability would be, or would be translated into, a cost score for a decision alternative.) It is at the discretion of project management how risks should be evaluated and synthesized; however, if the project is relatively mature and risks are better defined, each performance objective can be more easily and justifiably assigned a performance measure through a variety of popular methods at project management's disposal including QRA, JCL or one-dimensional Confidence Level (CL) modeling, analogy-based risk assessment, some combination of these, or another of the many related analyses. (QRA is discussed later in this section.) Other technical risk analyses such as Probabilistic Risk Analysis (PRA) are likely to be performed concurrently and will also drive performance measures.

After each alternative is analyzed, with a score or some other data assigned to each performance objective, the process of deliberation over the decision alternatives commences. Depending on the project, one of various methods and levels of rigor will be pursued. (Again, several of these are referenced in the *NASA* *Risk Management Handbook*.) As an example, once all the alternatives' performance measures have been quantitatively or qualitatively characterized, they could be compared side-by-side. For small projects, project management may choose an alternative using a minimally rigorous comparison method, which can be used to craft a "selection statement" capturing the decision's justification. A much different case would involve the technical team "normalizing" the performance measures (that is, preparing them for a precise, "apples-to-apples" synthesis) as well as, potentially, some of the details associated with key underlying risks. In this case, project management may even execute a method for creating an overall normalized score for each alternative, such as an overall probability of meeting every performance objective. (For more information, see the *NASA Risk Management Handbook* for a rough approach.) Regardless, a method of some rigor will be used to evaluate and justify the alternative ultimately selected.

With a single alternative selected, the decision team should coalesce on a final risk list and ready it for CRM process planning. The PP&C Risk Management function, in concert with other PP&C functions and the project's technical organization, should identify which risk data characteristics from the selected alternative's list are the most important to project management and which it advises should be the most useful for the project to track as it moves forward. Ideally, these characteristics, such as probability of occurrence and discipline-specific scoring (e.g., cost, schedule, safety metrics), will have driven the winning alternative's performance measures. In an effort to seamlessly pass risk insight to the project's risk managers, these dimensions of data should be crisply captured and communicated as soon as the alternative selection has been made.

3.7.3.1B Facilitate the Development of a Risk Management Plan (RMP) That Includes a Definition of a Continuous Risk Management (CRM) Process

The risk management process described heretofore has exposed most of the elements that constitute a CRM process. The project's performance objectives should be at least somewhat well understood as a result of down-select activities, and the risks that were identified and studied should be ready for tracking and subjected to a more sophisticated analysis on a continuing basis. In preparation for CRM, either concurrent with or directly after the initial RIDM process (or whatever related process was used to determine the initial project design architecture), the project should create a RMP that includes elements of interest to PP&C. (See Section 3.7.2.2 for a list of key elements.)

A fledgling project's nascent PP&C Risk Management function should be particularly interested in stakeholder expectations since the project's "risk posture" (the risk exposure picture used to manage and communicate issues) is a common area of interest both internally and externally. In effect, stakeholder expectations are the prescription for the types of risk information that should be identified, tracked, and analyzed on a continuous basis throughout a project's life cycle as part of the CRM process. (This information set should agree, to a large extent, with the results of the initial RIDM iteration.) Several iterations with stakeholders may be necessary to understand the right package of analyses and the cadence of updates.

Stakeholder expectations, determined preferably with an eye on Agency policy dictates, should very clearly identify the nature of risk analyses to be executed during each CRM cycle and the role of the PP&C Risk Management function in facilitating each analytical iteration. Among other areas, risk results will address the nature of a project's UFE posture, a programmatic health indicator very closely related to risk posture. (Typical CRM analyses used to size project UFE include QRA, SRA, and JCL, and others. QRA is generally described below. SRA is generally described in Section 3.4.3.1. JCL is described in Section 3.5.3.1.) The PP&C Risk Management function should consult with each stakeholder regarding the set of analyses that will be delivered and how each element will illuminate the project's risk posture, UFE posture, or other programmatic hallmarks. Part of these discussions should be devoted to education about the types of analysis systems available, the nuances of calculations and modeling, and how the results should be properly interpreted. Documentation of these agreements with stakeholders, including specification of selected analyses and guidelines for interpretation of results, is advisably included in the RMP[40].

Quantitative Risk Analysis (QRA)

QRA is a risk analysis method often used to discretely compare project UFE against a set of cost risks weighted stochastically by probability of occurrence. It often (but not necessarily) entails Monte Carlo simulation wherein each cost risk's consequence distribution is sampled and multiplied by another sample (a value of either '1' or '0') from a Bernoulli[41] distribution whose sole parameter p takes the value of the risk's probability of occurrence. The risks' resulting distributions' expected values (or any other standardized values from the distributions) are combined, giving an overall QRA value in dollars. In this way, the effects of improbable but highly consequential risks are appropriately scaled down.

Figure 3.7-2 is a notional result from a QRA run. Here, "Projected UFE" is outstripped almost every year by both the simple sum of cost risks ("Total Risks") and their weighted linear combination ("QRA"). QRA can not only produce this type of UFE comparison but also a top risk list in which high probability risks with large cost consequences achieve a high ranking.

---

[40] Stakeholder-selected analyses apply to all risks unless otherwise specified for special risk cases.

[41] The Bernoulli distribution is a discrete distribution having two possible outcomes labelled by $n = 0$ and $n = 1$ in which $n = 1$ ("success") occurs with probability p and $n = 0$ ("failure") occurs with probability $q = 1 - p$, where $0 < p < 1$. (Wolfram MathWorld).

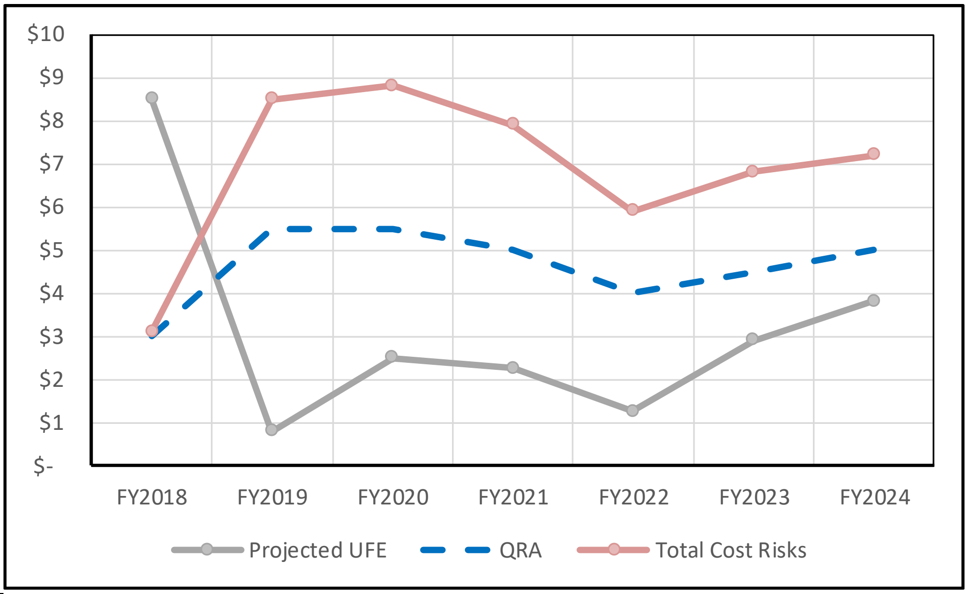


Figure 3.7-2 QRA versus UFE over Time

Selecting Risk Analyses

Some stakeholders such as Agency management will look to NASA policy as a guide for which analyses will be performed and the SE processes that trigger them. NPR 7120.5 contains many of these requirements that tie prescribed risk-intensive analyses like range estimating (risk-informed cost and risk-informed schedule confidence levels) and JCL analysis to a project's KDP milestones. These less frequent analyses are not necessarily involved in the CRM process but should relate closely to its products. For example, cost estimates can be updated during each CRM cycle and can significantly inform the LCCs provided at KDPs. The PP&C Risk Management function should seek guidance and awareness from project management regarding the requirements of semi-regular analytical activities outside the CRM process and work with the Cost Estimating/Cost Assessment function and the Scheduling function to ensure that an integrated approach is taken when performing these types of analyses.

Risk Management System (RMS)

After the CRM risk analyses are identified, the requirements of the project in capturing and tracking risk information will have become apparent and should in large part dictate the nature of the RMS, the infrastructure backbone and data warehouse of the CRM process. Among other aspects, ensuring that the risks are appropriately and completely characterized and that the risk information is current and accurate (i.e., risk quality is an extraordinarily important and often severely underutilized function of an RMS). The PP&C Risk Management function can provide initial assistance with RMS quality control as a natural consequence of preparing for certain risk analyses such as QRA and JCL whose integrity and value is highly dependent on complete, current, and "healthy" risk data. It is incumbent upon the PP&C Risk Management function, again using historical benchmarks and logical reasoning, to provide guidance to risk managers and owners about how they can ensure the accuracy, precision, and realism of risk information housed in an RMS before it is initialized. In fact, since this quality assurance role is so important, it is recommended that project management grant the PP&C functions, including the Risk Management function, a presence at risk working groups, risk reviews, and other critical risk discussions. The roles and responsibilities of the PP&C Risk Management function and other PP&C functions should be explicit in the RMP.

3.7.3.2. Control Activities

3.7.3.2A Implement Continuous Risk Management (CRM)

The approval of the RMP by project management signals the advent of the first CRM cycle in tandem with the launch of the RMS. The RMP, which contains the essence of the CRM strategy, will dictate the risk ownership hierarchy, cadence of lower-level risk discussions, RMS access and update privileges for various project personnel, and a list of project events that constitute triggers for major risk reviews. The initialization of the RMS should compel the PP&C Risk Management function to maintain risk consultation privileges (such as continuing input into managing risk quality and “sanity check” benchmarking, both of which are enabled by appropriate access to project risks as they are formally prepared and entered into the system). This initial risk identification and data entry pass should involve assessment of the quality and appropriateness of risks for incorporation into various stakeholder reporting products that will result from the suite of analyses dictated by the RMP. Quality control is incumbent upon all those who touch or own a risk, but the PP&C Risk Management function is in a special position to provide feedback at this critical juncture.

From this point forward, the RMS will serve as the authoritative repository for risk data. That is, any additional risks’ data not housed within the RMS, as well as any unidentified risks, should not be included within RMP-sanctioned analyses and decision making until officially integrated within the system. Otherwise, a common understanding of a vetted risk list will not exist and may lead to stakeholder confusion and conflict. It is important for the PP&C Risk Management function and other PP&C functions who together have tracked each risk from its inception to inform project authorities of major project issues that are not in the risk system and include them in risk-intensive analyses where appropriate.

As the project passes through certain CRM gates (as dictated by the RMP), or there is an extraordinary external action, the PP&C Risk Management function will be called upon to perform select analyses from the suite of RMP-sanctioned elements, which may likely require use of methods such as SRA and QRA. It is important to first negotiate expectations with the identified stakeholders by communicating an assessment of risk data quality, overall compatibility of RMS data with selected analyses, and related information necessary to properly couch the fidelity of the analytical results. After a common understanding is achieved *and documented*, the analysis cycle can begin in earnest with the PP&C Risk Management function maintaining regular communication with risk managers, risk owners, stakeholders, and all PP&C functions along the way. Risk analysis should not be performed without some degree of interaction with the appropriate PP&C functions (such as Cost Estimation/Cost Assessment, Scheduling, and Resource Management).

Ideally, the result of an analysis cycle is a bundle of information (e.g., presentations, spreadsheets, or graphics) that clearly captures the particular risk-related insight (such as the project's risk posture determined by synthesizing risk, cost, schedule, and other relevant programmatic information) requested by the project management team to support its adjudication of risk responses (also known as the "Plan" stage of the CRM). (Several examples of risk responses such as Accept, Mitigate, Watch, and Close are offered in the *NASA Risk Management Handbook*.) A results package that is not well organized and does not "tell the story" in an effective way will likely lead to stakeholder misunderstanding, frustration, and issuance of new analytical directives that will extend the overall CRM cycle. In other words, analytical results of any type that are poorly presented and documented confound rather than aid the dissemination of risk-related information.

An example of a meaningful risk analysis that has resonated with many NASA project managers is the production of a "top risk list" that clearly identifies, in some sense, the top issues of which the project and external stakeholders should be aware. QRA, JCL, SRA, and a more traditional cost risk comparison to available UFE are examples of analyses that produce, among other information, various subsets and ordering of top risks. The spirit of such a list is the intent to call out a project's "big issues" that should be addressed and tracked over time.

Tracking risk information, an inexact science to be sure, is critical in gaining previously unseen insight into how risks "live" over time and what their ultimate impacts will be. For example, a top risk with maximum schedule and cost consequence scores could reveal itself over time to be a less severe issue than originally thought, or it could manifest itself as more significant, spawning related risks and creating larger issues over time. The lives of risks can be complex; the PP&C Risk Management function should get as close as possible to each top risk, thereby enabling effective tracking, enhanced holistic insight, and comprehensive chronicling of a risk's response progression.

The PP&C Risk Management function is instrumental in tracking each top risk over time, with special care taken to capture its mitigation progress for risk management utility as well as any analysis being performed. Aided by historical benchmarking methods and standards of logic, this function should act as a check on CRM by tracking risk mitigation trends (and related information) and ensuring that they constitute a key aspect of its continued messaging to project management and other stakeholders. As a best practice, projects should maintain a threats and liens list. Trending this list's estimated consequence values and likelihoods can indicate whether the project is making progress in reducing its risks over time. In fact, trending should also figure into risk analysis in some substantive way if feasible; many analytical constructs are designed to incorporate this type of data explicitly.

The PP&C Risk Management function, supported by other PP&C functions, should continue its proactive role as it executes the control stage of the CRM cycle. Since risk tracking drives the context and justification for risk control actions, it is vital that this function continue its vigilance in monitoring the repercussions of risk response plans that are diverging from their original intent and remain diligent as a project prepares and initiates a successor cycle. In some NASA projects, the PP&C Risk Management function and other PP&C functions have become so important to risk management activities over successive CRM cycles that they have developed into top-level crafters of the overall story of project health as framed by risk posture. In this way, PP&C-centric risk analysis has established itself as an indispensable project management tool throughout the life of a project from infancy to mission end.

3.7.3.2B Execute Other RIDM Iterations as Necessary throughout the Project Life Cycle

The project may find that a content change is required that will affect the project's scope, necessitating another RIDM cycle to be executed. This would largely resemble the initial RIDM pass with one key exception: the CRM process already exists and can fuel the formulation of alternatives to be considered. These alternatives may be very large "game-changers" for the project or may be smaller trades in architectural elements or subelements. In any case, the CRM process would supply the initial information to the RIDM process, which, upon alternative selection, would be fed back into the CRM. Along the way, the PP&C Risk Management function would assist in simultaneous performance of RIDM and CRM activities and facilitate information exchange if appropriate.

3.7.4. Function Activities by Life-Cycle Phase

Table 3.7-2 depicts Risk Management activities by life-cycle phase.

Table 3.7-2 Risk Management Activities by Life-Cycle Phase

<table>
<tr><th>Pre-Phase A</th><th>Phase A</th><th>Phase B</th><th>Phase C</th><th>Phase D</th><th>Phase E</th><th>Phase F</th></tr>
<tr><td colspan="3">Identify Initial Risk</td><td colspan="4">Identify Risks</td></tr>
<tr><td colspan="2">Develop Risk Management Plan</td><td colspan="5"></td></tr>
<tr><td colspan="7">Evaluate Cost and Schedule Impacts</td></tr>
<tr><td colspan="2">Initial RIDM Iteration[42]</td><td colspan="5">Execute RIDM</td></tr>
<tr><td colspan="2"></td><td colspan="5">Execute CRM</td></tr>
<tr><td colspan="7">Develop Mitigation Plans (Implement as needed)</td></tr>
<tr><td colspan="7">Track/Trend Risks</td></tr>
</table>

[42] This initial RIDM pass may be completed far in advance of PDR.

3.8. Configuration and Data Management Function

3.8.1. Function Overview

The Configuration Management and Data Management (CM/DM) function is responsible for providing control of documentation, data, and technical characteristics of both configuration and non-configuration products for the project. The CM/DM function as applied to programmatic work products is responsible for providing visibility into and controlling changes to performance, functionality, and physical characteristics and requirements.

- CM ensures that the configuration baselines and control of the associated configuration information (associated data items, hardware, and software information etc.) are identified, accounted for in the project information architecture, and available and accessible, and that any proposed changes to baseline information are evaluated and dispositioned appropriately.

- DM provides for the control of data and information that is not identified as part of a configuration baseline. The DM function provides for the control and release of data and information and is implemented in order to acquire, access, control, protect, and use project data that is generated throughout the life cycle of a project.

Who performs the detailed activities of CM or DM or who chairs the CCB may vary between projects; the responsibility could reside with the PP&C organizations or the technical organization, it could be contracted out to an independent group, or it could be a combination of the above. Regardless of who executes CM or DM, the PP&C practitioner plays a vital role. The practitioner ensures CM/DM processes are in place and are correctly implemented including processes to capture and evaluate impacts of any requested changes. Impacts to requested changes include the assessment of integration of the change and whether the change is in scope.

The information provided in this handbook is an overview. Detailed guidance on CM can be found in the following handbooks and the CM standards endorsed by the NASA Technical Standards Program:

- Society of Automotive Engineers (SAE) American National Standards Institute (ANSI)/ Electronic Industries Alliance (EIA), ANSI/EIA-649B Configuration Management Standard, 2011.
- SAE EIA 649-2-2016 (or current revision) Configuration Management Requirements for NASA Enterprises
- Government Electronics Information Technology Association (GEIA), GEIA-HB-649 Configuration Management Standard Implementation Guide, 2005.
- International Organization for Standardization (ISO), ISO 10007:2014 Quality Management Systems—Guidelines for Configuration Management (CM)

The details of CM and DM of technical products (hardware/software, scientific data) are also described in *NPR 7123.1* Sections C.3.5 and C.3.6, respectively.

This section summarizes the overall CM/DM function at a high level for context but primarily focuses on the role of the PP&C practitioner in these activities. In case of discrepancies between this section and the above NASA-endorsed CM standards, the CM standards take precedence.

3.8.2. Integration with Other PP&C Functions, Inputs, and Outputs

The CM/DM function needs to effectively interact with the other PP&C functions to maintain control of PP&C and project-controlled products, to manage data provided by the other PP&C functions, and to coordinate and manage the change process. Interaction with entities external to PP&C is also needed to obtain and communicate key project information.

Figure 3.8-1 is a flow diagram for the CM/DM function that depicts major inputs and outputs received from and provided to other PP&C functions as well as external entities**.** Any given product may be both an input and an output depending on whether you are looking at the diagram for the function that is generating the product or receiving it. The flow diagram also summarizes key activities to consider during the planning and control phases when implementing this function**.** Section 3.8.3 discusses these key activities in detail and provides insight into the importance of the interactions with other PP&C functions.

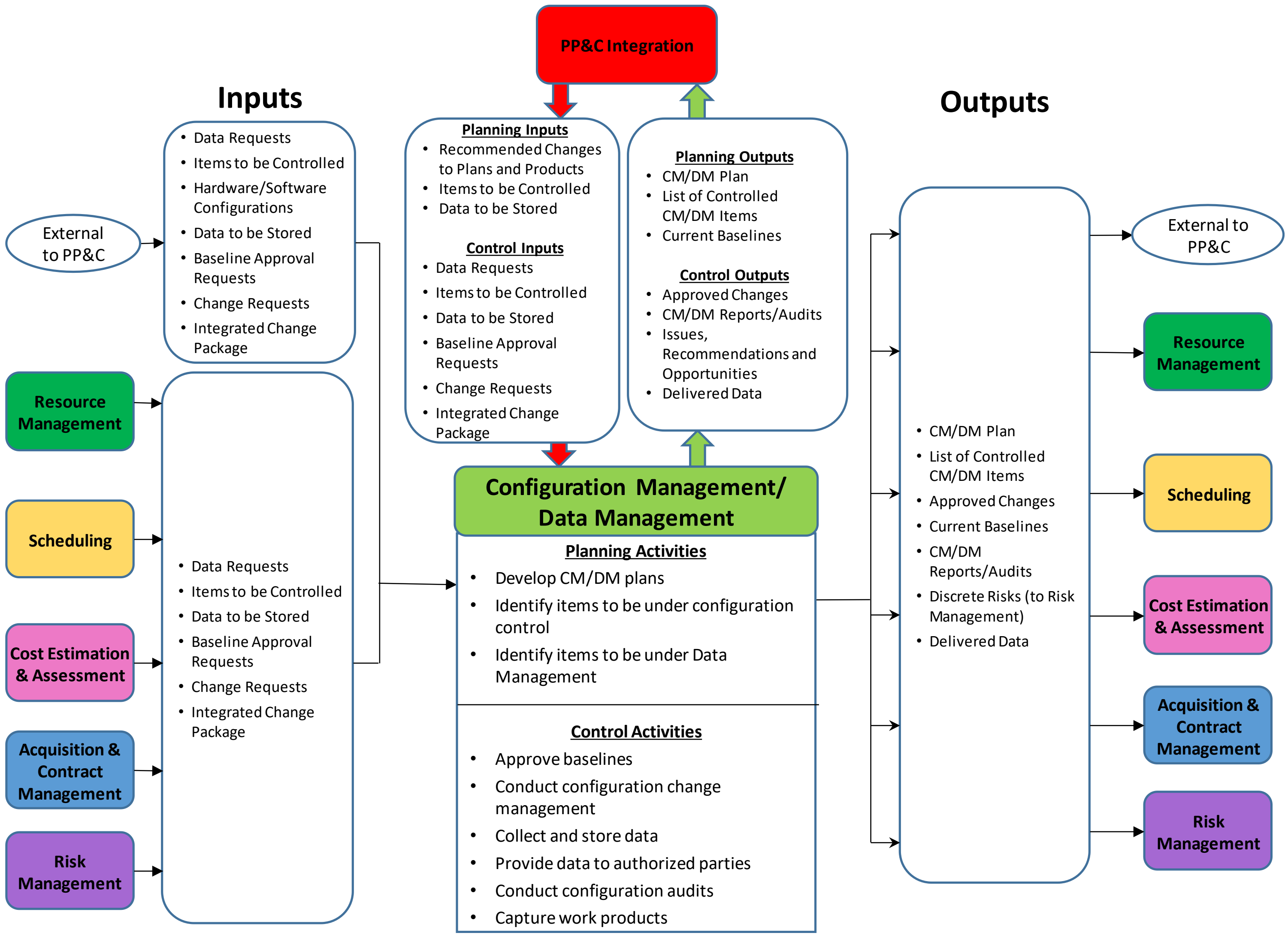


Figure 3.8-1 Typical Functional Flow Diagram for the Configuration and Data Management Function with Major Inputs and Outputs

Descriptive information is provided below for the inputs from external entities, and for the outputs depicted in Figure 3.8-1. Descriptive information for inputs from other PP&C functions can be found in the originating functions' sections (see Outputs) and in Appendix E: Description of Function Inputs and Outputs. (In addition, the description for one input that is provided by all other PP&C functions to CM/DM, "Integrated Change Package," is provided below.) Unique information on how this function uses inputs from other PP&C functions is also provided below and/or in Section 3.8.3.

Descriptions of all inputs and outputs in can be found in Appendix E. In addition, a consolidated "N by N" format visually depicting the interrelationships of inputs and outputs between the PP&C functions is provided in Appendix F: N-Squared Diagram of Inputs and Outputs.

3.8.2.1. Inputs

- **Data Requests**: Requests to the CM/DM function for any of the PP&C or other data under data control.

- **Items to be Controlled**: Programmatic information that needs to be placed under change control. This information may include cost baselines, the baseline IMS, Control Account Plans (CAPs), phasing plans, contract deliverables, cost trade-off analysis, and other risk and procurement documents identified and needing to be baselined.

- **Hardware/Software Configurations**: The current and historical composition of the hardware and software including software version number and operating system, hardware serial numbers, changes that have been incorporated since the last version, and other documentation as needed to fully describe the item under configuration control.

- **Data to be Stored**: PP&C and other project data identified as needing to be stored at any time during the life cycle.

- **Baseline Approval Requests:** Requests to place an item under baseline control.

- **Change Requests**: A request submitted to the CM/DM function to approve an initial release or a change to an item under configuration control.

- **Integrated Change Package**: Evaluation of a requested change to an item under change control. Package includes a description of the change; project organizations that evaluated the change; impacts of the change on other project products, activities, and documentation; and impacts to the project's cost, schedule, and risk. The package is reviewed for approval or disapproval by the appropriate project control board or decision maker.

- **Recommended Changes to Plans and Products**: Recommendations to the CM/DM function for changes and/or adjustments to the CM/DM plans and products.

3.8.2.2. Outputs

- **CM/DM Plan**: The CM/DM plan may be two separate documents, combined into one, or the information may be incorporated into other project documents such as the Project Plan, Systems Engineering Management Plan (SEMP), or other documentation as appropriate. In general, the plan(s) includes descriptions of how items to be controlled are identified, how changes to baselines will be processed, if control boards are to be used and associated roles and responsibilities, how baseline data will be accounted for, how access to the information will be authorized, and the frequency and manner in which configuration audits will be conducted. (The CM/DM plan is provided to PP&C Integration for review and comment prior to approval.)

- **Approved Changes:** Once the control board or other governing authority has made the decision to approve the requested changes, they are authorized, released to the community, and the requested changes are implemented for the associated baselines and items.

- **List of Controlled CM/DM Items:** A list of the products that will be under either CM or DM (also known as the Configuration Item List).

- **Current Baselines:** Baselines of the current items that are on the CM-DM list are made available to all technical teams and stakeholders. These include the configuration baselines, the PMB, financial reporting, baselined IMS, budgets, and documentation.

- **CM/DM Reports/Audits**: Periodic reports on the status of the CM/DM items should be available to all stakeholders on an agreed-to frequency and at key life-cycle reviews.

- **Delivered Data**: The requested data that was delivered to the authorized party.

- **Discrete Risks:** As an output, these are any specific risks identified by the CM/DM function.

- **Issues, Recommendations, Opportunities:** Issues and impacts including project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance. (For additional detail and examples, see Section 3.2.2.)

3.8.3. Function Planning and Control Activities and Tasks

CM/DM planning and control activities and tasks are outlined in Table 3.8-1 CM/DM Activities and Tasks. The activities and associated tasks are described in more detail below the table.

Table 3.8-1 CM/DM Activities and Tasks

CM/DM	
CM/DM Planning Activities and Tasks	**CM/DM Control Activities and Tasks**
Activity: Develop CM/DM plan(s) • Develop CM/DM plan(s) and procedures • Identify items to be under change control • Determine if CM/DM reports and configuration audits are to be held and at what frequency • Identify data items to be under data management • Determine what configuration verification activities will be implemented • Conduct training • As needed, delegate CM/DM requirements to suppliers **Activity: Identify configuration-controlled items** • Define and uniquely identify PP&C product configuration information **Activity: Identify items to be under data management** • Define product configuration information status, transmission, interfaces, and preservation	**Activity: Approve baselines** • Receive request to baseline item and place under control • Evaluate request for suitability to baseline • Place approved item under change control **Activity: Conduct change management** • Establish criteria for change and process for evaluations • Identify appropriate change approval authority • Capture and uniquely identify change requests • Manage initial release and proposed changes, dispositions, and updates to configuration items • Evaluate technical, schedule, and cost impacts of change to other documentation or activities • Assess potential effects of change impacting risk levels/exposure • Implement, verify implementation and document change **Activity: Collect and store data** • Receive data • Ensure source of data is authorized • Store data per plans **Activity: Provide data to authorized parties** • Receive data request • Determine if recipient is authorized • Distribute PP&C data product or give access to data **Activity: Conduct configuration and data audits**

CM/DM	
CM/DM Planning Activities and Tasks	**CM/DM Control Activities and Tasks**
	• Conduct configuration and data audits at the planned frequency • Provide a report of the audit results to the project

3.8.3.1. Planning Activities

3.8.3.1A Develop CM/DM Plan(s)

The CM/DM plan provides information on what approach/method the project expects for the conduct of CM and DM for all project products including technical, cost, risk, and schedule items. This plan is developed early in the life cycle and describes the organization, tools (e.g., configuration management system, library, database, etc.), methods, needed resources, and procedures for the CM/DM activities. The plan also delineates the approach for identifying items that will be placed under CM or DM control, the roles and responsibilities for executing CM/DM, and any audits that might be performed including their frequency. The DM plan should identify and plan for the proper level of protection for each type of data and secure data access, distribution, archiving, and disposal.

All Federal agencies are required by law and Agency policy to maintain and preserve records. Records are defined as "all books, papers, maps, photographs, machine readable materials, or other documentary materials, regardless of physical form or characteristics, made or received by an agency of the United States Government … as evidence of the organization, functions, policies, decisions, procedures, operations or other activities of the Government or because of the informational value of the data in them." The strategy for executing records management per *NPD 1440.6, NASA Records Management* and *NPR 1441.1, NASA Records Management Program Requirements* should be captured in the DM planning.

The PP&C practitioner should participate in the review of the plans to ensure that the plans adequately cover the cost, scheduling, and other PP&C related products. The plan should also capture the strategies for controlling the access, distribution, and disposal of proprietary/sensitive data and intellectual property based on negotiated rights. A part of the plan will be the identification of the need and frequency of configuration audits. The PP&C practitioner should ensure the products under their purview are included as appropriate. An estimate of the resources needed to support this effort will need to be developed and submitted as part of the budget process. The practitioner should also arrange for any training to ensure that PP&C team members have the appropriate level of understanding of the CM/DM principles, tools, and procedures that will be used. The key products of this activity are the baselined CM/DM plan(s) and PP&C resource estimates.

For additional information, see the CM plan outline in *NASA/SP-2007-6105, Systems Engineering (SE) Handbook*, Appendix M. For the DM activities, refer to Government Electronics Information Technology Association (*GEIA)-859, Data Management Standard*.

3.8.3.1B Identify PP&C Items to be under Change Control and Data Management

The specific PP&C products that will be placed under configuration control or data management need to be identified. The list of these products will change and mature as the project moves through its life cycle. Schemas or metadata to be captured and stored for each PP&C item under control need to be identified and documented. The change control authority for each PP&C item should also be determined. The key product of this activity is the approved list of PP&C items to be placed under CM or DM control. The PP&C practitioner will also be involved in reviewing both the technical and non-technical items being proposed for control to ensure all items that need to be controlled are included.

3.8.3.2. Control Activities

3.8.3.2A Approve Baselines

When an item is ready to be put under change control, the project team submits a request to the approval authority or control board. The authority will review the product for completeness and its readiness to be placed under change control. If the item is not stable enough to be baselined, the authority will request that the project continue to mature the product. If the item is ready, it is placed into the controlled location and future updates to the item will need to pass through approval by the approval authority or control board.

3.8.3.2B Conduct Change Management

As the project moves through the life cycle and concepts, designs, and physical versions of the technical product emerge, changes to the established baselined information on that product will be required. These changes will need to be identified, evaluated for benefit and impacts, and approved or disapproved by the appropriate decision maker for that particular item. This is often done through a Configuration (or Change) Control Board (CCB) chaired by the decision maker with change authority for the affected baseline.

It is important for the PP&C practitioner to assess the impacts including the cost and schedule impacts of all changes (technical and non-technical) proposed at the CCBs and to notify the CCB of omissions that are not being evaluated or discussed. Consideration of not only the change itself but how that change affects the cost plan and schedule will need to be made. Without this rigorous CM approach, decisions may be made without a clear understanding of the true implications for cost/schedule baselines. Figure 3.8-2 depicts a typical change control process.

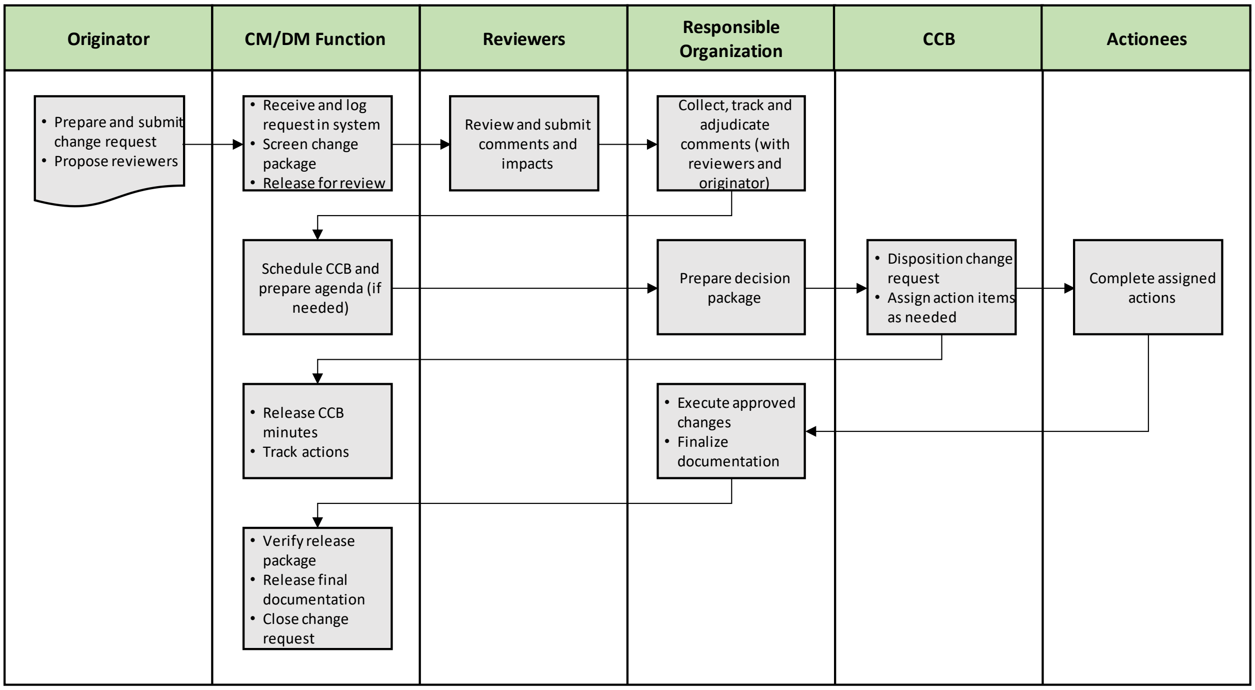


Figure 3.8-2 Typical Change Control Process

A CCB is a group of project stakeholders that is responsible for controlling the identified baselines by approving or disapproving proposed changes to baselines within the authority defined in its charter. Large projects may have more than one CCB, each addressing changes within their responsibility/charter and elevating those changes that are not within their authority to a higher level CCB. Control boards should be established as early as possible since the project will be generating products early in the life cycle that will need to be controlled. CCBs should have official charters, record meeting notes, assign action items, and monitor their progress to completion. Projects should establish CCBs during project Formulation. Multiple CCBs can be established; however, a distinct authority hierarchy of the multiple boards should be established to avoid confusion over lines of authority. It is important that the CCB meetings contain all technical and project control disciplines that will be impacted by the proposed changes.

Typically, changes to configurations are identified by either the developer or the customer. These changes may be the result of new or modified requirements, hardware changes needed to meet specifications, or changes to the project in order to reduce costs or schedules. A change request is generated and submitted to the appropriate CCB. As part of the change request, an analysis is provided to show the effectiveness of the proposed change and its impact on other work, product performance, form, fit, function, safety, costs, or schedules.

The CCB members evaluate the proposed change and its analysis and determine if it is in the best interest of the project and customer to perform the change. If the change is disapproved, additional work by the submitter may be requested for additional analysis and resubmittal, or it may be rejected completely. If the change is approved, a change directive may be issued outlining the scope of the approval and authorizing the submitter to perform the work to enact the change.

A CCB comprises members who represent the project, other stakeholders, and ad hoc members who provide information and support. The CCB chair is the project manager or a key leader in the project at the level appropriate for the specific CCB. A CCB usually includes key stakeholder leaders in the technical, business, quality, and safety organizations. The customer or customer representatives may also be CCB members. A CCB also includes support personnel such as the board secretary, SMEs, or other supporting personnel that might be required on specific topics.

3.8.3.2C Collect and Store Data

A key factor in the collection and storage of data is ensuring that there is a single authoritative source for each datum. The following definitions are important for understanding this aspect of the Data Management activities:

- **Authoritative Data**: Data that has been designated as valid for specific official projects. The designated data is controlled by processes.
- **Authoritative Source**: An application or repository identified as the official source for specific authoritative data.

Authoritative sources will be identified for all the technical, scientific, and PP&C data generated or used by the project, but each individual piece of data needs to have only one authoritative source. This will ensure that the data being used by the project is correct. From the moment the data is copied out of its authoritative source into another one, there is a risk that the data is out of date as changes to data in the authoritative source may not automatically be made in the copy, so the integrity of the data may be compromised. Existence of data discrepancies presents a high risk of making incorrect project decisions, having incorrect information being used in presentations or wrong information being provided for external audits. The PP&C practitioner will need to ensure that all the PP&C-related products have authoritative sources identified.

After the sources of the authoritative PP&C data are identified, the data is collected in the identified formats and stored according to plans and procedures. This will include all data generated through the PP&C efforts including lessons learned and any other data not already captured through the technical teams' execution of the Technical Data Management Process. As part of this process, the data integrity of the PP&C products will need to be checked to confirm its compliance with content and format requirements, and any errors will need to be identified and corrected. Some factors in the assessment of data quality are:

- **Accuracy**: Qualitative assessment that data accurately reflects a real-world object or matches the original source of data.
- **Completeness**: Degree to which values are present including information describing aspects of the actual data (i.e., metadata) such as name, type, format, content, and other descriptive information.

- **Consistency**: Degree to which redundant facts are equivalent across two or more databases.
- **Precision**: Degree to which data is known to the right level of granularity.
- **Timeliness**: Degree to which data is up-to-date and available.
- **Uniqueness**: Degree to which there are no redundant occurrences or records of the same object or event.
- **Validity**: Degree to which data conforms to its definition, domain values, and business rules.

An important factor in CM/DM is records retention. Projects are required to comply with NPR 1441,1 and NASA Record Retention Schedule (NRRS) 1441 *NASA Record Retention Schedules*, which describe NASA's records process and retention schedules, respectively. Storage of the data needs to be compliant with the established procedures, and the appropriate level of security safeguards needs to be maintained. The key product of this activity is the collected and stored PP&C-related data.

3.8.3.2D Provide Data to Authorized Parties

The PP&C data will need to be provided to the authorized parties according to plans and agreements. This may include maintaining an information library or reference to indicate the data that is available and its access instructions. Requests for PP&C data, either planned or unplanned, will be received and evaluated for authorization, delivery formats, and timing. These requests may also include requests between electronic systems. Once the data is sent, it may be necessary to confirm the proper receipt of the data and that it satisfied the needs of the requesting party. Assistance or training of the requesting parties may be required initially to ensure the proper access to the information. The key product of this activity is the provided data.

NASA generates an enormous amount of information, much of which is unclassified/non-sensitive in nature with few restrictions on its use and dissemination. However, some data may require restrictions on dissemination based on the International Traffic in Arms Regulations (ITAR) as indicated by the U.S. State Department, while other data may be controlled under the Export Administration Regulations (EAR) determined by the Department of Commerce. NASA also generates and maintains Classified National Security Information (CNSI) under a variety of Agency programs, projects, and through partnerships and collaboration with other Federal agencies, academia, and private enterprises. The PP&C practitioner needs to be aware that ITAR, EAR, and Sensitive but Unclassified (SBU) markings require the author, distributor, and receiver to keep control of the sensitive document and data or pass the control to an established control process. For more information on SBU data, see *NPR 1600.1*, *NASA Security Program Procedural Requirements*.

3.8.3.2E Conduct Configuration Audits

Configuration verification is accomplished by inspecting documents, products, and records; reviewing procedures, processes, and systems of operations to verify that the configuration item has achieved its required attributes; and verifying that the product's configuration is documented. For hardware products, this is sometimes divided into functional and physical configuration audits.

Configuration audits confirm that the configured product is accurate and complete. The PP&C practitioner will need to support audits on the PP&C documents/configurations and to make any corrections or edits needed to bring those items into compliance. The products of this function are the configuration audit findings and associated corrective actions.

For additional information on the CM activities and tasks, refer to SAE ANSI/EIA 649B, *Configuration Management Standard* and SAE EIA649-2-2016, *Configuration Management Requirements for NASA Enterprises*.

3.8.4. Function Activities by Life-Cycle Phase

Table 3.8-2 describes the CM/DM activities for each life-cycle phase:

Table 3.8-2 CM/DM Activities by Life-Cycle Phase

<table>
<tr><th>Pre-Phase A</th><th>Phase A</th><th>Phase B</th><th>Phase C</th><th>Phase D</th><th>Phase E</th><th>Phase F</th></tr>
<tr><td>Identify initial items for CM</td><td colspan="6">Update items for CM</td></tr>
<tr><td>Identify CM/DM Tool Options</td><td>Select CM/DM Tools</td><td colspan="5">Employ CM/DM tools</td></tr>
<tr><td colspan="6">Place phase products under CM</td><td>Archive CM items</td></tr>
<tr><td colspan="7">Manage changes</td></tr>
<tr><td>Identify Data to be Managed</td><td colspan="6">Update list of data to be managed</td></tr>
<tr><td colspan="6">Manage and provide data to authorized requestors</td><td>Archive Data</td></tr>
</table>

Appendix A: Acronyms

ABC	Agency Baseline Commitment
ACWP	Actual Cost of Work Performed
ADA	U.S. Anti-Deficiency Act
AFES	NASA's Award Fee Evaluation System
AFRC	NASA Armstrong Flight Research Center
ALR	Audit Liaison Representative
ANSI	American National Standards Institute
AO	Announcement of Opportunity
APMC	Agency Program Management Council
ARC	NASA Ames Research Center
ASM	Acquisition Strategy Meeting
ASP	Acquisition Strategy Planning
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BD	NASA HQ OCFO Budget Division
BEI	Baseline Execution Index
BOE	Basis of Estimate
BPR	Baseline Performance Review
CADRe	Cost Analysis Data Requirement
CAM	Control Account Manager
CAP	Control Account Plan
CCB	Configuration/Change Control Board
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CEH	*NASA Cost Estimating Handbook*
CEI	Current Execution Index
CFO	Chief Financial Officer
CFR	*Code of Federal Regulations*
CL	Confidence Level (one-dimensional modeling)
CM	Configuration Management
CMO	Center Management and Operations
CNF	Cost-No-Fee (contract type)
CNSI	Classified National Security Information
CO	Contracting Officer
CoF	Construction of Facilities
COR	Contracting Officer's Representative
CPAF	Cost-Plus-Award-Fee (contract type)
CPARS	Contractor Performance Assessment Reporting System
CPFF	Cost-Plus-Fixed-Fee (contract type)
CPI	Cost Performance Index
CPIF	Cost-Plus-Incentive-Fee (contract type)
CPM	Critical Path Method
CPR	Contract Performance Report

CR	Continuing Resolution
CRADA	Cooperative Research and Development Agreement
CRM	Continuous Risk Management
CSLA	Commercial Space Launch Act
DA	Decision Authority
DAU	U.S. Defense Acquisition University
DCAA	Defense Contract Audit Agency
DCI	(GAO) Data Collection Instrument
DCMA	Defense Contract Management Agency
DM	Data Management; Decision Memorandum
DPMC	Mission Directorate Program Management Council
DPMR	Deputy Project Manager/Resources
DR	Decommissioning Review
DRD	Data Requirements Description
EAC	Estimate at Completion
EAR	Export Administration Regulations
EIA	Electronic Industries Alliance
EOM	End of Mission
EPR	Estimated Price Reports
ES	Earned Schedule
ESA	European Space Agency
ETC	Estimate to Complete
EVM	Earned Value Management
EVMFP	Earned Value Management Focal Point
EVMS	Earned Value Management System
FA	Formulation Agreement
FAD	Formulation Authorization Document
FAR	Federal Acquisition Regulation
FDO	Fee Determination Official
FFP	Firm-Fixed Price (contract type)
FICA	U.S. Federal Insurance Contributions Act
FPAF	Fixed Price with Award Fee (contract type)
FPI	Fixed Price Incentive (contract type)
FPR	Facility Project Requirements
FRR	Flight Readiness Review
FTE	Full Time Equivalent (labor)
FY	Fiscal Year
G&A	General and Administrative (expense)
GAO	U.S. Government Accountability Office
GFE	Government-Furnished Equipment
GFP	Government-Furnished Property
GPE	Governmentwide Point of Entry
GR&A	Ground Rules and Assumptions
GRC	NASA Glenn Research Center
GSA	U.S. General Services Administration

GSE	Ground Support Equipment
GSFC	NASA Goddard Space Flight Center
HMI	Hit/Miss Index
HQ	NASA Headquarters
IAA	Interagency Agreement
IBR	Integrated Baseline Review
ICE	Independent Cost Estimate, In-house Cost Estimate
IDC	Indefinite-Delivery Contract
IDIQ	Indefinite Delivery, Indefinite Quantity (contract vehicle)
IEAC	Independent Estimate At Completion
IG	Inspector General
IMS	Integrated Master Schedule
IPA	U.S. Intergovernmental Personnel Act
IPAO	Independent Program Assessment Office
IPMR	Integrated Program Management Report
IT	Information Technology
ITAR	International Traffic in Arms Regulations
JACS	Joint Analysis of Cost and Schedule
JCL	Joint Cost and Schedule Confidence Level
JPL	NASA Jet Propulsion Laboratory
JSC	NASA (Lyndon B.) Johnson Space Center
KDP	Key Decision Point
KSC	NASA (John F.) Kennedy Space Center
LaRC	NASA Langley Research Center
LCC	Life-Cycle Cost
LCR	Life-Cycle Review
LOE	Level of Effort
MA	Management Agreement
MCR	Mission Concept Review
MD	Mission Directorate
MDAA	Mission Directorate Associate Administrator
MDR/SDR	Mission Definition Review or System Definition Review
MEL	Master Equipment List
MOU	Memorandum of Understanding
MPAR	Major Program Annual Report
MRR	Mission Readiness Review
MSFC	NASA Marshall Space Flight Center
N2	NASA budget database
NAII	NASA Advisory Implementing Instruction
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NF	NASA Form
NFS	NASA FAR Supplement
NICM	NASA Instrument Cost Model (tool)
NOA	New Obligation Authority

NODIS	NASA Online Directive Information System
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
NRRS	NASA Records Retention Schedule
NSPD	National Security Presidential Directive
OBS	Organizational Breakdown Structure
OCC	NASA HQ Office of the Chief Counsel
OCE	NASA HQ Office of the Chief Engineer
OCFO	NASA HQ Office of the Chief Financial Officer
ODC	Other Direct Cost
OGC	NASA HQ Office of General Counsel
OIG	NASA HQ Office of the Inspector General
OIIR	NASA HQ Office of International and Interagency Relations
OLIA	NASA HQ Office of Legislative and Intergovernmental Affairs
OMB	Office of Management and Budget
ONCE	One NASA Cost Engineering (database)
PBR	President's Budget Request
PBS	Product Breakdown Structure
PCA	Program Commitment Agreement
P-CAM	Project Control Account Manager
PCEC	Project Cost Estimating Capability (tool)
PDR	Preliminary Design Review
PEB	Performance Evaluation Board
PEP	Performance Evaluation Plan
PI	Principal Investigator
PMB	Performance Measurement Baseline
PMC	Program Management Council
PMT	Performance Measurement Technique
PO	Purchase Order
POC	Point of Contact
PPBE	Planning, Programming, Budgeting, and Execution
PP&C	Project Planning and Control
PR	Purchase Requisition
PRA	Probabilistic Risk Assessment
P/S	Planner/Scheduler
PSM	Procurement Strategy Meeting
QA	Quality Assurance
QRA	Quantitative Risk Analysis
RAM	Responsibility Assignment Matrix
R&D	Research and Development
REDSTAR	Resource Data Storage and Retrieval (library)
RFA	Request for Action
RFI	Request for Information
RFP	Request for Proposal
RFQ	Request for Quotation

RIDM	Risk-Informed Decision Making
RLS	Resource-Loaded Schedule
RMP	Risk Management Plan
RMS	Risk Management System
ROM	Rough Order of Magnitude
SAA	Space Act Agreement
SAAM	Space Act Agreement Maker (system)
SAP	Systems Application Products (financial system)
SBU	Sensitive But Unclassified
SDR	System Definition Review
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SID	NASA HQ OCFO Strategic Investments Division
SIR	Systems Integration Review
SLOC	Software Lines of Code
SMA	Safety and Mission Assurance
SMART	NASA Schedule Management and Relationship Tool
SME	Subject Matter Expert
SMP	Schedule Management Plan
SOW	Statement of Work
SP	NASA Special Publication
SPG	Strategic Programming Guidance
SPI	Schedule Performance Index
SRA	Schedule Risk Assessment, (Schedule Risk Analysis)
SRB	Standing Review Board
SRR	System Requirements Review
SSC	NASA (John C.) Stennis Space Center
STAT	Schedule Test and Assessment Tool
SUA	Software Usage Agreement
TBD	To Be Determined
TCSR	Technical, Cost, Schedule, and Risk (report)
TD	Time-Dependent (cost)
TI	Time-Independent (cost)
T&M	Time and Materials (contract type)
ToR	Terms of Reference
TPM	Technical Performance Measure
TPOC	Technical Point of Contact
TRL	Technology Readiness Level
U/C	Uncertainty
UCA	Undefinitized Contract Action
UFE	Unallocated Future Expenses
WBS	Work Breakdown Structure
WYE	Work Year Equivalent (labor)

Appendix B: Glossary

Acquisition. Obtaining or advancing the development of the systems, research, services, construction, and supplies to fulfill the Agency's mission and other activities which advance the Agency's statutory objectives.

Acquisition Strategy. The plan or approach for using NASA's acquisition authorities to achieve the mission of a project. It includes the recommendations from make/buy analyses, the recommendations from competed/directed analyses, proposed partnerships and contributions, proposed infrastructure use and needs, budget, and any other applicable considerations.

Acquisition Strategy Meeting (ASM). 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.

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 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 project alternatives (including technical performance, risk, LCC, and programmatic aspects).

Baseline Execution Index (BEI). Measures actual work accomplished against the schedule baseline by comparing the cumulative number of tasks actually completed to the cumulative number of "baselined" tasks scheduled to be completed.

Basis of Estimate (BOE). The documentation of the ground rules, assumptions, and drivers used in developing the cost and schedule estimates including applicable model inputs, rational or justification for analogies, and details supporting cost and schedule estimates.

Budget. A financial plan that provides a format estimate of future revenues and obligations for a definite period of time for approved programs, projects, and activities.

Current Execution Index (CEI). Compares forecast dates from one status period to the next to determine how well the near term schedule represents what actually happens. It represents the fidelity of the forecast schedule and the project's or contractor's ability to execute tasks as projected each month.

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 t) awards and notices of awards; job orders or task letters issued under basic ordering agreements; letter contracts; orders such as POs under which the contract becomes effective by written acceptance or performance; and bilateral contract modification. Contracts do not include grants and cooperative agreements.

Control Account. A documented scope of technical, cost, and schedule objectives within a project corresponding to a WBS element that has a responsible organizational element or individual identified. The control account is represented in a RAM as the intersection of the WBS and the OBS.

Control Account Manager. A manager responsible for a control account and for the planning, development, and execution of the budget content for such accounts.

Cost Analysis Data Requirement. A formal document designed to help managers understand the cost and cost risk of projects. The CADRe consists of a Part A "Narrative" and a Part B "Technical Data" in tabular form, both provided by the project or Cost Analysis Division. Also the project ream produces the project LCC estimate schedule and risk identification, which is appended as Part C.

Decision Authority. The individual authorized by the Agency to make important decisions on programs and projects under his/her authority.

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.

Earned Value Management (EVM). A tool 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, enabling management to gain insight into project status and project completion costs and schedules. Two essential characteristics of successful EVM are EVMS data integrity and carefully targeted monthly EVM data analyses (e.g., identification of risky WBS elements).

Earned Value Management System (EVMS). An integrated management system and its related subsystems that 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.

Encumbrance. Encumbrance is the process by which a hold against UFE is made. The money has not necessarily been moved yet to the account that created the need, but the hold has been placed. It is different from a lien in that a lien identifies a specific task, a justification, and a cost and schedule impact whereas an encumbrance is just a monetary amount associated with that lien.

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 projects through the Agency's funds distribution process.

Hit/Miss Index (HMI). Indicates, on a percentage basis, whether tasks actually completed were the ones planned to be completed in a specific period according to the schedule baseline.

Input. For the purpose of this handbook, an "input" is any item required by one of the PP&C functions to perform its function, generate a product or result, or provide a service. Inputs can be internal or external to the project and may be an output from another function.

Integrated Baseline Review (IBR). A risk-based review conducted by project management 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.

Integrated Master Schedule (IMS). A logic network-based schedule that reflects the total project scope of work, traceable to the 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.

Joint Cost and Schedule Confidence Level (JCL). (1) The probability that cost will be equal to or less than the targeted cost and the schedule will be equal to or less than the targeted schedule date. (2) A process and product that helps inform management of the likelihood of a project's programmatic success. (3) A process that combines a project's cost, schedule, and risk into a complete picture. JCL is not a specific methodology (e.g., RLS) or a product from a specific tool. The JCL calculation includes consideration of the risk associated with all elements regardless of whether or not they are funded from appropriations or managed outside of the project. JCL calculations include the period from KDP C through the hand-over to operations, i.e., end of the on-orbit checkout.

Key Decision Point (KDP). The event at which the Decision Authority determines the readiness of a project to progress to the next phase of the life cycle (or to the next KDP).

Liens (Risk). Events that are having or likely to have a negative impact on project cost, schedule, or technical performance. May represent an encumbrance on project funds or UFE.

Life-Cycle Cost (LCC). 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 (LCR). A review of a project designed to provide a periodic assessment of the technical and programmatic status and health of a project at a key point in the life cycle, e.g., PDR or CDR. Certain life-cycle reviews provide the basis for the Decision Authority to approve or disapprove the transition of a project at a KDP to the next life-cycle phase.

Output. For the purpose of this handbook, an "output" is any item generated by one of the PP&C functions. Outputs can be an input to another function or may be delivered/provided external to the project.

Organizational Breakdown Structure (OBS). 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, 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 (PMB). The time-phased cost 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 required, or other performance measurement techniques if EVM is not required. The PMB does not include UFE.

Procurement. The acquiring of supplies or services (including construction) by contract with appropriated funds by and for the use of the Federal Government through purchase or lease whether the supplies or services are already in existence or must be created, developed, demonstrated, and evaluated.

Procurement Strategy Meeting (PSM). 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 FAR and NFS and incorporates NASA strategic guidance and decisions from the ASM to ensure the alignment of the individual procurement action with NASA's portfolio and mission.

Program. A strategic investment by a Mission Directorate or Mission Support Office 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 defines a strategic direction that the Agency has identified as critical.

Project. A specific investment identified in a Program Plan having defined requirements, a 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.

Quantitative Risk Analysis (QRA). A risk-intensive method for probabilistically summarizing risks for use in UFE sizing, resource management, cost estimating, and other PP&C-related activities.

Rebaselining. The process that results in a change to a project's ABC.

Replanning. The process by which a project updates or modifies its plans.

Responsibility Assignment Matrix (RAM). A chart 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. The RAM is the result of cross-referencing the OBS with the WBS. Cross-referencing the WBS and OBS creates control accounts that facilitate schedule and cost performance measurement. The control account is the primary point for work authorization, work performance management, and work performance measurement; i.e., where the planned value is established, earned value is assessed, and actual costs are collected.

Risk. In the context of mission execution, risk is the potential for performance shortfalls that 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 RIDM and CRM in an integrated framework. RIDM informs SE 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 project.

Risk-Informed Decision Making (RIDM). 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.

Schedule Risk Assessment (SRA). The process of performing a probabilistic risk assessment on a project schedule. This type of schedule assessment is based on using Monte Carlo simulations that incorporate "minimum," "maximum," and "most likely" estimates for task durations.

Schedule Margin. The allowance carried in projected schedules to account for uncertainties and risks. Margins are allocated during the schedule formulation process based on assessments of risks and are typically consumed as the program/project proceeds through the life cycle.

Space Act Agreement (SAA). 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."

Stakeholder. An individual or organizational customer having an interest (or stake) in the outcome or deliverable of a project.

Standing Review Board (SRB). The board 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 ToR, life-cycle requirements in NPR 7120.5, entrance and success criteria in NPR 1723.1, and maturity matrices in the *NASA Space Flight Program and Project Management Handbook (NASA/SP-2014-3705).*

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., project). The tailoring process results in the generation of deviations and waivers depending on the timing of the request.

Termination Review. A review initiated by the Decision Authority for the purpose of securing a recommendation as to whether to continue or terminate a project. Failing to stay within the parameters or levels specified in controlling documents will result in consideration of a termination review.

Terms of Reference (ToR). A document specifying the nature, scope, schedule, and ground rules for an independent review or independent assessment.

Threats. Events that may have a negative impact on project cost, schedule, or technical performance. Project funds or UFE are not yet allocated to its mitigation.

Unallocated Future Expenses (UFE). The portion of estimated cost required to meet a specified confidence level that cannot yet be allocated to the specific project WBS subelements because the estimate includes probabilistic risks and specific needs that are not known until these risks are realized.

Waiver. A documented authorization releasing a project from meeting a requirement after the requirement is put under configuration control at the level the requirement will be implemented.

Work Breakdown Structure (WBS). A product-oriented hierarchical division of the hardware, software, services, and work tasks required to produce the project's end product(s), structured according to the way the work will be performed and reflecting the way in which project costs and schedule, technical, and risk data are to be accumulated, summarized, and reported.

Work Breakdown Structure (WBS) Dictionary. A document that describes the work content of each WBS element in product-oriented terms and relates each element to the progressively higher levels of the structure.

Work Package. A unit of work established by the CAM that is required to complete a specific job. A work package consists of detailed jobs or material items identified by the implementer for accomplishing work required to complete the project/contract. A work package has the following characteristics:

a) It represents units of work at levels where work is performed.

b) It is clearly distinguished from all other work packages.

c) It is assigned to a single organizational element.

d) It has scheduled start and completion dates and, as applicable, interim milestones that represent physical accomplishment.

e) It has a budget or assigned value expressed in terms of dollars, man-hours, or other measurable units.

f) Its duration is limited to a relatively short span of time, or it is subdivided by discrete value milestones to facilitate the objective measurement of work performed, or it is LOE.

g) It is integrated with detailed engineering, manufacturing, or other schedules.

Appendix C: Scaling

This handbook covers a wide range of projects big and small. Scaling is a process to adjust a project's best practices, activities, and requirements to accommodate a project's unique size, complexity, risk posture, and other characteristics (e.g., high profile) to achieve mission success efficiently and economically. Scaling may involve tailoring requirements. (See definition below from NPR 7120.5.) The idea of scaling PP&C activities is to develop and use PP&C processes and products that meet but do not exceed the needs of the project team. The planning activities should be adequate to allow the project team to understand the scope of the project, the interfaces between the major participants, the schedule when activities must be completed, and the resources required to accomplish the project scope within the schedule timeframe. Compared with large projects, smaller projects with fewer pieces of hardware and fewer contributing organizations will not need the same level of PP&C processes and products to enable the planning and control of the development, integration, and operation of the hardware. For this topic, the following definition applies:

- **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., project). The tailoring process results in the generation of deviations and waivers depending on the timing of the request. (See NPR 7120.5.)

Understanding the category of a project is a first step in evaluating the appropriate level of scaling. All projects are assigned to Category 1, 2, or 3 based on the project LCC estimate and other factors. Large or human spaceflight projects are designated Category 1 and the smaller robotic missions are designated Category 3. Category 1 missions follow requirements with the most rigor, often without any tailoring as indicated in the Project Plan and the associated compliance matrix. Category 3 projects typically employ more scaling as appropriate for their size and complexity.

Another factor in determining the appropriate level of scaling is the assigned risk classification for payloads. Appendix B of *NPR 8705.4 Risk Classification for NASA Payloads* defines four risk levels for payloads ranging from Class A (high priority, very large, high cost) to Class D (lower priority, small, lower cost).

Scaling such activities as methodologies for estimating the costs and tools for scheduling of missions also depends on a number of factors related to the type, quantity, heritage, and dependencies and constraints in designing, building, and integrating engineering systems and units being developed and produced. It is important to work with the technical team to determine which factors are significant to scale appropriately.

C.1 Tailoring of PP&C Requirements

There is currently no governing NPR specifically for PP&C activities; however, there are several NPRs that already contain PP&C-related requirements. Refer to the current versions of the governing NPRs for the authoritative source of requirements.

Large, complex, or higher-priority missions (Category 1 or Type A) would receive the most rigor to meet programmatic requirements, often without any tailoring as indicated in the Project Plan and the associated compliance matrix. However, smaller or less complex missions (Category 3/Class D) would be expected to appropriately tailor the governing requirements.

The following PP&C requirements are examples of tailoring for size and complexity of a project:

- EVM principles for small projects may be applied as noted in Appendix H: Letter on Guidance and Expectations for Small Projects of this handbook and used for in-house, small Category 3 projects with development costs greater than $20M and a LCC estimate below $150M.
- JCL and external cost and schedule commitments (ABC external commitment) are not applicable to small Category 3 projects with LCC below $250M. (See current requirement in NPR 7120.5.)
- CADRe is not mandatory for small Category 3/Class D projects, but data collection for smaller projects is critical for future estimating capabilities and is strongly encouraged.

C.2 Scaling PP&C Activities

Scaling a PP&C practice can include:

1. Adjusting the scope and depth of documentation including the Project Plan.
2. Adjusting the number, formality, and timing of LCRs.
3. Using less formal tools (e.g., spreadsheets instead of a given financial or risk tool).
4. Adjusting the depth of the WBS. Very small projects may only need a WBS that goes to level 3 or 4 whereas a very large project like the James Webb Space Telescope may require a WBS that goes to level 7 or deeper.
5. Adjusting the formality of EVM on projects that do not meet the criteria for a formal EVMS.

Table C-2 provides examples of scaling PP&C activities based on project type.

Table C-2 Examples of Scaling Based on Project Type

PP&C Activity	Project Type
Project Plan	Class A - D projects can expect to have to develop this document for capturing the overall approach to implementing the mission in accordance with Appendix H of NPR 7120.5.
	Class E & F projects can expect to develop a document that captures the overall approach to implementing the mission but may be limited to just the WBS, Rough Order of Magnitude (ROM) cost, schedule, resources, acquisition concept, descope options, etc.
Schedule	For Class A – C projects, the schedule will be typically documented in an IMS.

PP&C Activity	Project Type
	For Class D projects, the schedule will be an IMS at the appropriate level of detail.
	For Class E projects, the schedule may be documented in a Gantt chart of key project milestones unless IMS is required for EVM.
	For Class F projects, the schedule is typically documented in a Gantt chart of key project milestones.
Acquisition Plan	For Class A & B projects, this plan is required. The acquisition strategy and long-lead procurements are first put in the FA (NPR 7120.5 Appendix F.3, Section 11.0) and then the Project Plan (NPR 7120.5 Appendix H.3, Section 3.4).
	For Class C & D projects, this plan is required but not as a stand-alone plan. The acquisition strategy and long-lead procurements are first put in the FA (NPR 7120.5 Appendix F.3, Section 11.0) and then the Project Plan (NPR 7120.5 Appendix H.3, Section 3.4).
	For Class E projects, the acquisition information is incorporated in the project planning documentation (reference Project Plan (NPR 7120.5 Appendix H.3, Section 3.4))
	For Class F projects, the quantity and type of work is typically incommensurate with requiring a formal Acquisition Plan.

Appendix D: Sample Questions to Ask by Life-Cycle Phase

These questions are examples that serve to illustrate the factors, situations, issues, and concerns that may influence PP&C's products and plans. Each project would customize its specific questions based on the project's circumstances.

Questions to consider during Pre-Phase A and Phase A

Programmatic

1. What are the assumptions?
   - What are the elements of risks in those assumptions
2. What are the key constraints?
   - Cost, schedule, launch date, etc.
3. Are there any non-compliance issues?
   - NPR 7120, ITAR, etc.
4. What are the environment/ political issues?
   - What is the competition for funds?
   - Is the project consistent with the *NASA Strategic Plan*?
   - If applicable, is the project consistent with the *National Academy of Science (NAS) Decadal Survey*?
   - What other external factors exist?

Requirements

5. How defined are the Level 1 requirements?
6. Are there any unique requirements?
7. What is the heritage assumption?
8. Is there any technology development?
9. Are the correlations consistent with similar missions?
   - Power, mass, burn rate, etc.

Funding

10. How realistic is the funding profile?

Schedule

11. Is the schedule consistent with similar missions?

Cost/Risk

12. Is the cost estimate credible?
    - i.e., mission to Moon vs. Mars, same price
13. Have you reconciled any disconnects with the Independent Cost Estimate (ICE) conducted in support of MDR/SDR and KDP B?

14. How does the phased cost compare to similar missions?
15. Is the risk list defined?
    – Does the estimate address them?
    – What is the biggest risk inherent in the estimate?
    – What are the risks in the contract proposals?
16. What are the descope options?
    – Are they realistic?
    – When does the decision need to be made?
    – What are the impacts to cost and schedule?

<u>Schedule Margins and UFE</u>

17. How realistic are the schedule margins and UFE?

<u>Workforce</u>

18. What is the workforce profile? Is it achievable?

<u>Contracts</u>

19. How current are the contractor rates?
20. What is known about the system contractor?
    – Is their business base up or down?
21. How should termination liabilities be proposed?
22. Any proposals from foreign entities or proposed foreign contractors?
23. Are there any long lead items that are problematic?
    – i.e., actuators.

<u>Partnerships</u>

24. Are there any international partner contributions?

<u>Questions to consider during Phase B</u>

<u>Programmatic</u>

1. What are the changes from Phase A?
    – Contract rates
    – Termination and liability shift
    – Funding
    – Any new technical issues
2. Any political/environment changes?
    – Personnel
    – Funding
    – Other project performance
    – International partner agreement
3. How credible is the planning?

- Does it capture the scope?
- What is the methodology for establishing control accounts?
- Is it compliant with the EVM baseline?
  - Work packages, schedule, performance measuring techniques

4. Is the plan executable?

Funding

5. Is the recent PPBE funding forecast consistent with the proposal or the project baseline to be authorized at KDP C? If not, what flexibility is available to modify the PPBE plan to better align with the desired cost profile? How will the project have to adjust its schedule and cost estimate if flexibility is not available?

Schedule

6. Has the schedule captured the scope of work for the project?
7. Does the network logic make sense?
   - Was a health check performed?
   - Is cost and schedule integrated?
   - Is the WBS product-oriented (versus organizationally oriented)?
8. How credible is the schedule?
   - Is the detailed schedule linked to the master schedule?
   - Is the critical path identified?
   - Was a health check performed?
   - Are the schedule and schedule margin consistent with similar missions?
   - Are durations reasonable?
9. Is the project schedule aligned and balanced with the line organization's internal schedule?
   - Number of line items.
   - Connection between the two schedules.

Cost/Risk

10. Is there full cost and schedule integration in the baseline to be authorized at KDP C?
11. Are there any disconnects between the authorized Formulation Agreement costs and Phase A costs?
12. Does the ICE show the Phase C/D estimate to be credible and realistic?
13. Have the various ICE's been reconciled?
14. What new risks have emerged?
    - What risks have been mitigated or eliminated?
15. How realistic is the project UFE?
16. Have procedures been established for managing liens during Implementation?
17. What is the plan for any IBR?

Schedule Margins and UFE

18. What are the schedule margin and UFE burn down profiles doing?
    - How similar is it to other "like" missions?

Workforce

19. Are there any changes in the workforce makeup?
20. Are the key team members in place?

Contracts

21. Are there any changes in the contract?
    - What is the plan for negotiation?
    - What is the negotiation goal and strategy?
22. What are the long-lead items? Are there any issues?

Questions to consider during Phase C/D

Funding

1. Does the current-year funding profile support the project's current-year cost and schedule requirements?
    - Is the project's carry-over of unobligated and uncosted funds consistent with its planned expenditures for the current year?
    - Has the project entered the fiscal year behind schedule or at a higher- or lower-than-planned "burn rate" such that the current year's planned work content is in jeopardy?
    - Is the project obligating and costing on a monthly basis consistent with plan? If the project is exceeding its plan, is it at risk of requiring an operating plan change to accommodate needed additional funding to maintain schedule? If it is behind its plan, is it at risk of work content slipping to a future year, increasing out-year cost and budget requirements?
    - Is the project managing UFE and schedule margin within the current year such that it is not shifting current-year liens, threats, or risks to be addressed in a subsequent year? Is it pushing off current-year content to accommodate a lower-than-required UFE level in the face of emerging unexpected risks?
    - Is international partner delivery slipping such that the project may have to slow down some of its planned current-year expenditures?
    - Is the project keeping a focus on the funding requirements that bypass its direct budget such as launch services or any Space Communication costs? (The project is responsible for tracking these costs even though the project may not directly execute these funds.)
    - Is the carry-forward into the next fiscal year sufficient to support the project under a Continuing Resolution (CR)? What is the current funds exhaustion date?
2. Are there any potential issues that will impact the management of project funding?

Schedule

1. Have there been any internal or external changes that warrant a reexamination of the schedule's reasonability as compared with similar missions?
   – How does the schedule relate to the rule-of-thumb standard for similar missions?
2. What is the ratio between the number of planned starts versus actual starts on tasks for the period and cumulative-to-date?
3. What is the ratio of the number of tasks planned to complete versus the number of tasks actually completed during the period and cumulative-to-date?
4. What is the ratio of costs expended to complete tasks versus the planned costs to complete tasks for the period and cumulative-to date?
   – Ex: If the plan was to spend $200,000 to complete four tasks during the period and the project completed only three but spent $250,000 on those three, then there is a problem.
5. How consistent is the critical path from period to period?
   – Does it change frequently? If so, why, and what resource impacts are there?
   – Are there significant workarounds? Workarounds add cost. They are not efficient; otherwise, they would have been the original plan.
6. What is schedule margin utilization and is the schedule margin funded?
   – How much float is in the schedule?
7. Are the hardware deliveries to assembly, test, launch and operations on track according to plan?
8. Is the incompressible test list consistent with the schedule?
9. How is the schedule margin quantified and held?
10. Are key drivers identified, aligned with the risk list, and compared to the mitigation plan?

Cost/Risk

1. What are the cost expenditure percentages by key milestones (PDR, CDR, SIR)?
   – If 40% of the budget was spent by CDR, is that consistent with previous similar missions?
2. Have cost overruns occurred to maintain or improve schedule, or are cost and schedule indicators both deteriorating?
3. Are the cost ratios for key resources consistent with similar missions?
   – Ex: $$ per Kg; $$ per Watt, etc.
4. How are costs performing against margin trades? (e.g., power, mass, data rate, etc.)
   – Ex: The project decided to trade some mass for extra power. What has that done to the cost forecast?
5. How are costs (and schedule) for key deliverables/subsystems performing as compared to similar missions?
   – Ex: risk areas such as power supply, reaction wheels, actuators, antennas, radar subsystem, cryo-coolers, etc.
6. How does the burn rate compare to the plan? If it stays flat, how does that compare to the Estimate at Completion (EAC)? Look at the budgeted work to go (i.e., unearned Budgeted Cost of Work Performed (BCWP)). If the burn rate per month remains stable, how does it compare with the project EAC?

  - Ex: If the total budget for a major task is $20 million at launch and the project has earned $14 million and spent $15 million, the budgeted work to go is $6 million ($20-$14).
  - If the project is spending $1 million per month, which is expected to be flat until launch and launch is 8 months away, it suggests the project will be over budget by $3 million. ($15 million spent + $8 million to go = $23 million. The budget is $20 million; therefore, the project will be over budget by $3 million.)
7. Is there any uncertainty relative to the differences in cost and obligations?
8. What is the timing of contract cost: actual versus accrual?
9. Is there a significant difference between NF 533 and SAP data?
10. Was a vendor capability analysis performed for key vendors who are on the critical path?
  - What are the fallback options for sole source?
  - What are the risk mitigation plans?

Schedule Margins and UFE

1. Have margin and UFE utilization retired the risks on the risk list?
2. What are the margin and UFE burn-down percentage at key milestone events (CDR, SIR)?
3. How have margin and UFE utilization affected the schedule?
  - Ex: added people, therefore created workarounds, slips?
4. Is the margin and UFE utilization consistent with the design principles?
  - The UFE balance should be based on ETC
5. How are margins and UFE being utilized?
  - Scope change
  - Growth (workmanship, technical issues, complexity, poor planning, omissions)
  - Risk buy-down
6. Is the margin and UFE balance reasonable after liens are incorporated?
  - Are liens managed in accordance with the procedures defined during Phase B?
7. What is the project's understanding of UFE held at the Mission Directorate and/or the program levels and how to request allocation of that UFE to the project if needed?
8. Are margins and UFE being allocated realistically for WBS items that historically have a high overrun probability?
  - Bypass
  - Contracts
  - Labor at assembly, test, launch, and operations

Work Force

1. Is the workforce profile reasonable?
  - Are there any steep ramp-ups, ramp-downs, significant spikes, inconsistent man-loading (Example: 20 FTE one month, 50 the next, then 10 the third, and 30 the fourth)?
  - Is the workforce plan consistent with historical data? (Example: History shows project workforce tends to stay flat during the last 6 months of the project before

launch. If the workforce is planned to roll off the last 6 months of the project before launch, forecast an FTE risk.)
    - Is the workforce front-loaded? Back-loaded?
    - How does the project workforce profile line up with the workforce profile of the larger organization?
2. Is the workforce plan consistent with the funding profile?
3. Does the staffing correlate to the funding profile or the work schedule?
4. Is the workforce plan consistent with the schedule and costs incurred and the Estimate To Complete (ETC)?
    - Example: The fractional FTEs on projects have significant impacts on the project's ETC. Compare fractional FTEs with actual people.
5. What is the magnitude of the labor rate variance? What is the impact on the ETC and schedule?
    - Example: A high labor category was planned, but the project is using a lower labor category or vice versa.
6. What is the performance, composition, and quality level of the people on the team?
    - Example: A senior level manager may perform less well than a junior on a lower level task or vice versa.

Trends

1. What are the key performance trends (e.g., CPI and SPI) for the past three months? Six months? What are the trends on key subsystems and high risk tasks? What are they saying?
2. What are the workforce trends as compared to the plan over the past three months? Six months?
3. Is the EAC sufficient to complete the scope?
4. What do the major contractor performance trends indicate over the past 3 and 6 months? How are contractor workforce versus cost versus schedule comparisons?
5. How are cost expenditures as compared to schedule accomplishment?
    - Are costs going up to maintain or improve the schedule?
    - Are costs on plan and is the schedule on plan?
    - Are costs going up and the schedule deteriorating?
6. How are performance trends as compared to similar missions at similar points in their life cycles?
7. Has the project implemented any of the corrective actions identified in prior reviews, and how has that impacted cost and schedule performance?
    - Is the risk matrix evaluated to determine impacts of cost and schedule?

Contracts

1. Are there any special or unique provisions in solicitations or any special or unique contract clauses or special requirements that could increase risk, thereby increasing cost and impacting schedule?
2. Are directed changes to the contract priced and negotiated? Are they on the lien list or in the EAC?

   - Are there known and documented directions to proceed with the changes?
   - Or, are there any missing documented or verbal directions to proceed with the changes?
3. Are there any changes at the contractor facility that could impact the project relative to cost, schedule, and workforce?
   - Example: Loss of business at their facility on other projects or proposals might result in the workforce staying longer on the project and driving up rates.
   - Example: Winning new business at their facility could mean key resources will be taken off the project and moved to new projects, which might have schedule implications.
4. How has that contractor performed on similar missions?
5. How have contractor cost expenditures lined up against key milestones?
6. Is the contractor workforce profile consistent with its cost and schedule?

Appendix E: Description of Function Inputs and Outputs

Table E-1 provides, in alphabetical order, descriptions of all outputs of the seven PP&C functions (which are also inputs to other functions and external entities) and descriptions of all inputs from external entities to the PP&C functions. The source(s) of the inputs and outputs are identified in the second column of the table.

Note: 1) When multiple functions provide the same output to a function, the description in Table E-1 is that of the receiving function. 2) Inputs and outputs common to multiple functions may be customized by each function. For these inputs and outputs, the part of the description that is generally applicable to all the functions is provided in Table E-1. For a description of the customization, see the applicable function section (3.2 – 3.8))

Table E-1 Description of Function Inputs and Outputs

Input and Output Descriptions	Source Function
Acquisition Milestones: Acquisition milestones establish the dates when contracts are expected to complete key events or to provide project deliverable(s). Acquisition milestones are key acquisition events that are identified within the baseline IMS. *(Note: This is both an input and an output for these functions. Scheduling provides initial acquisition milestones to Acquisition and Contract Management for use in developing solicitations. Acquisition and Contract Management, in turn, provides milestones established in awarded contracts to Scheduling.)*	**Acquisition and Contract Management, Scheduling**
Acquisition Plan: Documents the project's approved acquisition strategy that enables the project to meet its mission objectives and provides the best value to NASA. It identifies all major acquisitions and provides summary information on each acquisition. It describes completed or planned studies supporting make-buy decisions and describes the supply chain and procedures used to identify, monitor, and mitigate supply chain risks. It identifies 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. The Acquisition Plan is provided to PP&C Integration for review and comment prior to approval.	**Acquisition and Contract Management**
Acquisition Strategy: The project's approved Acquisition Strategy for using NASA's acquisition authorities to achieve the project's mission within planned cost and schedule. The strategy addresses plans for	**PP&C Integration**

Input and Output Descriptions	Source Function
obtaining the systems, research, services, construction, and supplies needed to fulfill the mission, including in-house work plans, any known procurement(s), plans for partners and their roles and anticipated contributions, and plans for obtaining commitments for these contributions.	
Acquisition Strategy Meeting (ASM) Results: The ASM is a review by senior Agency management of the project's proposed acquisition strategy. If required, it is held before authorization of resource expenditures for any major acquisitions. Impacts are considered to the Agency workforce and maintaining core capabilities, resource availability, make-or-buy decisions, Center assignments, and potential partners, risk, and other planning decisions from an Agency perspective. The ASM results in either approval or modification of the project's proposed acquisition strategy. Results of the ASM are also used to develop and finalize the Acquisition Plan.	**External** (to PP&C Integration, Acquisition and Contract Management)
Acquisition Timeline: The planned dates when solicitations are expected to be released, proposals from offerors evaluated, and contracts awarded.	**Acquisition and Contract Management**
Adjusted Plans: Updates to the project's plans based on approved options/corrective actions. Examples include updates to the baselined IMS, LCC, EAC, and modification of existing contracts.	**PP&C Integration**
Analysis Schedule: An IMS or analysis schedule is used as the foundational framework for a JCL. It comprehensively includes well-defined tasks that are logically sequenced and justifiably interdependent. A project's analysis schedule is often a consolidation of its baseline IMS and other schedule data that preserves appropriate detail for elements that are more critical and summarizes those that are less important. Its structure ideally enables incorporation of risks, task uncertainty, and cost into a self-contained analysis.	**Scheduling**
Annual Phasing Plan: A plan of obligations, costs, FTEs, WYEs, and ODCs for each fiscal year in the project's life cycle provided at the WBS level deemed appropriate by project management. The plan is typically broken out by month for the current fiscal year and actuals are reported against the plan on a monthly basis.	**Resource Management**
Applicable Requirements, Constraints, GR&A, and Stakeholder Expectations: These define and bound the scope of PP&C products developed by all PP&C functions. Identification helps to minimize or	**PP&C Integration**

Input and Output Descriptions	Source Function
eliminate oversights that can result in PP&C products that fail to meet the needs of the project, its customers, and stakeholders. An example of an applicable requirement is the requirement to produce a JCL. Examples of constraints include fixed launch dates and constraints on development costs. Examples of GR&A include participation by other foreign entities and the expected cost of institutional support. Examples of stakeholder expectations include types and frequencies of reports.	
Approved Changes: Once the control board or other governing authority has made the decision to approve the requested changes, they are authorized, released to the community, and the requested changes are implemented for the associated baselines and items.	**Configuration and Data Management**
Assessment Results & Recommendations: Analysis of remaining risk and project and external issues with the potential to impact performance. Forecast of integrated cost and schedule performance and EAC based on current performance, work remaining, and likely impacts of remaining risk and issues. Identification of key issues and performance drivers and any decisions that need to be made by project management. Recommendations including candidate options and/or corrective actions for controlling project performance and the expected impacts of each recommendation on integrated cost and schedule performance, EAC, and remaining risk.	**PP&C Integration**
Assessments, Issues, Recommendations, Decisions: These are assessments of cost and schedule performance at the individual contract level (taken from the performance reports input); issues and opportunities pertaining to individual contracts (taken from the issues, recommendations, and opportunities output); and recommendations and decisions pertaining to individual contracts (taken from the assessment results and recommendations input and the decisions and actions input). This information is provided to the CO and COR for each contract.	**Acquisition and Contract Management**
Assessments of Proposed Contract Modifications: Assessments of the cost and schedule impacts submitted by contracts for proposed modifications. The Acquisition and Contract Management function ensures and coordinates these assessments that are conducted by the Resource Management and Scheduling functions and reviewed by the PP&C Integration function.	**Acquisition and Contract Management**
Baseline Approval Requests: Requests to place an item under baseline control.	**PP&C Integration, Resource Management,**

Input and Output Descriptions	Source Function
(Note: This is provided as an input to the CM/DM function. The description above is from the corresponding CM/DM input. Each providing function may customize the description of its corresponding output.)	**Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Risk Management, External**
Budget Planning Information: Budget planning information includes all estimated project costs and obligations to include FTEs, WYEs, ODCs, procurements, partnerships, travel, facilities, and other costs for each fiscal year during all phases of a project.	**Resource Management**
Business Decisions: Decisions on how the project will plan, manage, and control cost and schedule including the identified and agreed-to set of PP&C indicators that will be used throughout the life cycle to monitor and trend PP&C-related activities; identification and definition of interfaces between PP&C functions and interfaces between PP&C functions and project technical processes and systems and organizations, systems, and processes external to the project including suppliers; what reports to generate and when they will be produced; and how changes will be incorporated into the executable plan, EAC, etc.	**PP&C Integration**
CADRe Products: A formal project document that describes the programmatic, technical, LCC and cost/schedule risk information of a project. It describes a NASA project at specific milestones and provides a historical record of cost, schedule, and technical project attributes so that estimators can better estimate future analogous projects. The CADRe is an integrated product owned by the project manager that results from the LCR process. In addition to cost estimates and BOEs, a CADRe contains detailed programmatic data and technical descriptions. The NASA cost community assists in the compilation of the CADRe and ensures that the project constructs and provides a submission when required.	**Cost Estimation/Cost Assessment**
Center / Organization Rates: Current and projected rates by NASA Center for cost elements such as civil service labor, benefits, and facilities usage.	**External** (to Resource Management)**, Resource Management**

Input and Output Descriptions	Source Function
Change Requests: A request submitted to the CM/DM function to approve an initial release or a change to an item under configuration control. *(Note: This is provided as an input to the CM/DM function. The description above is from the corresponding CM/DM input. Each providing function may customize the description of its corresponding output.)*	**PP&C Integration, Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Risk Management, External**
CM/DM Plan: The CM/DM plan may be two separate documents, combined into one, or the information may be incorporated into other project documents such as the Project Plan, SEMP, or other documentation as appropriate. In general, the plan(s) includes descriptions of how items to be controlled are identified, how changes to baselines will be processed, if control boards are to be used and associated roles and responsibilities, how baseline data will be accounted for, how access to the information will be authorized, and the frequency and manner in which configuration audits will be conducted.	**Configuration and Data Management**
CM/DM Reports/Audits: Periodic reports on the status of the CM/DM items should be available to all stakeholders on an agreed-to frequency and at key LCRs.	**Configuration and Data Management**
Constraints and Ground Rules and Assumptions (GR&A): These include Mission Directorate and program constraints and GR&A levied on the project, including mission objectives, goals, and success criteria. They may also be derived from stakeholder expectations and project and programmatic requirements including the project budget and project funding and technical requirements. Constraints and GR&A may be documented in the FAD, the FA, DMs, MAs, and Program and Project Plans.	**External** (to PP&C Integration)
Contract Cost Plans: An estimate of when funds will be obligated to each of a project's applicable contracts and when work is expected to be completed for contractual costing purposes. For cost-reimbursable contracts, the contractor is required to submit a time-phased baseline cost plan. Proper funding of termination liability should be taken into consideration.	**Acquisition and Contract Management**

Input and Output Descriptions	Source Function
Contractor Deliverables: These include contractor financial management reports and contractor invoices, the WBS, WBS Dictionary, and baseline IMS, EVM deliverables when applicable, and other deliverables required by the contract. The financial management reports are the monthly and quarterly NF 533s or the contractor's invoices. See *NPD 9501.1, NASA Contractor Financial Management Reporting System* and *NPR 9501.2, NASA Contractor Financial Management Reporting* for more detailed information on NF 533 requirements. EVM deliverables include the IPMR. Other deliverables may include monthly progress reports. The Acquisition and Contract Management function accepts and reviews deliverables to ensure they are consistent with contract requirements and provides the deliverables to the Resource Management and Scheduling functions for analysis and assessment of contract performance.	**External** (to Acquisition and Contract Management)**, Acquisition and Contract Management**
Contract Pre-Award Documents and Products: This includes documented results of market research, PR packages and other inputs to solicitations including RFPs and RFQs. PP&C contributes to the following components of PR packages: financial requirements on contracts; SOW; identification of deliverables and delivery schedule; contract reporting requirements (CDRLs/DRDs); Government in-house cost estimate; WBS of the Government in-house cost estimate and cost charts; EVM requirements if applicable; evaluation criteria factors, instructions, and numerical weights; and identification of applicable NPDs and NPRs, etc. This information is provided to the Center Procurement Office and, upon request, to other PP&C functions, including the Cost Estimation/Cost Assessment function to facilitate development of the project's cost estimate.	**Acquisition and Contract Management**
Contracts: The project's contracts as awarded and/or as modified. Contracts are provided to other PP&C functions upon request, including the Cost Estimation/Cost Assessment function to facilitate development of the project's cost estimate. *(Note: This is both an External input to Acquisition and Contract Management, and an output from Acquisition and Contract Management to other PP&C functions.)*	**External** (to Acquisition and Contract Management), **Acquisition and Contract Management**
Contributions to Plans and Agreements: Contributions to the FA, Project Plan, Review Plan, and LCR ToR.	**PP&C Integration**

Input and Output Descriptions	Source Function
Control Account Plan: A CAP displays the control account scope and budget in time-phased work packages and planning packages, cost element visibility, and performance measurement techniques for each work package. It also reflects responsible performing organizations and includes at least one WBS charge number.	**Resource Management**
Cost Estimate & BOE: A documented, risk-adjusted forecast of future cost representing a specific scope of work. Features include (but are not limited to) the following: ○ **Cost Modeling Framework:** Every cost forecast is rendered by a data-driven algorithmic construct. There are three primary classes: ▪ *Analogy-based*: Scaling, augmenting, or otherwise simply adjusting an appropriate analogue data point. ▪ *Parametric*: Mining historical datasets to derive statistical relationships between cost and cost drivers (such as objectively measured complexity, mission characteristics, and level of realized heritage). ▪ *Engineering Build Up*: "The computation of the cost of (each) WBS element by estimating at the lowest level of detail (often referred to as the "work package" level) wherein the resources to accomplish the work effort are readily distinguishable and discernable." ○ **Total Variation in Forecasted Cost:** The cost estimate probability distribution resulting from simulation or analytical methods. Point estimates do not contain the full range of effects induced by discrete risks and classes of uncertainty, providing an incomplete picture of the universe of cost outcomes. Thus, it is codified Agency best practice to stochastically incorporate into the cost estimate's model all elements that contribute to total cost variation within a predetermined scope. Using a resultant cost distribution, a one-dimensional "confidence level" can be determined by assessing the cumulative probability of cost scenarios below a given budget figure. ○ **Milestones and Updates:** After the initial estimate is created, usually constructed using parametric or analogy methods, updates are made at milestones in the project's life cycle such as LCRs and rebaselining events (and in some cases, more often at the discretion of stakeholders). NPR 7120.5 requires the delivery of a cost estimate expressed as a range at KDP B and in the form	**Cost Estimation/Cost Assessment**

Input and Output Descriptions	Source Function
of a LCC at KDP C (alongside the cost-loading inherent to the JCL product). Along the way, PP&C should monitor the maturity of project data, which will dictate the appropriate methods of estimating. ○ **Basis of Estimate:** Generally, the BOE should provide "sufficient information (about) how the estimate was developed so that independent cost analysts—or other review team members—could reproduce the estimate" and understand the logic of how the estimate was derived. Key BOE elements here include: ▪ GR&A including content (e.g., performance period, work and major tangible elements, requirements, mission milestones), risk, and opportunity scope. ▪ A dossier of project data being used as model inputs including (if possible) other types of BOEs (e.g., for schedule, technical parameters, and risks). ▪ Detailed documentation of the cost estimating methods used including a traceable path between historical datasets and the models they drive. ○ **Cost Phasing:** A characterization of how costs (including FTEs, WYEs, and ODCs) are spread over the time scope of the estimate; that is, calibrated to the appropriate granularity (e.g., weeks, months, quarters, or years). Budget plans, often expressed in years, are sometimes compared to the estimate's cost phasing as part of the larger programmatic assessment.	
Current Baselines: Baselines of the current items that are on the CM-DM list are made available to all technical teams and stakeholders. These include the configuration baselines, the PMB, financial reporting, baselined IMS, budgets, and documentation.	**Configuration and Data Management**
Data Requests: Requests to the CM/DM function for any of the PP&C or other data under data control. *(Note: This is provided as an input to the CM/DM function. The description above is from the corresponding CM/DM input. Each providing function may customize the description of its corresponding output.)*	**PP&C Integration, Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management,**

Input and Output Descriptions	Source Function
	Risk Management, External
Data to be Stored: PP&C and other project data identified as needing to be stored at any time during the life cycle. *(Note: This is provided as an input to the CM/DM function. The description above is from the corresponding CM/DM input. Each providing function may customize the description of its corresponding output.)*	**PP&C Integration, Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Risk Management, External**
Decision Packages: The supporting organizations identify the amount of funding, workforce, and infrastructure that is needed to accomplish the responsibilities and tasks assigned to them by the project. These needs are documented in decision packages or other guidance documents and are supported with rationale. The project manager reviews and approves decision packages.	**External** (to Resource Management)
Decisions & Actions: Options and/or corrective actions approved for implementation by the project manager including associated decision packages. Plans for implementing, tracking, and reporting on the results of the options/corrective actions including: ○ Specific tasks, an implementation schedule, and responsible project organizations. ○ Expectations for when results will be realized including specific, quantified improvements and/or stability in integrated cost and schedule performance, EAC, and risk status performance over time. ○ Identification of any program, Mission Directorate, or Congressional approvals needed to implement the option/corrective action, including renegotiation of the project's MA and DM.	**PP&C Integration**
Descope Options: A list of candidate descope options developed early in the project life cycle. These options can provide an orderly process	**PP&C Integration**

Input and Output Descriptions	Source Function
should a reduction in scope be needed later during the life cycle of the project. PP&C Integration supports the development of candidate descope options and enables a systems view to ensure that all potential interactions are identified including impacts to cost, schedule, and risk. The project maintains the list of descope options, keeps records on descopes taken, and continues to solicit descopes to add to this list.	
Delivered Data: The requested data that was delivered to the authorized party.	**Configuration and Data Management**

Discrete Risks: Identified, documented potential events that each carry an estimated consequence and an associated likelihood (probability of occurrence). A discrete risk's information profile should contain the following characteristics: ○ **Risk Statement and Narrative Description**: According to the *NASA* *Risk Management Handbook*, each risk should contain the following: ▪ **Risk Statement**: "A concise description of an individual risk that can be understood and acted upon. Risk statements have the following structure: 'Given that [CONDITION], there is a possibility of [DEPARTURE] adversely impacting [ASSET], which can result in [CONSEQUENCE].' " ▪ **Narrative Description**: "Additional detail regarding the events, circumstances, and interrelationships within the activity that may affect the individual risk. This description is more detailed than can be captured in the risk statement." ○ **Risk Mitigation Plan**: As part of the initial risk identification, the risk owner may provide a plan for reducing the risk's consequences and likelihood to acceptable levels. This plan usually involves significant effort (e.g., cost, people, and time) outside the baseline project plan, although it may align with previously planned work in special cases. ○ **Cost and Schedule Consequences**: Among other types of consequences, these equate to the risk's impacts on the cost and schedule dimensions of a project's baseline plan. The severity of these impacts is usually expressed as scores calibrated to a project's risk matrix. In the ideal case, a risk owner, with potential involvement from the PP&C Risk Management, Cost Estimation/Cost Assessment, and Scheduling functions, should provide justified cost and schedule impact estimates (and their associated uncertainties) in addition to the matrix scores. Note that a newly "accepted" risk's cost consequences should be incorporated into project cost estimates and budget plans; likewise, the accepted schedule consequences should augment the baseline IMS and related schedules. ○ **Probability of Occurrence**: The probability ($0\% < p < 100\%$) that the consequences associated with the risk will be realized given the current state of risk mitigation (or lack thereof). Ideally, a properly crafted and executed mitigation plan will reduce the probability of occurrence to levels acceptable to the	**PP&C Integration, Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Configuration and Data Management, External**

Input and Output Descriptions	Source Function
project. The risk owner (or the Risk Management team itself) may choose to apply a degree of uncertainty to the probability of occurrence. ○ **Risk Response**: The preliminary or formal planned action associated with a risk. If the risk is already being addressed in some way before a formal response is adjudicated, the risk owner may provide a risk response to the Risk Management team for consideration. For example, if a risk's mitigation plan is already part of baseline work being executed, the risk owner may recommend "mitigate" as an appropriate initial response. Ideally, a risk response's status and related progress is tracked and reported on a regular basis. *(Note: This is provided as an input to the Risk Management function. The description above is from the corresponding Risk Management input. Each providing function may customize the description of its corresponding output. The Risk Management function also provides Discrete Risks as an output to other PP&C functions. The description of Discrete Risks as an output from Risk Management (see below) provides information on how the Risk Management function may modify the characteristics of Discrete Risks.)*	
Discrete Risks: The Risk Management team supported by the PP&C Risk Management function frames the body of risks for project management decision making and programmatic analyses. Each risk has the following characteristics, many of which may have been authored, examined, or modified by the Risk Management team after receipt from risk owners as inputs through the RMS: ○ **Risk Statement and Narrative Description**: These passages may be updated by the Risk Management team in the interest of clarity, technical accuracy, messaging salience, brevity, or some other justifiable end. ○ **Risk Mitigation Plan**: The official mitigation plan including the necessary resource and time allocations by project management may augment or replace that which may have been originally provided by the risk owner. Schedulers, resource managers, and cost estimators should include the scope of project-approved mitigation efforts into their analysis products. ○ **Cost and Schedule Consequences**: Scoring provided by risk owners may be updated by the Risk Management team in consultation with the Scheduling and Cost Estimation/Cost Assessment functions as a result of the risk analysis and review	**Risk Management**

Input and Output Descriptions	Source Function
process wherein benchmarking, subject matter consultation, or other insight-driven techniques could illuminate the most appropriate score values. The detailed cost and schedule consequence estimates should be incorporated into probabilistic frameworks maintained by several PP&C functions. ○ **Probability of Occurrence**: This may also be updated and used as above. ○ **Risk Response**: The Risk Management team will officially adjudicate the appropriate response and/or control action for each risk.	
Earned Value Management Analyses and Reports: For contracts, a project-level IPMR is typically provided on a monthly basis to provide technical, schedule, and cost status information. The purpose of the IPMR is to provide early identification of problems that may have significant cost, schedule, and/or technical impacts and report the effects of management actions and project status information for use in making and validating management decisions. Projects integrate contract IPMR, in-house, and other data to produce a project level IPMR.	**Resource Management**
EVM Implementation Plan: The EVM Implementation Plan establishes guidance for the effective application, implementation, and utilization of EVM on NASA projects. Projects describe how they will implement and scale the *NASA EVM System Description* identifying how the project EVM capability complies with the EVM requirements of the EIA-748 standard for EVMS. The plan includes the schedule and resources required to ensure proper and effective design, documentation, implementation, and maintenance of the management system.	**Resource Management**
Executable Plan (IMS, LCC, JCL, UFE): A recommended executable plan is provided to the Decision Authority in support of KDP C. The executable plan, with or without modification, is approved and authorized by the project's Decision Authority at KDP C. It captures the integrated set of technical, science, cost, schedule, resource, and facility requirements of the project in the WBS, schedule, resource baseline, and budget. The baseline IMS, LCC estimate, JCL, and UFEs are key elements of the executable plan. These products are also part of the ABC.	**PP&C Integration**
External Requirements, Governing NASA Policies: Applicable NPDs, NPRs, Federal regulations, Center policies, lessons learned, and best practices including Agency handbooks.	**External** (to PP&C Integration, Acquisition and

Input and Output Descriptions	Source Function
(Note: The description in each function identifies requirements and policies applicable to that function.)	Contract Management)
Governing NASA Policies: Applicable Agency NPDs, NPRs, Center policies, lessons learned, and best practices, including Agency handbooks. *(Note: The description in each function identifies policies applicable to that function.)*	**External** (to Cost Estimation/Cost Assessment, Resource Management, Risk Management, Scheduling)
Hardware/Software Configurations: The current and historical composition of the hardware and software including software version number and operating system, hardware serial numbers, changes that have been incorporated since the last version, and other documentation as needed to fully describe the item under configuration control.	**External** (to Configuration and Data Management)
Historical Cost Benchmarks: PP&C should equip itself with historical information on which it may base cost models and against which it may benchmark resultant cost estimates. Ideally, PP&C should gain access to a cost knowledge base, either formal (such as the ONCE or REDSTAR databases) or semi-formal, from which it may distill normalized cost and supporting data and draw conclusions. (A notional example: *History shows that avionics hardware and software complexity tends to drive cost more than simple structural components of spacecraft.*) Among the useful dimensions of comparison are technical, schedule, and risk information. Using history as a benchmark, PP&C can provide context for cost analyses.	**External** (to Cost Estimation/Cost Assessment)
Historical Risk Benchmarks: The PP&C Risk Management function should equip itself with historical risk information against which it can benchmark a project's identified risks. Ideally, access should be gained to a risk knowledge base, either formal or semi-formal, from which normalized risk treatment guidance can be distilled and conclusions drawn. (A notional example: *Avionics hardware and software tend to have more identified risks than simple structural components of spacecraft.*) Among the useful dimensions of comparison are risks' cost consequence, schedule consequence, likelihood, and mitigations plans. The use of history as a benchmark provides context for risk management and risk-intensive analyses.	**External** (to Risk Management)

Input and Output Descriptions	Source Function
Historical Schedule Benchmarks: If available, the schedule development process should make use of historical schedule databases at each NASA Center. This data can be used to validate task duration estimates and analyze scheduling logic of similar types of projects and schedule activities.	**External** (to Scheduling)
IMS/IMS Status: The IMS/IMS status and progress updates for work performed in-house, by contractors, and by other implementation entities. The baseline IMS is the end result of the IMS development process and is the project management-approved schedule to be used in guiding project implementation and measuring project performance. Management approved additions/deletions and revisions are captured in the IMS status update. Changes to the baseline IMS are configuration-controlled.	**Scheduling**
Infrastructure Planning Information: All Center equipment, facilities, technical capability, and other services required for project completion, identified for each project life-cycle phase by fiscal year. The PPBE process enables negotiation of any differences considering conflicts identified by the Resource Availability Conflicts input and Center and Mission Directorate guidance.	**Resource Management**
Infrastructure Requirements: The facilities, aircraft, personal property, equipment, environmental, and information technology resources that are needed to support the project. Facility requirements may include modification or upgrade of existing facilities to modify capability or increase capacity.	**External** (to Resource Management)
Initial Risk List: The initial set of risks to be accounted for in the PP&C analyses, including integrated cost and schedule estimates that characterize the executable plan. *(Note: This is an output from both functions. The Risk Management function's description includes additional information on how the list is derived.)*	**PP&C Integration, Risk Management**
Inputs to Performance Evaluations: Periodic evaluations are conducted by the CO, COR, and project to assess contractor performance. PP&C provides inputs to these performance evaluations that include but are not limited to quality of work, cost performance, timely performance, effectiveness of management, compliance with labor standards, and compliance with safety standards.	**Acquisition and Contract Management**

Input and Output Descriptions	Source Function
Integrated Change Package: Evaluation of a requested change to an item under change control. Package includes a description of the change; project organizations that evaluated the change; impacts of the change on other project products, activities, and documentation; and impacts to the project's cost, schedule, and risk. The package is reviewed for approval or disapproval by the appropriate project control board/ decision maker. *(Note: This is provided as an input to the CM/DM function. The description above is from the corresponding CM/DM input. Each providing function may customize the description of its corresponding output.)*	**PP&C Integration, Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Risk Management, External**
Integrated Cost and Schedule Baseline: The integrated cost and schedule baseline is established based on the cost, schedule, and UFE for which the project manager has management control. This cost, schedule, and UFE is documented in the KDP C MA per the KDP DM. The integrated cost and schedule baseline needs to be consistent with the available funding plan. This baseline becomes the foundation against which the project's cost and schedule performance is assessed, adjustments are made, and EACs are developed. (This project-level integrated cost and schedule baseline is not to be confused with the PMB. A subset of this baseline without UFE allocated and specific for a particular contract or at the project level is often referred to as the PMB.)	**Resource Management**
Internal Task Agreements: Documented agreements and commitments with Center organizations for the work to be performed including scope of work, receivables/ deliverables, schedule, budget, assumptions, and other information as required such as EVM reporting.	**External** (to Resource Management)
Issues, Recommendations and Opportunities: Issues, recommendations, and opportunities may be identified by external entities (including the project, program, Mission Directorate, Agency) and any of the PP&C functions. Issues include project and external events and situations that may affect the project's cost and schedule performance. Recommendations include proposed approaches for addressing identified issues, and are inputs for developing options and/or corrective actions for controlling cost and schedule performance. Opportunities include proposals for improving cost and schedule performance.	**Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Risk Management, Configuration and Data**

Input and Output Descriptions	Source Function
○ Examples of project events include adverse trends in technical performance measures, and an inability to develop planned technologies. It is essential to work closely with the entire project team to quickly identify issues and to help project coworkers better understand the interrelationships between technical events and the project's cost and schedule. ○ Examples of external events include an unexpected change to the project's funding profile, nationwide industry issues, and changes in the contractor's business profile. ○ Examples of opportunities range from leveraging beneficial external events, to taking innovative approaches to doing business, to capitalizing on identified synergies with another project. *(Note: This is provided as an input to the PP&C Integration function. The description above is from the corresponding PP&C Integration input. Each providing function may customize the description of its corresponding output.)*	**Management, External**
Items to be Controlled: Programmatic information that needs to be placed under change control. This information may include cost baselines, the baseline IMS, Control Account Plans (CAPs), phasing plans, contract deliverables, cost trade-off analysis, and other risk and procurement documents identified and needing to be baselined. *(Note: This is provided as an input to the CM/DM function. The description above is from the corresponding CM/DM input. Each providing function may customize the description of its corresponding output.)*	**PP&C Integration, Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract Management, Risk Management, External**
JCL Analysis: According to NPR 7120.5, JCL is defined as a "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 Phase D." By being "risk-informed," the characteristic of having mapped all discrete risks and classes of uncertainty within scope to JCL model elements, the JCL intends to ensure that adequate budgets and schedules are reflected in the Project Plan. Only a certain subset of projects requires a JCL. According to NPR 7120.5, at KDP C, projects with an estimated LCC greater than $250 million are required to develop a RLS	**Cost Estimation/ Cost Assessment**

Input and Output Descriptions	Source Function
and perform a “risk-informed” probabilistic analysis that produces a JCL.	
KDP Decisions, Decision Memoranda (DM), and Management Agreements (MA): At KDPs, the Decision Authority decides whether and how the project progresses in its life cycle; authorizes the project cost, schedule, and content parameters that govern remaining life-cycle activities; and assigns actions if needed. (See NPR 7120.5, Section 2.3.1 for a definition of the Decision Authority.) KDP decisions and actions are recorded in the KDP DM. The MA is part of the DM and defines the parameters including cost and schedule and authorities for which the project manager has management control and accountability. The KDP C DM and MA establish the project’s ABC, JCL levels at which the project will be budgeted and funded (which may be different), and UFE that will be held at the project level and above the project level.	**External** (to PP&C Integration, Resource Management)
List of Controlled CM/DM Items: A list of the products that will be under either configuration or data management (also known as the Configuration Item List).	**Configuration and Data Management**
Monthly Integrated Performance and Analysis Reports: Current integrated cost and schedule performance, trends and variances, and the project’s risk posture; analyses of cost and schedule variances and trends; identification of data correlations and causal relationships, key drivers and sensitivities; and status of UFE, liens, and threats.	**PP&C Integration**
OBS: The OBS or organizational structure displays the organizational relationships and uses them for assigning work in a project, providing an organizational structure for the project.	**Resource Management**
Operating Plans: Operating plans are the funding execution plans after the annual appropriations levels are received based on Mission Directorate guidance. Plans may be revised as needed during the year. Revisions to operating plans require approval.	**Resource Management**
Other Factors Influencing Cost: There are many ancillary elements that should be factored into cost analyses as appropriate. These include but are not limited to the following items: ○ General economic conditions such as those that drive certain commodities and labor rates. ○ Local economic conditions such as the availability of a contractor’s workforce and contract pricing.	**External** (to Cost Estimation/Cost Assessment)

Input and Output Descriptions	Source Function
○ Domestic and foreign political economic factors such as commodity prices, budget "austerity" efforts, and change of Presidential and Agency administrations.	
Partnership Milestones: Partnership milestones establish the dates associated with partnerships such as when partnerships need to be executed and when partners are expected to complete events or international partners are expected to provide project deliverable(s). Partnership milestones may be identified within the baselined IMS.	**PP&C Integration**
Performance Metrics: Performance metrics are project measurements that communicate vital information about the status or performance of a system, process, or activity for contractor and in-house efforts. *(Note: The description in each function is customized based on how the function uses this External input.)*	**External** (to Resource Management, Scheduling)
Performance Reports: A comparison of actual versus planned obligations, actual versus planned accomplishments, costs, WYE, and FTE with corresponding characterization of notable variances. These reports should include estimates for status of UFE, liens and threats, accrued costs, cost-to-go, assessment of work accomplished, cumulative cost and schedule impacts of risks, EAC based on current trends and identified variances, and identification of data correlations and causal relationships, key drivers, and sensitivities. (When performance issues appear in the data, the performance report should include specific identification of the troubled contract or activity.)	**Resource Management**
Planned Partnerships: Partnerships planned by the project. This information is used to facilitate identification of the appropriate NPDs and NPRs and selection of the appropriate type of agreement. For each planned partnership, information includes identification of the partner and beneficiaries, whether or not foreign entities are involved, description of the partner's responsibilities. and description of NASA's responsibilities (including provision of personnel, facilities, and laboratories), etc.	**External** (to PP&C Integration)
PP&C Management and Control Plan: This plan is an optional, project-level document intended to support an integrated, organized summary of a project's PP&C activities in one document. The plan provides an overview of the PP&C organization and describes the guidelines and processes to be used for the different PP&C activities. Activities addressed in the plan include resource and funds management,	**PP&C Integration**

Input and Output Descriptions	Source Function
work management, cost estimation and schedule development, and schedule, cost, and integrated performance management.	
PPBE Submission: The Planning, Programming, Budgeting, and Execution (PPBE) process of resource alignment and control is a comprehensive, top-down approach to support the Agency's vision and mission. It includes complete budget formulation, development of fully executable Agency operating plans and execution plans, and ends with execution of the budget during performance. The submission for the current PPBE cycle includes the New Obligation Authority (NOA) required for project-budgeted resources, the ensuing year (draft operating plan), the budget request year, and forward leaning budgets reflecting a total life-cycle requirement. It also includes overguide requests and rationale. The content of the PPBE submission is codified in the N2 data collection system (per Mission Directorate guidance), which itemizes the NOA in terms of procurements dollars, FTE, and travel.	**Resource Management**
Product Requests: Requests for products from the other PP&C functions for support of internal reviews, independent reviews such as LCRs, KDPs, audits, and external reports.	**PP&C Integration**
QRA: Quantitative Risk Analysis (QRA) is a risk-intensive method for probabilistically summarizing risks for use in UFE assessment, resource management, cost estimating, and other PP&C-related activities.	**Risk Management**
RAM: An intersection of the WBS and the OBS, the Responsibility Assignment Matrix (RAM) describes the participative roles in completing tasks or deliverables for a project. The RAM is especially useful in clarifying roles and responsibilities for the support provided by matrix organizations.	**Resource Management**
Recommended Changes to Plans and Products: Recommendations to other PP&C functions for changes and/or adjustments to their plans and products.	**PP&C Integration**
Requested Products: Products from the other PP&C functions needed to support internal reviews, independent reviews such as LCRs, KDPs, audits, and external reports. *(Note: This is provided as an input to the PP&C Integration function. The description above is from the corresponding PP&C Integration input. Each providing function may customize the description of its corresponding output.)*	**Resource Management, Scheduling, Cost Estimation/ Cost Assessment, Acquisition and Contract**

Input and Output Descriptions	Source Function
	Management, Risk Management, Configuration and Data Management
Requirements for Acquisition: Requirements for procurements to facilitate the identification of the appropriate FAR and NFS regulations, Agency policies, requirements, directives, and procedures for inclusion in the solicitation and resulting contract. Requirements include technical, safety mission assurance, EVM, environmental, quality assurance, risk management, IT, IT security, physical security, health security, property, export control, etc.	**External** (to Acquisition and Contract Management)
Resource Availability Conflicts: RLSs provide the capability for over-allocation reporting, which can identify those tasks where resource conflicts exist. If manual processes are used to integrate resources and schedule, similar reporting is possible but can be much more difficult to produce.	**Scheduling**
Resource Phasing: If the IMS is resource-loaded, it provides time-phased requirements for labor, material, and equipment. RLSs help to ensure cost and schedule integration and provide the resource requirements needed to ensure that project resources are available.	**Scheduling**
Review and Audit Results: Review team (e.g., SRB) reports including findings and recommendations. Audit final reports including findings and agreed-to actions.	**External** (to PP&C Integration)
Review, Audit, External Report Products: Products provided to review teams for internal and independent reviews, to the project's Decision Authority for KDPs, to audit leads for GAO, OIG, and other audits, and to the OCFO and the project's Mission Directorate for the quarterly data call, GAO DCIs, and external reports.	**PP&C Integration**
Risk Management Plan (RMP): The project-level control document detailing how each risk management process step will be carried out in accordance with technical provisions and intra-project coordination guidelines. An RMP also includes but is not limited to the following elements: ○ Identification and analysis of stakeholders (e.g., Agency management, project management, Mission Directorate	**Risk Management**

Input and Output Descriptions	Source Function
personnel, SRBs, etc.) as well as a detailed characterization of risk information needs. ○ Identification of risk-intensive analyses to be performed during each CRM cycle. ○ Development of a RMS that adheres to the CRM process. ○ Establishment of risk tolerance criteria, thresholds, and elevation protocols (the specific conditions under which a risk management decision must be elevated through management to the next higher level). ○ Delineation of the processes for coordination of risk management activities and sharing of risk information with other affected organizational units. ○ Establishment of risk communication protocols between management levels including the frequency and content of reporting as well as identification of entities that will receive risk tracking data from the unit's risk management activity. The Risk Management team develops the RMP with support from the PP&C Risk Management function. A preliminary RMP is developed before the first RIDM iteration is executed to help guide the project's nascent risk evaluation process. The RMP is provided to PP&C Integration for review and comment prior to approval.	
Schedule Analysis Reports: Examples of typical analysis reporting include schedule health check, critical path analysis, schedule performance and work-off trend, BEI, CEI, HMI, total slack analysis, schedule milestone comparison, schedule margin tracking, etc. Additional descriptions and illustrations of the above formats are found in *NASA/SP-2010-3403*, *NASA Schedule Management Handbook*, Chapter 7.	**Scheduling**
Schedule Estimates & BOE: The schedule estimates and schedule BOE are outputs of the schedule planning phase and a specific requirement stated in NPR 7120.5. During project Formulation, the schedule estimates are continually updated as the design matures. Assumptions in the development of the schedule are documented in the schedule BOE. Schedules are baselined prior to project implementation. A one-dimensional schedule CL is provided with the preliminary schedule range estimate developed for KDP B.	**Scheduling**

Input and Output Descriptions	Source Function
Schedule Risk Assessment (SRA): An SRA is a forecast resulting from the stochastic simulation of the IMS or an analysis schedule whose tasks are loaded with duration uncertainty and discrete schedule risks. SRA results include but are not limited to the following reports: ○ Resultant distributions that measure variability of an ultimate project end date, such as a hardware delivery or launch date, or interim milestones or tasks. ○ Top schedule risks in terms of impact on milestones, criticality, or other metrics. ○ Other analyses including sensitivity of downstream schedule elements to the variability of tasks or milestones, correlation among tasks, and a characterization of schedule reserve relative to schedule targets.	**Scheduling**
Schedule Management Plan: This plan may be established as a standalone document or as a specified section within the Project Plan. The key topics included are the scheduling approach, roles and responsibilities, tools to be used, IMS development processes, update and maintenance processes, analysis techniques, IMS baseline control, reporting formats, and data archival.	**Scheduling**
Stakeholder Expectations: The needs and objectives of the customer (project manager, program, Mission Directorate, and Agency) and other key stakeholders including anticipated products or support expected from the PP&C organization. The stakeholders' expectations need to be documented, and it is important to ensure a common understanding of the expectations between the customer, other key stakeholders, and the PP&C team. *(Note: The description in each function is customized based on how the function uses this External input.)*	**External** (to Cost Estimation/Cost Assessment, PP&C Integration, Risk Management)
Strategic Programming Guidance: Flowing from the Agency's OCFO through the Mission Directorates, budget guidelines as part of the PPBE process are updated annually to support the February release of the President's Budget Request to Congress for the upcoming fiscal year appropriations. The *Strategic Programming Guidance (SPG)* provides high-level resource guidance that includes the initial funding controls based on decisions from a SPG senior managers' review of new or open issues, disconnects, revisions needed to address OMB settlement, and the ASP review. The SPG provides high-level program and institutional guidance on the strategic priorities, directions, and assumptions to	**External** (to Resource Management)

Input and Output Descriptions	Source Function
develop budgets and performance measurements. The SPG is focused on the budget year + 4 out years and can request data for projects extending into the future and plan for new initiatives, but it is not used to review competitive project selection within existing programs. The resulting Agency guidance is coordinated with and released to the Mission Directorates as a data call to projects to provide budget estimates into the PPBE process (assumptions, deadlines, and formats).	
Technical Requirements, Concepts, Architecture, and Designs: Quantitative and qualitative descriptions of the project technical characteristics from which cost estimates will be derived. The nature of the input details required will likely vary based upon the cost modeling framework chosen. The project technical description should identify any area or issue that could have a major cost impact (e.g., risks) and therefore needs to be addressed by the Cost Estimation/Cost Assessment function.	**External** (to Cost Estimation/Cost Assessment)
Technical Requirements, Concepts, Architecture, and Designs: PP&C practitioners translate these inputs into acquisition, cost, resources, and time-phasing requirements, which in turn provide the basis for the acquisition strategy, budget requests, the project schedule, and resource needs. The realism of the business approach and requirements is dependent on the interrelationship of the project management, technical, and business aspects of project planning.	**External** (to PP&C Integration)
Technical Requirements, Concepts, Architecture, and Designs: Examples that drive the schedule include the project work scope, mission concepts, trade studies, system requirements, test and verification requirements, safety requirements, hardware and software specifications, system design, interface design, tooling requirements/design, manufacturing standards, unique project assumptions, known risks, etc. These inputs should be clearly articulated by the project technical team and incorporated into the project IMS. The project work scope may be identified in the Project Plan or in a collection of other project documents (e.g., Acquisition Plan, verification plan, request for proposal, contracts, WBS/WBS Dictionary, etc.). A clear understanding of the work content is necessary before a valid schedule can be developed. Inputs include realistic task duration estimates, proper task sequencing, and valid constraints that impact work flow. Other project-specific inputs that may affect schedule development and control can be gleaned from the various project work scope documents. These inputs should be clearly articulated and vetted with the TPOC that is the closest possible to the work being performed.	**External** (to Scheduling)

Input and Output Descriptions	Source Function
Technical Requirements, Concepts, Architecture, and Designs: PP&C practitioners translate these inputs into acquisition, cost, resources, and time-phasing requirements, which in turn provide the basis for the acquisition strategy, budget requests, the project schedule, and resource needs. The realism of the business approach and requirements is dependent on the interrelationship of the project management, technical, and business aspects of project planning. Salient risks associated with the potential inability of the designs and architecture to adhere to requirements and other programmatic constraints should be the centerpiece of continuing discussion.	**External** (to Risk Management)
Top Risk Lists: Top risk lists are key among the various risk analysis products. In some sense, these call out drivers that are the greatest contributors to select dimensions of a project's performance risk including cost and schedule. These lists can be generated using several methods including SRA.	**Risk Management**
UFE, Liens, and Threats Trends: A comparison of available UFE versus the risk list, often described in terms of threats, liens, and sometimes, encumbrances. A threat is a risk that might be realized and needs to be watched. A lien is a threat that is likely to be realized or has been realized and may require additional funding or use of UFE. A lien identifies a specific task, a justification, and a cost and schedule impact. Encumbrance is the process by which a hold against UFE is made. The money has not necessarily been moved yet to the account that created the need, but the hold has been placed. Encumbrance is a monetary amount associated with a lien. Trend data is useful on these measures.	**Resource Management**
Unallocated Future Expenses (UFE) Targets: 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 the scope of probabilistic risk and uncertainty. NASA policy closely ties project UFE determination to JCL analysis. According to policy, Mission Directorates are required to plan projects based on a 70 percent JCL to ensure funding (which is in no case less than the equivalent of a 50 percent JCL) for projects is consistent with the MA. It is prudent for projects not subject to the JCL requirement to nevertheless justify their desired levels of UFE to the Decision Authority at life-cycle milestones.	**Cost Estimation/ Cost Assessment**
Work Breakdown Structure and WBS Dictionary: The WBS is a product-oriented family tree that decomposes the scope of work into manageable segments to facilitate planning and control of cost,	**Resource Management**

Input and Output Descriptions	Source Function
schedule, and technical content. The WBS Dictionary is a document that describes the work content of each WBS element in product-oriented terms and relates each element to the respective, progressively higher levels of the structure.	
Workforce Planning Information: The number of civil service FTEs and contractor WYEs required for each fiscal year. The PPBE process enables negotiation of any differences considering conflicts identified by the Resource Availability Conflicts input and Center and Mission Directorate guidance.	**Resource Management**

Appendix F: N-Squared Diagram of Inputs and Outputs

The inputs and outputs from each of the seven PP&C functions can be represented in an "N by N" format that shows all the inputs and outputs of each function in a consolidated format. Using this format, one can easily trace outputs going to other functions as inputs. To read the diagram, a function's output is read along the rows and its inputs are in the columns. For example, as shown in Figure F-1, the information that would be contained in the square with the "X" would represent the outputs of the Acquisition & Contract Management function that would be passed to the Risk Management function as an input to that function.

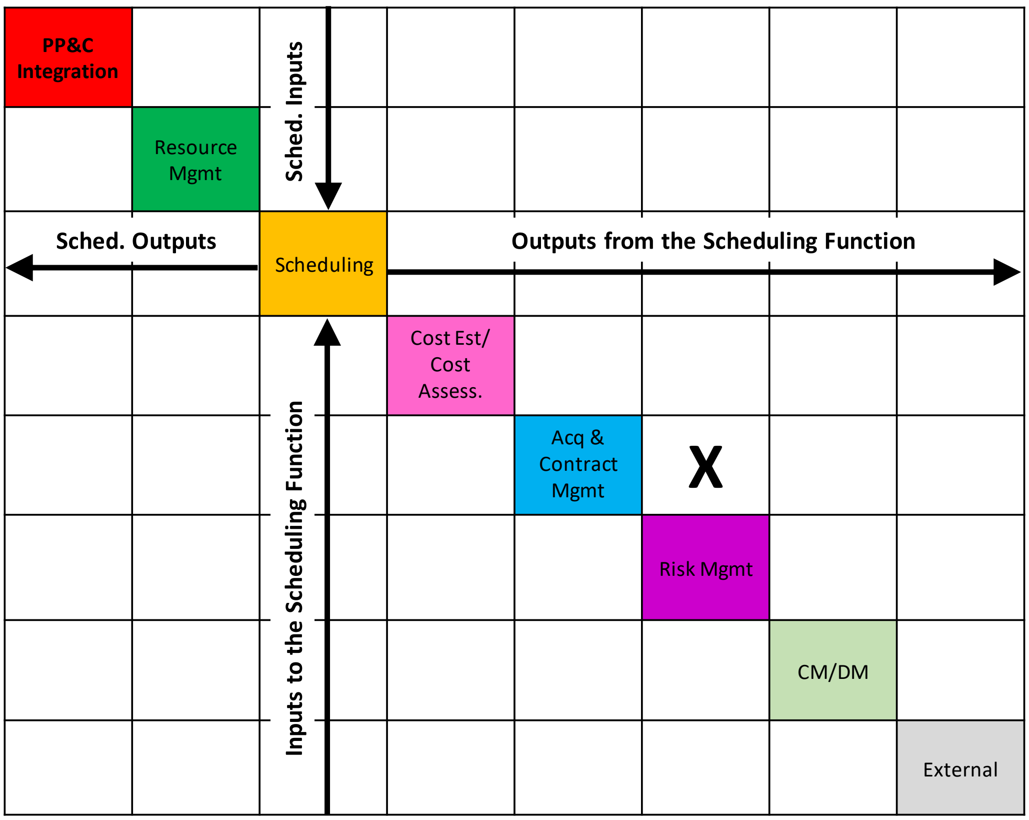


Figure F-1 Reading an N-Squared Diagram

Table F-1 depicts the N-Squared diagram for the seven PP&C functions and indicates the expected inputs and outputs to other organizations and functions outside of PP&C. Due to its length, the table is broken into several parts.

Table F-1 N-Squared Diagram for the PP&C Functions

	Resource Management	Scheduling	Cost Estimation/Cost Assessment	Acquisition & Contract Management	Risk Management	CM/DM	External
PP&C Integration	Planning • Applicable Requirements, Constraints, GR&A, Stakeholder Expectations • Executable Plan (IMS, LCC, JCL, UFE) • Acquisition Strategy • PP&C Management and Control Plan • Recommended changes to Plans and Products • Product requests • Partnership Milestones Control • Monthly Integrated Performance and Analysis Reports • Assessment Results & Recommendations • Decisions & Actions • Adjusted Plans • Product requests	Planning • Applicable Requirements, Constraints, GR&A, Stakeholder Expectations • Executable Plan (IMS, LCC, JCL, UFE) • Acquisition Strategy • PP&C Management and Control Plan • Recommended changes to Plans and Products • Product requests • Partnership Milestones Control • Monthly Integrated Performance and Analysis Reports • Assessment Results & Recommendations • Decisions & Actions • Adjusted Plans • Product requests	Planning • Applicable Requirements, Constraints, GR&A, Stakeholder Expectations • Executable Plan (IMS, LCC, JCL, UFE) • Acquisition Strategy • PP&C Management and Control Plan • Recommended changes to Plans and Products • Product requests • Partnership Milestones Control • Monthly Integrated Perf. & Analysis Reports • Assessment Results & Recommend. • Decisions & Actions • Adjusted Plans • Product requests	Planning • Applicable Requirements, Constraints, GR&A, Stakeholder Expectations • Executable Plan (IMS, LCC, JCL, UFE) • Acq. Strategy • PP&C Mgmt. & Control Plan • Recommended changes to Plans and Products • Product requests • Partnership Milestones Control • Monthly Integrated Perf. & Analysis Reports • Assessment Results & Recommend. • Decisions & Actions • Adjusted Plans • Product requests	Planning • Applicable Req, Constraints, GR&A, Stakeholder Expectations • Executable Plan (IMS, LCC, JCL, UFE) • Acq. Strategy • PP&C Mgmt & Control Plan • Recommended changes to Plans and Products • Product requests • Discrete Risks • Partnership Milestones Control • Monthly Integrated Perf. & Analysis Reports • Assessment Results & Recommend. • Decisions & Actions • Adjusted Plans • Product requests • Discrete Risks	Planning • Recommended changes to Plans and Products • Items to be Controlled • Data to be Stored Control • Data Requests • Items to be Controlled • Data to be Stored • Baseline Approval Request ~~Approval~~ • Change Requests • Integrated Change Package	Planning • Executable Plan (IMS, LCC, JCL & UFE) (Recommended) • Acquisition Strategy • Partnership Milestones • Initial Risk List • Contributions to Plans and Agreements • Business Decisions • PP&C Management and Control Plan • Descope Options • Review, Audit, External Report Products Control • Monthly Integrated Performance and Analysis Reports • Assessment Results & Recommendations • Decisions & Actions • Adjusted Plans • Review, Audit, External Report Products

PP&C Integration			Cost Estimation/Cost Assessment	Acquisition & Contract Management	Risk Management	CM/DM	External
<u>Planning</u> • WBS/WBS Dictionary, OBS, RAM • Budget, Workforce and Infrastructure Planning Information • EVM Implementation Plan • PPBE Submission • Operating Plans • Integrated Cost and Schedule Baseline • Requested products <u>Control</u> • Annual Phasing Plan • EVM Analyses/Reports • Performance Reports • UFE, Liens, and Threats Trends • PPBE Submission, Operating Plans • Issues, Recommendations and Opportunities • Requested products	**Resource Management**	• WBS/WBS Dictionary • OBS • Budget, Workforce, and Infrastructure Planning Information • Annual Phasing Plan • Performance Reports • EVM Implementation Plan • EVM Analyses/Reports • Center/ Org Rates • Integrated Cost and Schedule Baseline	• WBS/WBS Dictionary • Annual Phasing Plan • EVM Analyses/Reports • Center/ Organization Rates • Integrated Cost and Schedule Baseline	• WBS/WBS Dictionary • Annual Phasing Plan • Performance Reports	• EVM Analyses/ Reports • WBS/WBS Dictionary • Annual Phasing Plan • Discrete Risks	• Data Requests • Items to be Controlled • Data to be Stored • Baseline Approval Requests • Change Requests • Integrated Change Package	• OBS, RAM • PPBE Submission • Integrated Cost and Schedule Baseline • Operating Plans • Control Account Plan • EVM Implementation Plan
<u>Planning</u> • Schedule Estimates & BOE • Schedule Management Plan • Requested products <u>Control</u> • IMS/IMS Status • Schedule Analysis Reports • Issues, Recommendations and Opportunities • Requested products	• IMS/IMS Status • SRA • Schedule Analysis Reports • Resource Phasing • Resource Availability Conflicts	**Scheduling**	• SRA • Analysis Schedule • IMS/IMS Status	• Acquisition Milestones	• Discrete Risks • Schedule Analysis Reports • SRA	• Data Requests • Items to be Controlled • Data to be Stored • Baseline Approval Requests • Change Requests • Integrated Change Package	• Schedule Management Plan • IMS /IMS Status • Schedule Analysis Reports

PP&C Integration	Resource Management	Scheduling				CM/DM	External
Planning • Cost Estimate & BOE • JCL Analysis & UFE Targets • Requested products Control • Cost Estimate & BOE • Issues, Recommendations and Opportunities • Requested products	• Cost Estimate & BOE • JCL Analysis & UFE Targets	• Cost Estimate & BOE • JCL Analysis & UFE Targets	**Cost Estimation/Cost Assessment**	• Historical Cost Benchmarks	• Discrete Risks • Cost Estimate & BOE • JCL Analysis & UFE Targets	• Data Requests • Items to be Controlled • Data to be Stored • Baseline Approval Requests • Change Requests • Integrated Change Package	• Cost Estimate & BOE • JCL Analysis & UFE Targets • CADRe Products
Planning • Acquisition Timeline • Acquisition Plan • Requested products Control • Issues, Recommendations and Opportunities • Assessments of Proposed Contract Modifications • Requested products	• Acquisition Plan • Acquisition Timeline • Contract Cost Plans • Contractor Deliverables	• Acquisition Milestones • Acquisition Timeline • Contractor Deliverables	• Acquisition Plan • Contract Pre-Award Documents and products • Contracts	**Acquisition & Contract Management**	• Acquisition Timeline • Discrete Risks	• Data Requests • Items to be Controlled • Data to be Stored • Baseline Approval Requests • Change Requests • Integrated Change Package	• Acquisition Plan • Contract Pre-Award Documents & Products • Inputs to Performance Evals • Assessments, Issues, Recommendations, Decisions • Assessments of Proposed Contract Modifications
Planning • Initial Risk List • Discrete Risks • QRA • Risk Management Plan • Requested products Control • Top Risk Lists, Discrete Risks, QRA • Issues, Recommendations and Opportunities • Requested products	• Discrete Risks • QRA	• **Discrete Risks**	• Discrete Risks • QRA	• Discrete Risks	**Risk Management**	• Data Requests • Items to be Controlled • Data to be Stored • Baseline Approval Requests • Change Requests • Integrated Change Package	• Top Risk Lists • Risk Management Plan

PP&C Integration	Resource Management	Scheduling	Cost Estimation/Cost Assessment	Acquisition & Contract Management	Risk Management		
Planning • CM/DM Plan • List of Controlled CM/DM items • Current Baselines Control • Approved Changes • CM/DM Reports/Audits • Issues, Recommendations and Opportunities • Delivered Data	• CM/DM Plan • Approved Changes • List of Controlled CM/DM Items • Current Baselines • CM/DM Reports/Audits • Delivered Data	• CM/DM Plan • Approved Changes • List of Controlled CM/DM Items • Current Baselines • CM/DM Reports/Audits • Delivered Data	• CM/DM Plan • Approved Changes • List of Controlled CM/DM Items • Current Baselines • CM/DM Reports/Audits • Delivered Data	• CM/DM Plan • Approved Changes • List of Controlled CM/DM Items • Current Baselines • CM/DM Reports/Audits • Delivered Data	• CM/DM Plan • Approved Changes • List of Controlled CM/DM Items • Current Baselines • CM/DM Reports/Audits • Delivered Data • Discrete Risks	**CM/DM**	• CM/DM Plan • Approved Changes • List of Controlled CM/DM Items • Current Baselines • CM/DM Reports/Audits • Delivered Data
Planning • External Requirements, Governing NASA Policies, Constraints, GR&A, Stakeholder Expectations • Technical Requirements, Concepts, Architecture, Designs • Review and Audit Results • KDP Decisions, DMs, MAs • ASM results • Planned Partnerships Control • Updated Constraints, GR&A, Stakeholder Expectations • Review and Audit Results • KDP Decisions, DMs, Mas • Issues, Recommendations and Opportunities	• Governing NASA Policies • Strategic Programming Guidance • KDP Decisions, DMs, MAs • Decision Packages • Infrastructure Requirements • Internal Task Agreements • Performance Metrics • Center/Organization Rates	• Governing NASA Policies • Technical Requirements, Concepts, Architecture and Designs • Historical Schedule Benchmarks • Performance Metrics	• Governing NASA Policies • Other Factors Influencing Cost • Stakeholder Expectations • Technical Requirements, Concepts, Architecture and Designs • Historical Cost Benchmarks	• External Requirements, Governing NASA Policies • ASM Results • Requirements for Acquisition • Contracts • Contractor Deliverables	• Governing NASA Policies • Stakeholder Expectations • Technical Requirements, Concepts, Architecture and Designs • Historical Risk Benchmarks • Discrete Risks	• Data Requests • Items to be Controlled • Hardware/ Software Configurations • Data to be Stored • Baseline Approval Requests • Change Requests • Integrated Change Package	**External**

Appendix G: PP&C Management and Control Plan

The PP&C Management and Control Plan is an optional, project-level document intended to support an integrated, organized summary of a project's PP&C activities in one place. This consolidation of information might be considered roughly equivalent to the Systems Engineering Management Plan (SEMP) but encompasses the project's PP&C efforts. Supplying this plan as part of the project's retrievable documents is an option for meeting the NPR 7120.5 requirements for PP&C schedule and cost control plans.

In this plan, the project's PP&C team describes the guidelines and processes to be used for the different PP&C activities, e.g., schedule management. If the project plans to use applicable Agency and/or Center institutional guidelines and processes, they may be described or referenced. The project's Schedule Management Plan and Earned Value Management (EVM) Implementation Plan, when applicable, may also be referenced.

The PP&C Management and Control Plan is prepared by the PP&C integration manager with input from the Resource Management, Cost Estimation/Cost Assessment and Scheduling leads, and approved by the project manager. The PP&C Management and Control Plan is preliminary at KDP B and baselined at the end of Phase B for KDP C.

PP&C Management and Control Plan Template

Table of Contents

4.0 Cost Estimation
4.1 Roles and Responsibilities
4.2 Estimating Methodologies
4.3 Basis of Estimate
4.4 Independent Cost Assessments and CADRe

5.0 Schedule Development and Management
5.1 Roles and Responsibilities
5.2 Schedule Products
5.2.1 Integrated Master Schedule
5.2.2 Basis of Estimate
5.2.3 Schedule Risk Assessment
5.2.4 Analysis/JCL Schedule
5.3 Managing the Schedule
5.3.1 Updating the Schedule
5.3.2 Schedule Margins
5.3.3 Schedule Metrics
5.3.3.1 Health checks
5.3.3.2 Indices
5.3.4 Critical Path Analysis
5.3.5 Schedule Performance Evaluation and Reporting
5.3.6 Configuration Control and Change Management

6.0 Cost and Integrated Performance Management
6.1 Roles and Responsibilities
6.2 Integrated Cost and Schedule Products
6.2.1 Integrated Cost and Schedule Baseline
6.2.2 Estimate at Completion
6.2.3 JCL Analysis and UFE Targets
6.3 Managing Integrated Cost and Schedule Performance
6.3.1 Updating Performance
6.3.2 Performance Metrics
6.3.3 Performance Evaluation and Reporting
6.3.4 Strategies to Control Cost and Schedule Risk
6.3.5 Configuration Control and Change Management
6.4 Mitigation Approach

Appendix A: Work Breakdown Structure (WBS) Dictionary
Appendix B: Responsibility Assignment Matrix

Description of Sections

The text in italics describes the content to be provided for each the section. The intention is not to create new content rather than organize and collect content that already needs to be developed in one place. This template provides one example of a suggested organization with major sections and subsection content; however, the organization of this control plan would be up to the project.

1.0 Executive Summary

A high-level description of how the project will plan, manage, and control cost and schedule. Provide an overview of the life-cycle NOA profile, project schedule, workforce profile, and UFE and schedule margin attrition profiles. Provide an overview of the management approach for managing UFE and schedule margin. Document requirements levied on the project's PP&C effort. Provide an overview of the PP&C Office. Document PP&C stakeholder expectations.

1.1 PP&C Overview

1.1.1 Life Cycle Cost, Life Cycle Schedule, Workforce and Obligation Profiles

Describe the project's Life-Cycle Cost (LCC), NOA profile and the schedule, workforce, and obligation profiles. Examples: schedule life-cycle phase durations, workforce on-ramps and off-ramps, and long-lead funding.

1.1.2 UFE and Schedule Margins

Describe the project's approach to establishing UFE and schedule margin, and provide UFE and schedule margin attrition profile by fiscal year or project life-cycle phase.

Describe guidelines used for developing schedule margin. Describe the guidelines for the level of UFE to retain as the project progresses through the life cycle.

Describe the relationship between the time-phased baseline obligation profile, the time-phased UFE profile, and the project-funding requirements.

Identify the authority and process for controlling and distributing UFE to WBS elements. Describe the process for managing and tracking UFE.

1.1.3 Liens and Threats Management

Describe processes for tracking and managing encumbrances, liens, and threats including when resources are encumbered by a lien, when a lien is included in the Estimate at Completion (EAC), and guidelines for quantifying threats. In the absence of applicable Mission Directorate, Center, or program policies or guidelines, define liens and threats as they will be used by the project and identify any relationships between liens, threats, and risks.

1.1.4 Applicable Requirements

Document or reference requirements for the project's PP&C effort levied by applicable governing Agency NPRs (e.g., NPR 7120.5, NPR 7120.7, NPR 7120.8) such as requirements for

EVM; cost and schedule range estimates, cost confidence level, schedule confidence level for KDP B; Resource-Loaded Schedule (RLS) or cost-loaded schedule and JCL for KDP C; etc.

Document any planned (preliminary PP&C Management and Control Plan) or approved (baselined PP&C Management and Control Plan) waivers or tailoring.

1.2 Project PP&C Office

Describe the organizational structure of the Project PP&C Office. Document the specific roles, responsibilities, and expectations for each suborganization and/or key position within the Project PP&C Office including the PP&C integration manager.

[Insert Project PP&C Office Organization Chart]

Identify other Centers involved in supporting the PP&C efforts. Document or reference commitments from those Centers for the defined scope of work, associated resources (e.g., workforce) and costs.

Identify and define the roles, responsibilities, and authorities required to perform the activities of each PP&C function.

Identify how the PP&C organization is staffed including required expertise levels. Identify training requirements for members of the PP&C team and PP&C training recommendations for project management and other key project team personnel.

Document key interfaces within the Project PP&C Office and between the Project PP&C Office, the project technical team, and Center and Agency.

Identify the business rhythm to be used by the PP&C Office for collecting, integrating, and reporting PP&C information including expectations for the information (period of performance (i.e., begin and end dates), frequency requirements (e.g., monthly)), who provides the information, and how the information will be integrated and reported.

Identify the project standard for the definition of the number of hours in an FTE and WYE to be used among participating Centers so that there is commonality throughout the project. Ensure that the schedule calendar is consistent with the accounting calendar to enable accurate correlation of cost data to schedule performance.

Document the norms, protocols, and expectations for communication and reporting to be used within the Project PP&C Office and with the project, program, Center, Mission Directorate, and Agency, and with prime and support contractors and partners.

1.3 PP&C Stakeholder Expectations

Identify internal and external PP&C stakeholders and document their expectations including cost and schedule reporting expected and how they intend to use PP&C products. Identify *measures that will be used to monitor satisfaction of stakeholder expectations. Reference any formal or informal agreements with stakeholders.*

2.0 Resources and Funds Management

2.1 Funds Management

Describe the process for obtaining project resources and the plans to control and distribute project funds.

2.1.1 PPBE

Describe PP&C's role in the annual PPBE process and in presenting the project's annual PPBE updates to the program office, Center, and NASA customers.

Describe documentation required to support the PPBE including current funding status, projections of future-year funding requirements, and data such as narrative descriptions, planned and actual cost data, obligation, workforce, and New Obligation Authority (NOA) requirements for each year in the project life cycle.

Describe the approach used to reconcile the project's NOA submission with the guideline, how adjustments are made to planned work to ensure the project stays within funding limits when the annual NOA guideline or actual disbursement of funds made by NASA HQ (such as during a Continuing Resolution (CR)) is different from the plans submitted, and the results of those adjustments (e.g., slowdown of work). Describe the project's approach for negotiating revised current year and/or future years funding to achieve project goals.

2.1.2 Cost Phasing

Describe the approach to phasing costs by fiscal year and provide the project's cost-phasing profile.

2.1.3 Carry Forward Planning

Describe the approach to ensure adequate funding to continue work uninterrupted at the change of the fiscal year.

2.2 Obligations Management

Describe the process for distributing, tracking, and controlling project funds. Describe how contractor funding requests are validated. Describe how obligations are planned, tracked, and reviewed. Describe when obligation profiles are updated and provided to the Agency. Identify the elements that make up the total project funding requirement.

Include the obligations profile for the prime contractor, other major procurements, and other counterparts including grants and partners and other Centers. For the preliminary plan at KDP B, this information may be To Be Determined (TBD) if the prime contractor, other major *procurements, and other counterparts have not been awarded/established. For the baseline plan at KDP C, include the contractor obligations profile including contractor termination liability. For other counterparts, describe the process to distribute funds and the frequency.*

3.0 Work Management

3.1 Roles and Responsibilities

Identify who is responsible for establishing guidelines to be used in developing and managing the project WBS, work agreements, and control accounts. Identify who is responsible for developing and managing the WBS, work agreement, and control accounts as identified in the RAM. Identify who owns them and who needs to approve them.

3.2 Work Breakdown Structure

Describe the WBS, the approach for developing the WBS, by whom it is developed, the level of detail to which it is developed, and how the WBS is used by the project to conduct planning, conduct cost estimating and budgeting, collect costs, and report status. Describe the WBS Dictionary and its purpose. Identify the organization responsible for maintaining the WBS and how change to the WBS and WBS Dictionary is managed. Any updates to the WBS should be reflected in the final WBS at KDP C.

3.3 Work Authorization and Control Accounts

Describe the processes used by the project to authorize work. Specifically, provide an overview of the use of work agreements, who develops and approves them, the elements included in work agreements, and when work agreements for future life-cycle phases are developed.

Outline the elements of a Control Account Plan (CAP) and the approach and frequencies at which control accounts are to be reviewed and analyzed.

3.4 Change Control

Describe how changes to work agreements/control accounts are managed. Include how changes are initiated, documentation required (including any forms used), and who may initiate changes. Identify when a work agreement/control account may be revised and who ensures that work agreements/control accounts are revised appropriately. Describe the processes for approving and communicating changes.

4.0 Cost Estimation

Describe how the project will develop and validate cost estimates during the project life cycle.

4.1 Roles and Responsibilities

Identify who is responsible for establishing guidelines to be used in developing and managing project cost estimates. Identify who is responsible for developing the cost estimates and when *they are developed. Identify who owns the cost estimates, who needs to approve them, and who is responsible for ensuring cost performance is within plan. Identify other roles involved in supporting cost estimate and BOE development, independent cost assessments, and CADRe submittals.*

4.2 Estimating Methodologies

Describe how guidelines are established for estimating exercises and the areas addressed by those guidelines. Describe the estimating methodologies used and how those methodologies evolve as the project progresses through the life cycle. Describe how engineering build-up estimates are developed (who develops them and where they get the information needed to develop them).

4.3 Basis of Estimate

Address requirements for cost BOEs including the requiring authority, when they are required, any requirements specific to different types of estimating methodologies, who develops BOEs including the integrated project BOE, who needs to review and approve the BOEs, and any format requirements.

4.4 Independent Cost Assessments and CADRe

Identify when independent cost assessments are performed, who performs them, and the project's role in independent assessments. Provide an overview for how the project will comply with CADRe requirements, when data for the CADRe are collected, who collects the data, and the project's role in providing CADRe data.

5.0 Schedule Development and Management

5.1 Roles and Responsibilities

Identify who is responsible for establishing guidelines to be used in developing and managing project schedules. Identify who is responsible for developing the various schedule products and when these products are developed. Identify who owns the schedules, who needs to approve the schedules, and who is responsible for achieving the schedules. Identify other roles involved in supporting schedule development, schedule configuration control and change management, impact analysis, critical path analysis, and developing workaround scenarios.

5.2 Schedule Products

5.2.1 Integrated Master Schedule

Describe the approach for developing the IMS including key inputs to the IMS.

Discuss any non-standard modeling techniques and the use of constraints in the schedule. Define receivables and deliverables and the project's processes for managing receivables and *deliverables including the frequency at which their status is tracked and how changes are analyzed and reported. Describe the project's approach to the use of schedule margin.*

Describe how the IMS is used by the project including how it is used to support performance measurement.

5.2.2 Basis of Estimate

Address requirements for schedule BOEs including the requiring authority, when they are required, who develops BOEs, who needs to review and approve the BOEs, and any format requirements.

5.2.3 Schedule Risk Assessment

Describe the approach for conducting the schedule risk assessment and who is responsible for it.

5.2.4 Analysis Schedule

Describe the approach for developing the analysis schedule if required including how it is related to the IMS, who is responsible for developing it, and who reviews it.

5.3 Managing the Schedule

5.3.1 Updating the Schedule

Describe the project processes and frequencies for updating the schedules and reporting schedule performance.

Identify the schedule management tools that will be used and how they will be used.

5.3.2 Schedule Margins

Describe schedule margins and how schedule margins are tracked and reported.

5.3.3 Schedule Metrics

5.3.3.1 Health Checks

Describe the types, frequencies, and purposes of health checks performed on the schedule and the tools used to perform the health checks. Identify who performs the health checks.

5.3.3.2 Indices

Identify the schedule performance metrics used to analyze schedule performance and the schedule performance reports generated. Identify when the metrics and reports are updated and who the reports are provided to.

5.3.4 Critical Path Analysis

Define the critical path and how the critical path is used. Identify who conducts assessments of the critical path and the frequency of those assessments. Describe the approach for identifying and resolving issues with the critical path. Identify when and where the status of critical path is reported.

5.3.5 Schedule Performance Evaluation and Reporting

Describe the approach for ensuring progress, assessing performance, and developing accurate forecasts including who is responsible for providing status information, how often status information is to be provided, and the specific status information expected. Identify who is responsible for assessing impacts to the current plan and critical path, developing corrective action plans to recover schedule slips, and mitigating impacts to the critical path.

5.3.6 Configuration Control and Change Management

Describe the processes for schedule configuration control and change management. Identify schedule features that are not under configuration control. Identify schedule features that are under configuration control and the scenarios under which change to these features is allowed. Describe the process for changing the baseline when needed including actions that must be approved by the project.

6.0 Cost and Integrated Performance Management

6.1 Roles and Responsibilities

Identify who is responsible for establishing guidelines to be used in management of cost and integrated cost and schedule performance. Identify who is responsible for developing the Integrated Cost and Schedule Baseline, who owns the baseline, and who needs to approve it. Identify other roles involved in supporting integration of cost and schedule information from contracts, in-house efforts, and costs and schedules associated with Center services, grants, partners, and other participating elements of the project. Identify who is responsible for tracking, analysis, and assessment of integrated cost and schedule performance including developing recommendations for options and/or corrective actions for maintaining performance within plan.

6.2 Integrated Cost and Schedule Products

6.2.1 Integrated Cost and Schedule Baseline

Describe the approach for developing the Integrated Cost and Schedule Baseline including the key inputs.

Describe how the Integrated Cost and Schedule Baseline is used by the project including how it is used to support performance measurement.

6.2.2 Estimate at Completion (EAC)

Describe the approach for developing the EAC including the key inputs.

Identify the frequency at which the project conducts (develops/updates) a comprehensive EAC. Identify project expectations for incremental EAC updates and the EAC estimating methodology to be used for incremental EAC updates.

Describe how the EAC is tracked and reviewed to ensure EAC validity. Identify the criteria for changing the EAC. Identify the guidelines for determining that the EAC should be updated. Describe the process for updating the EAC.

6.2.3 JCL Analysis and UFE Targets

Describe the approach for conducting the JCL analysis and establishing UFE targets if required.

6.3 Managing Integrated Cost and Schedule Performance

6.3.1 Updating Performance

Describe the project processes and frequencies for updating and reporting on the project's cost and integrated cost and schedule performance.

Identify the cost and integrated performance management tools that will be used on the project and how they will be used.

6.3.2 Performance Metrics

Identify the set of PP&C performance indicators to ensure proper progress and management of the integrated cost and schedule including the frequency at which indicators need to be updated and tracked and the variance thresholds to be used. These include:

- *Cost trends and variances (plan, actual, UFE, EVM metrics, NOA);*
- *Schedule trends and variances (critical path slack/float, critical milestone dates);*
- *Staffing trends and variances (FTE, WYE);*
- *Cost and schedule impacts associated with TPM trends;*
- *Trends in the cost and schedule impacts of risks including cumulative impacts and probabilistic impacts.*

6.3.3 Performance Evaluation and Reporting

Identify the tools and processes used to maintain comprehensive, integrated cost and schedule performance information. Describe the performance assessment techniques and any applicable *general guidelines for measurable work without earned value reporting. Identify roles and responsibilities for collecting, distributing, and analyzing performance data, metrics, and reports resulting from performance analysis, how this information is used, and when and how performance metrics and reports are communicated to project management.*

6.3.4 Strategies to Control Cost and Schedule Risk

Describe the project's approach to managing cost and schedule risk including the frequency at which the cost and schedule impacts of risks are determined and how these impacts are used in analyses and forecasting. Address the use of UFE, liens, threats, and schedule margin to manage cost and schedule risk.

6.3.5 Configuration Control and Change Management

Describe the processes for Integrated Cost and Schedule Baseline configuration control and change management. Identify scenarios under which change is allowed. Describe the process for changing the baseline when needed including actions that must be approved by the project.

6.4 Mitigation Approach

If the project has cost growth or schedule extensions, describe the mitigation approach for taking corrective action prior to triggering either external reporting requirements or the need to replan or rebaseline. This includes the mitigation approach for taking corrective action prior to triggering the 30 percent breach threshold if the project is exceeding the development cost documented in the Agency Baseline Commitment (ABC). Describe how the project will support a rebaseline review in the event the Decision Authority directs one. (For additional detail on this subject, see Section 5.5.4 and Figure 5-11 in the NASA Space Flight Program and Project Management Handbook*.)*

Appendix 1 Work Breakdown Structure (WBS) Dictionary

For the preliminary PP&C Management and Control Plan, the WBS Dictionary should go at least to level 3 of the WBS for hardware and software elements. For the final submittal, the WBS Dictionary should go to the level deemed appropriate by project management.

Appendix 2 Responsibility Assignment Matrix (RAM)

For the preliminary PP&C Management and Control Plan, the planning RAM can be used (intersection of OBS and WBS is an 'X'). For the final submittal, a dollarized RAM (intersection of OBS and WBS is a dollar value) should be used.

Appendix H: Letter on Guidance and Expectations for Small Projects

The following excerpt is from a letter signed by Robert Lightfoot, NASA Associate Administrator, published September 26, 2014. It provides guidance for small Category 3, Risk Classification D Space Flight Projects with a life-cycle cost under $150 million. A complete copy of the letter can be found in the NODIS library under the "Other Policy Documents" menu in the OCE tab at the bottom left of the screen.

TO: Distribution

FROM: Associate Administrator

SUBJECT: Guidance and Expectations for Small Category 3, Risk Classification D (Cat3/Class D) Space Flight Projects with Life-Cycle Cost Under $150M

The intent of this letter is to provide guidance and expectations in applying project management requirements to small Cat3/ClassD space flight projects with a life-cycle cost (LCC) under $150M. NASA policy recognizes the need to accommodate the unique aspects of each program or project to achieve mission success in a safe, efficient, and economical manner within acceptable risk. This flexibility is achieved through tailoring as per NPR 7120.5E and the risk classification guidance per NPR 8705.4.

Tailoring is both an expected and accepted part of establishing proper requirements for all category and class projects and especially so for small Cat3/ClassD projects. History has shown, however, that tailoring is not being implemented throughout the Agency. Projects are diverse and Agency leaders should assess each project on a case-by-case basis and look for tailoring opportunities to reduce unnecessary burden on projects. Tailoring is enabled by NASA policy and is especially necessary for these small projects to align requirement implementation to project scope, mitigate application of over rigorous or unnecessary requirements, and reduce burden on small projects with limited resources. Centers, Mission Directorates (MD), and support offices are expected to support the projects in tailoring and encourage them to review their own practices and provide similar clarification, scoping and/or relief from unnecessary requirements.

Following are general guidelines and expectations for small Cat3/ClassD space flight projects with a LCC under $150M (from here on referred to as small Cat3 projects) based on the 7120.5E compliance matrix. The attached compliance matrix provides a requirement-by-requirement clarification and guidance on tailoring flexibility.

- Implementing Centers/projects are expected to propose innovative and streamlined implementation approaches for these missions.
- Most project products (e.g., control plans) may be included as sections of the project plan, or may be a different format other than a separate text document. The products are to be configuration controlled, used by the project to do its work with sufficient content for life-cycle and independent reviews.

- Projects may propose a tailored life-cycle review plan and obtain approval from the Decision Authority (DA) to implement. The review plan may include combining, omitting, or applying agile approach to the reviews, as approved by the DA.
- An Independent Review Team is used to perform independent assessments of the project in place of an IPAO Standing Review Board (SRB). The independent review team must be independent of the project as defined in the SRB Handbook (Appendix A).
- Governance is consistent with 7120.5E and the recent delegation of authority decision at the March 2014 APMC. Mission Directorate Associate Administrators will consider delegation of decision authority of small Cat3 projects at each Key Decision Point (KDP). The projects may propose delegation for MD consideration.
- Earned Value Management (EVM) principles for small projects may be applied as per the attached EVM guide and used for in-house small Cat3 projects with development costs greater than $20M and a LCC estimate below $150M.
- Joint Confidence Level and External Cost and Schedule Commitments (ABC external commitment) are not applicable to small Cat3 projects with a LCC below $150M. Small Cat3 projects are required to develop a NASA internal cost and schedule commitment (ABC internal commitment).
- Cost Analysis Data Requirement (CADRe) is not mandatory, but data collection for smaller projects is critical for future estimating capabilities and is strongly encouraged.

The desired project outcome is for an approved tailoring and implementation approach allowing innovation while maintaining programmatic performance against plan within acceptable risk. Through experience gained in implementation of tailoring for the small Cat3 projects, the Agency will assess future potential policy changes.

The EVM guidance that was attached to the letter discusses scaling the EVM for small projects based on the following seven principles.

Principle 1 Plan all work scope of the program to completion

Principle 2 Break down the program work scope into finite pieces that are assigned to a responsible person or organization for control of technical, schedule and cost objectives

Principle 3 Integrate program work scope, schedule, and cost objectives into a performance measurement baseline plan against which accomplishments are measured. Control changes to the baseline

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

Principle 5 Objectively assess accomplishments at the work performance level

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

Principle 7 Use EVMS information in the organization's management processes

Appendix I: Uncertainty versus Risk: Functional Definitions from a Programmatic Analysis Perspective

1. Introduction

There is significant incongruity across NASA, government, industry, and academia over the definitions of "risk" versus "uncertainty" and how the two concepts interplay within the programmatic arena. The U.S. Government Accountability Office (GAO) characterizes this incongruity appropriately in its *Schedule Assessment Guide: Best Practices for Project Schedules*:[43]

> Definitions of risk and uncertainty are interrelated and vary across organizations, government agencies, and even fields of study.

A survey of relevant literature reveals many conflicting nomenclatures: In some cases, risk is a subset of overall uncertainty. In other cases, the opposite hierarchical relationship is true, consistent with the definition of risk in NASA's *Agency Risk Management Procedural Requirements (NPR 8000.4)*:[44]

> **Risk.** In the context of mission execution, risk is *operationally* defined as a set of triplets:
>
> The *scenario(s)* leading to degraded performance with respect to one or more performance measures (e.g., scenarios leading to injury, fatality, destruction of key assets; scenarios leading to exceedance of mass limits; scenarios leading to cost overruns; scenarios leading to schedule slippage).
>
> The *likelihood(s)* (qualitative or quantitative) of those scenarios.
>
> The *consequence(s)* (qualitative or quantitative severity of the performance degradation) that would result if those scenarios were to occur.
>
> **Uncertainties** are included in the evaluation of likelihoods and consequences.

Here, uncertainties appear as characterizations of each risk's parameters. This reflects the NASA risk community's philosophy, which portrays uncertainty primarily as an element of risk and not necessarily as a separate entity.[45]

---

[43] http://www.gao.gov/products/GAO-16-89G

[44] *Agency Risk Management Procedural Requirements Appendix A*

[45] Appendix A in NPR 8000.4 also includes a separate, different definition of uncertainty that can be interpreted as including the scope of risk events: "An imperfect state of knowledge or a variability resulting from a variety of factors including, but not limited to, lack of knowledge, applicability of information, physical variation, randomness or stochastic behavior, indeterminacy, judgment, and approximation."

In other instances, risks are defined as "uncertain events" and are mutually exclusive from elements classified as uncertainty; in still others, risk is used interchangeably with uncertainty in the development of a forecast's range.

This incongruity has made crafting a definition of uncertainty for the NASA PP&C community a particular challenge that has not yet been addressed in a comprehensive way. This appendix establishes a *functional* definition that unifies treatment of risk and uncertainty across the major types of stochastic programmatic analyses conducted by the PP&C community.

2. Framework

The following practical approach to defining risk and uncertainty is based directly on the underlying technical and programmatic analyses. This approach is consistent with the *NASA Space Flight Program and Project Management Handbook* and the *NASA Cost Estimating Handbook (CEH) Version 4.0*, which contain the following similar *functional* definitions:

Table I-1: Definition of Risk and Uncertainty in NASA Handbooks

Source	"Risk" Definition	"Uncertainty" Definition
NASA Space Flight Program and Project Management Handbook	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.	The indefiniteness about a project's baseline plan. It represents the fundamental inability to perfectly predict the outcome of a future event.
NASA Cost Estimating Handbook (CEH)	An event not in the project's baseline plan that is an undesirable outcome (discrete risk). This definition is similar to one that one would see in a risk matrix. The event is characterized by a **probability** of occurring and an expected **impact** if the event did occur.	The indefiniteness about a project's baseline plan. It represents our fundamental inability to perfectly predict the outcome of a future event. Uncertainty is characterized by a probability distribution, which is based on a combination of the prior experience of the assessor and historical data.

The following framework is consistent with the conceptual usage of risk and uncertainty within the NASA risk community and NASA programmatic analyses:

$$Total\ Forecast\ Variation = Risks\ Events + Uncertainty$$

Table I-2: Definition of Variation, Risk, and Uncertainty

Variation	Risk	Uncertainty
A forecast's calculated distribution; the overall range of probability-weighted values that lend structure to the ultimate result of a stochastic programmatic analysis.	*NASA Space Flight Program and Project Management Handbook, NASA Cost Estimating Handbook*, and NPR 8000.4A definition	*The indefiniteness associated with implementing an organization's baseline plan (which includes Goals, Objectives, and Performance Requirements). It represents the fundamental inability to predict the outcome of a future event.*

The term "variation" resolves the hierarchical dilemma between risk and uncertainty by establishing an inclusive parent term that sets the two elements in a mutually exclusive relationship representing their respective applications in various programmatic analysis frameworks. This terminology approach is also flexible enough to accommodate the NASA risk community's conception of uncertainty within the context of risk parameters if they themselves are viewed as individual forecasts.

The following profiles outline features of "total variation," "risk event," and "uncertainty" as dictated by the above framework.

~Profile: Total Variation

Features

- **Definition**: A forecast's calculated distribution; the overall range of probability-weighted values that lend structure to the ultimate result of a stochastic programmatic analysis.
- Total range or distribution of potential outcomes resulting from a forecast model.
- Driven by both discrete risk events and any parameter, modeling, or other type of uncertainty.

Examples by Discipline

- **Schedule**: "The project will finish as early as March 2nd or as late as May 4th. The most likely end date is April 1."

- **Cost**: “$25 million in reserves is needed to cover 75% of the resultant cost distribution cases.”

- **Technical**: “Due to technical risks and various uncertainties associated with subsystem design, the overall spacecraft mass could grow between 15% and 25%.”

~Profile: Risk Event

Features

- **Definition**: An event not in the project’s baseline plan that has an undesirable outcome. The event is characterized by a likelihood (probability of occurrence) and an expected impact if it occurs.

- Well understood outcome informed by analogous events from history and special analyses.

- Deliberately mapped to a performance objective, commitment, or requirement.

- Manageable; something can be done about it (often by application of “effort” in the form of people, time, materials, funding, and other scarce resources).

- Traceable, discrete input into a modeling environment; can be added or removed easily in support of sensitivity cases.

Examples by Discipline

- **Schedule**: “There is a 75% chance that the ECLSS module will fail the initial qualification test, adding 40 days for retesting.”

- **Cost**: “There is a 55% chance that the project will run out of materials for constructing the ground test equipment, requiring $10,000 for a new order.”

- **Technical**: “There is a 10% chance that that the mass of the spacecraft will increase by 15 kg due to the addition of a second backup flight computer.”

~Profile: Uncertainty

Features

- **Definition**: The indefiniteness associated with implementing an organization’s baseline plan (which includes goals, objectives, and performance requirements). It represents the fundamental inability to predict the outcome of a future event.

- Mutually exclusive from risk events (except in the special case wherein uncertainty characterizes risk parameters like likelihood and consequence, as set forth in NPR

8000.4). Justified, documented ranges that make a special effort to not include identified or unidentified risk events….

- …however, in some cases, it is appropriate for uncertainty to include potentially undiscovered, underspecified, or formally identified discrete risks given proper justification, traceability, and no better available risk inclusion method.
- Less easily mapped to a particular objective than risks.
- Range of parametric values due to dispersion in historical data or Subject Matter Expert (SME) opinion.
- Not (yet) subject to mitigation, such as modeling uncertainty or the uncertainty arising from unknown sources (i.e., an "error" term or factor).

Examples by Discipline

- **Schedule**
  - Uncertainty in the duration of a task under nominal (baseline) conditions irrespective of identified risk issues and their associated probabilities.
  - Uncertainty in productivity (e.g., learning curves, engineering drawing rates, etc.).
- **Cost**
  - Uncertainty in cost model parameters, like realized spacecraft design heritage, mass, etc., regardless of potential risk events involving major unexpected technical changes or perturbations.
  - Uncertainty in the relationship between the body of analogies in the historical dataset and identified cost drivers.
  - Uncertainty in future labor rates and material prices.
  - Uncertainty in funding level.
- **Technical**
  - Uncertainty in spacecraft mass growth due to unclear historical trends, lack of system detail, or predictive limitations of mass estimating methods.
  - Uncertainty in future mission requirement changes not captured by discrete risks.

The distinction discussed above between the concepts of uncertainty and risk follows naturally from everyday situations. A PP&C analyst traveling to the 9th floor of an unfamiliar building could elect to take the elevator in an effort to arrive on time to an important meeting. Her estimate of the ride's duration naturally (and somewhat optimistically) includes an appraisal of the nominal case in which no distinct event slows the pace, such as a mechanical breakdown or the end of a well-attended meeting on an upper floor that results in high demand for the elevator. Even though no such risk event occurs in the best case, the PP&C analyst still does not know with *certainty* how fast the elevator will ascend and what its normal traffic patterns are. The uncertainty associated with the nominal case exists within the analyst's intuitive estimate regardless of whether risk events are given proper attention. An elevator ride forecast that includes a comprehensive total variation scope would consider both uncertainty around the nominal case and risk events that could fundamentally alter the ride's duration.

3. Application to Stochastic Programmatic Analyses

Establishing definitions is not enough; it is also important to address how the terms are applied across programmatic analyses, unifying general risk and uncertainty treatment. To begin, the various terminology delineations must be examined within select stochastic programmatic analyses:

Table I-3: Manifestation of Total Variation, Risk, and Uncertainty in Stochastic Programmatic Analyses

Programmatic Discipline/Technique	Manifestation		
	Total Variation	Risk	Uncertainty
Joint Confidence Level Modeling	**Total joint distribution** resulting from a JCL model; **marginal distributions** of cost and schedule	Discrete risk events with a **likelihood of** a **task duration consequence and/or a cost consequence**	**Task duration uncertainty and cost or resource uncertainty**
Schedule Risk Assessment (SRA)	**Total distribution** resulting from a schedule model	Discrete risk events with a **likelihood of a task duration consequence**	**Task duration uncertainty**
Cost Estimating	**Total distribution** resulting from a cost model	Discrete risk events with a **likelihood of a cost consequence**	Cost model **parameter and modeling uncertainty**
Quantitative Risk Analysis (QRA)	**Probabilistic sum** of discrete risk events	Discrete risk events with a **likelihood of a cost consequence**	**Limited role** of uncertainty

There are analogous relationships among variation, risk, and uncertainty across these three categories of analysis. This suggests the existence of a universal (if general) treatment of these elements within stochastic programmatic analyses.

4. Inclusion of Uncertainty within Stochastic Programmatic Analyses

As delineated above, uncertainty includes variation around forecasting elements (or a forecast itself) separate from the influence of risks. For each programmatic component (such as regression equation constants or task durations found within a schedule) comprising a mathematical model, there is a dimension of *risk-free* variation around its baseline value that accounts for imperfect knowledge and estimating accuracy.

The appropriate distribution with which to express the uncertainty surrounding each model element may be obtained from a variety of sources, such as historical data, technical analyses, and Subject Matter Expert (SME) experience. In the elevator example, uncertainty is assumed in the speed of the elevator and traffic patterns. The analyst could obtain a clearer picture of the dispersion of elevator speeds by visiting the building the day before and performing time trails. She could also record the frequency at which people enter and exit the elevator on each of the building's nine floors. She could further ascertain all possible cases (given no special risk events) by consulting a colleague working in the building who has experience riding the elevator every day. Using this information, she could determine the profile of probability associated with various elevator ride durations (often called a "probability distribution"). In similar ways, programmatic forecasters can obtain a portfolio of data from which to derive the correct probability distribution to apply to fundamental factors that drive estimates of all types.

5. Inclusion of Risk Events within Stochastic Programmatic Analyses

Since risk events lend themselves to salience, controllability, and traceability much more readily than uncertainty, PP&C should take great care in adjudicating risk treatment within programmatic modeling environments (while, of course, giving uncertainty its due consideration). Given that *all* estimates regardless of type are the outputs of a modeling construct of some complexity, a primary focus of PP&C should be to ensure that risks are handled with precision and treated in an equitable, coherent fashion across its suite of analyses. (Otherwise, the story coming from PP&C to stakeholders may not be optimally integrated due to internal inconsistency.)

The following are five general classes of risk treatment within programmatic analyses:

A. **Modify Model Inputs**: Adjust the parameter distributions used within the model in a justifiable way to account for each risk's effect. To ensure traceability (and separability of risks from baseline uncertainty), this should be done in stepwise fashion to accommodate risks incorporated in this manner. (In some rare cases, it is more appropriate for a group of risks to drive the same adjustment.)

B. **Add Discrete Elements**: Create a discrete subelement of the model (or add an ancillary model) that reflects risk consequence and mitigation. These supplements may utilize an estimating method or modeling framework that is different from that of the primary model.

C. **Adjust the Resultant Distribution**: More holistic risks, which can affect many factors that drive cost, schedule, or other elements within the model, may justify a gross adjustment to the resultant estimate's total distribution. This may be especially appropriate when using the analogy method of estimating. (**Caveat**: This must be fully justified to pass independent scrutiny.)

D. **Assess Inclusion of Risk in Source Data**: In some cases, a discrete risk's effects are sufficiently captured in the dataset used to create the model and have no marginal impact on the estimate. (**Caveat**: This must be fully justified to pass independent scrutiny.)

E. Some other traceable, defendable treatment.

To illustrate these classes of risk treatment, the following examples are provided for three select programmatic analysis contexts:

Table I-4: Discrete Risk Treatment Classes across Stochastic Programmatic Analyses

Programmatic Analysis Framework	(A) Modify Model Inputs	(B) Add Discrete Elements	(C) Adjust the Resultant Distribution	(D) Assess Inclusion of Risk in Source Data
Schedule Risk Assessment & Joint Confidence Level	Adjust task duration distributions and/or TI/TD cost distributions to accommodate risk effects.	Tie discrete risks to schedule tasks.	Apply a gross adjustment to the resultant joint distribution. (Must be justified.)	Justify that a risk is included in history- or SME-driven assessment of model inputs.
Parametric Cost Estimating	Traceably adjust parametric distribution for each individual risk (or group of risks).	Create a discrete sub-element of the cost model that reflects the cost associated with the risk consequence and mitigation.	Apply a gross adjustment to the resultant cost distribution. (Must be justified.)	Justify that a risk is included in history- or SME-driven assessment of model inputs.
Engineering Build Up CE	Adjust cost elements' distributions for each individual risk (or group of risks).	Tie discrete risks to cost elements.	Apply a gross adjustment to the resultant cost distribution. (Must be justified.)	Justify that a risk is included in history- or SME-driven assessment of model inputs.

The above discussion is meant simply to illustrate the commonality of risk treatment classes across programmatic analysis contexts. Though regression-based models are, for example, somewhat different in structure and forecasting philosophy from “build up” models, risk treatment within both types is similar (with some nuanced differences).

Appendix J: Contract Types

Cost - In cost or cost-no-fee contracts, the contractor is reimbursed allowable, allocable, and reasonable costs but receives no fee. Generally, cost contracts are used for research and development work performed by non-profits and educational institutions, for facilities contracts, and for research and development or production contracts with for-profit contractors when the contractors expect to derive some commercial benefit from the contracts. These contracts provide little incentive to the institution or contractor to control costs.

Cost-sharing - Cost-sharing contracts provide for reimbursement of an agreed-upon portion of a contractor's allowable, allocable, and reasonable costs and no payment of fee. The contractor assumes responsibility for a share of the incurred costs in expectation of receiving substantial compensating benefits. Cost-sharing contracts can be used for basic and applied research efforts performed by non-profit and educational institutions as well as for-profit contractors.

Cost-Plus-Fixed-Fee (CPFF) - CPFF contracts include an estimated cost to deliver a specified product (completion type) or Level-Of-Effort (LOE) (term type) and a fixed-fee amount. In general, the contractor is totally reimbursed for the allowable, allocable, and reasonable costs incurred on the contract and is paid a fixed fee regardless of costs reimbursed. CPFF contracts are used for research, design, or study efforts where cost and technical uncertainties exist, and it is desirable to retain as much flexibility and opportunity for change as possible. These contracts provide only a minimum incentive to the contractor to control costs.

Cost-Plus-Award-Fee (CPAF) - CPAF contracts include an estimated cost and an award fee amount that is paid based upon subjective evaluations of contractor performance. The award fee determination is made unilaterally by the Government and is not subject to Disputes clause procedures. Approval from the Assistant Administrator for Procurement is required to use this type of contract.

NASA employs two types of award-fee incentives:

- Service-type award fee is used where the contract deliverable is the performance of a service over any given time period and contractor performance is definitively measurable within each evaluation period.

- End-item award fee is used where the contract deliverables are end-items and the true quality of contractor performance cannot be measured until the end of the contract.

While not encouraged, a base fee which is paid based on the contractor achieving at least satisfactory performance may be included in non-services contracts. Contracts for hardware may also include a performance incentive.

CPAF contracts offer significant evaluation flexibility in two ways:

- The flexibility to evaluate on a judgmental basis, taking into consideration both contractor performance levels and the conditions under which such levels were achieved; and
- The flexibility to adjust evaluation plans quickly to reflect changes in Government management emphasis or concern.

Cost-Plus-Incentive-Fee (CPIF) - CPIF contracts provide for a target cost and target fee, a minimum and maximum fee, and a fee-adjustment formula (e.g., 70/30, 60/40), all established at contract award. The fee and fee-adjustment formula incentivize only cost performance. If desired, separate incentives may be included for other significant performance elements such as accomplishments, schedule, or quality. Upon contract completion, the formula is applied and, subject to the minimum and maximum fee limits, the fee is increased from target fee for underruns and decreased for overruns. Regardless of the final cost outcome, the contractor's risk is limited since the fee paid cannot be less than the minimum fee. However, the minimum fee can be zero or even a negative number. All allocable, allowable, and reasonable costs incurred on the contract are paid.

Fixed-Price Incentive (FPI) - FPI contracts include a target cost and target profit, a ceiling price, and a profit-adjustment formula. Unlike CPIF contracts, there is no ceiling or floor on profit. At the end of the contract, using the formula, target profit is either increased for a cost underrun or decreased for an overrun up to a ceiling price. The contractor assumes full responsibility for all costs incurred beyond the ceiling. The contractor must successfully perform to the contract requirements within the ceiling price. FPI contracts are appropriate when a realistic firm target cost and profit and a profit formula that provides a fair and reasonable incentive for the contractor can be established at the outset of the contract. Technical and cost uncertainties must be reasonably identified, and the parties should be confident that performance can be achieved.

Fixed Price with Award Fee (FPAF) - A fixed price consisting of all estimated costs and profit is established at contract award along with an additional, separate award-fee amount. The fixed price is paid for satisfactory performance; the award fee is earned, if any, for performance beyond that required. Procurement officer approval is required for this type of contract. FPAF combinations are used when the Government, although wanting to incentivize the contractor to deliver at an excellent or outstanding technical level, is unable to define that level in quantitative terms; or when metrics are not available or their use is not practical. (See FAR 16.404 (Fixed price contracts with award fees) for conditions for use of this type of contract.)

Firm-Fixed-Price (FFP) - A price consisting of all estimated costs and profit is established at contract award, and it is not subject to adjustment in light of actual costs of performance. The contractor must deliver conforming products or services regardless of the cost. Under this type of contract, the contractor assumes the maximum cost risk; however, opportunity to earn profit is not limited, thus encouraging contractor efficiency and economy. It allows accurate obligation of funds at the start of the contract and is the easiest and least costly type of contract for the Government to administer.

Indefinite-Delivery Contract (IDC) - FAR 16.5 outlines Indefinite-Delivery Contracts (IDCs). There are three types of IDCs: 1) definite-quantity contracts; 2) requirements contracts, and 3) indefinite-quantity contracts.

The appropriate type of IDC may be used to acquire supplies and/or services when the exact times and/or exact quantities of future deliveries are not known at the time of contract award. Requirements contracts and indefinite-quantity contracts are also known as delivery-order contracts for supplies or task-order contracts for services.

IDCs limit the Government's obligation to the minimum quantity specified in the contract. IDCs may provide for any appropriate cost or pricing arrangement under FAR Part 16 (contract types listed above). Cost or pricing arrangements that provide for an estimated quantity of supplies or services (e.g., estimated number of labor hours to be provided) also need to comply with the procedures of FAR 16.5 (Indefinite-Delivery Contracts).

The various types of IDCs offer advantages:

- All 3 types permit Government stocks to be maintained at minimum levels and direct shipment to users.

- Indefinite-quantity contracts and requirements contracts permit flexibility in both quantities and delivery scheduling and ordering of supplies or services after requirements materialize.
- Requirements contracts may permit faster deliveries when production lead time is involved because contractors are usually willing to maintain limited stocks when the Government will obtain all of its actual purchase requirements from the contractor.

Time-and-Materials (T&M) and Labor-Hour Contracts - FAR 16.6 (Time-and-Materials, Labor-Hour, and Letter Contracts) outlines T&M and labor-hour contracts, two other types of compensation arrangements that do not completely fit the mold of either fixed-price or cost-reimbursement contracts. T&M and labor-hour contracts both include fixed labor rates but only estimates of the hours required to complete the contract. These contract types are generally considered to most resemble cost-reimbursement contracts because they do not require the contractor to complete the required effort within an agreed-to maximum price, and payment to the contractor is for actual hours worked.

Time and Materials (T&M) Contract. Contracts are used to acquire supplies or services on the basis of direct labor hours at specified fixed hourly rates that include wages, overhead, General and Administrative (G&A) expenses, and profit. Materials are priced at cost including (if appropriate) material handling costs. A T&M contract affords the contractor no positive profit incentive to control material or labor costs effectively. This contract type is often used for repair, maintenance, or overhaul work to be performed in emergency situations. A time and materials contract may be used only after the CO executes a written determination and finding that no other contract type is suitable. When the contract includes a ceiling price, its breach is at the contractor's risk. If the ceiling price is subsequently raised through a contract modification, the contract file documentation must justify the increase. Although the agreed upon hourly rate per direct labor hour is an important source selection factor, the contractor's technical and managerial skills are more important including his reputation for getting the job done. The contractor will get paid for hours and materials expended. Therefore, awarding to a marginal producer that charges a cheaper price per hour but expends more hours due to its ineffectiveness may not be the most beneficial solution.

Labor-Hour Contract. A labor-hour contract is a variation of the T&M contract, differing only in that materials are not supplied by the contractor.

Letter Contracts - In accordance with FAR 16.603 (Letter contracts), a letter contract is a written preliminary contractual instrument that authorizes the contractor to begin work immediately. NASA uses this type of contract when (1) the government's interests demand that the contractor be given a binding commitment so that work can start immediately and (2) when negotiating a definitive contract is not possible in sufficient time to meet the requirement. The letter contract should be as complete and definite as feasible under the circumstances and should include the EVMS clauses that are appropriate for the planned type of contract. The letter contract will also include a negotiated definitization schedule that includes the dates for submission of the contractor's price proposal and a target date for definitization. The schedule will provide for definitization of the contract within 180 days after the date of the letter contract or before completion of 40 percent of the work to be performed, whichever occurs first.

Appendix K: PP&C Requirements for Projects in NPR 7120.5

Table K-1 PP&C Requirements Found in NPR 7120.5

7120.5 Section	PP&C Requirement
2.2.2	This work shall be organized by a product-based WBS developed in accordance with the Program and Project Plan templates (appendices G and H).
2.2.6	In preparation for these LCRs, the program or project shall generate the appropriate 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 in phases C and D (and programs at the discretion of the MDAA) with a life-cycle cost estimated to be greater than $20 million and Phase E project modifications, enhancements, or upgrades with an estimated development cost greater than $20 million shall perform earned value management (EVM) with an EVM system that complies with the guidelines in ANSI/EIA-748, Standard for Earned Value Management Systems.
2.2.8.1	EVM system requirements shall be applied to appropriate suppliers in accordance with the NASA Federal Acquisition Regulation (FAR) Supplement, and to in-house work elements.
2.2.8.2	For projects requiring EVM, Mission Directorates shall conduct a pre-approval integrated baseline review as part of their preparations for KDP C to ensure that the project's work is properly linked with its cost, schedule, and risk and that the management processes are in place to conduct project-level EVM.
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 (e.g., the cost and schedule data sheet) that provide further details.
2.4.1.3	During Formulation, the Decision Memorandum shall establish a target life-cycle cost range (and schedule range, if applicable) as well as the Management Agreement addressing the schedule and resources required to complete Formulation.
2.4.1.5	All projects and single-project programs shall document the Agency's life-cycle cost estimate and other parameters in the Decision Memorandum for Implementation (KDP C), and this becomes the ABC.
2.4.2	All programs and projects develop cost estimates and planned schedules for the work to be performed in the current and following life-cycle phases (see Appendix I tables).

7120.5 Section	PP&C Requirement
2.4.2	As part of developing these estimates, the program or project shall document the basis of estimate (BOE) in retrievable program or project records
2.4.3	Tightly coupled and single-project programs (regardless of life-cycle cost) and projects with an estimated life-cycle cost greater than $250 million shall develop probabilistic analyses of cost and schedule estimates to obtain a quantitative measure of the likelihood that the estimate will be met in accordance with the following requirements.*
2.4.3.1	Tightly coupled and single-project programs (regardless of life-cycle cost) and projects with an estimated life-cycle cost greater than $250 million shall provide a range of cost and a range for schedule at KDP 0/KDP B, 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. *
2.4.3.2	At KDP I/KDP C, tightly coupled and single-project programs (regardless of life-cycle cost) and projects with an estimated life-cycle cost greater than $250 million shall develop a resource-loaded schedule and perform a risk-informed probabilistic analysis that produces a JCL.*
2.4.4	Mission Directorates shall plan and budget tightly coupled and single-project programs (regardless of life-cycle cost) and projects with an estimated life-cycle cost greater than $250 million based on a 70 percent joint cost and schedule confidence level, or as approved by the Decision Authority.*
2.4.4.1	Any JCL approved by the Decision Authority at less than 70 percent shall be justified and documented.*
2.4.4.2	Mission Directorates shall ensure funding for these projects is consistent with the Management Agreement and in no case less than the equivalent of a 50 percent JCL.*
	Table I-4 Project Milestone Products Maturity Matrix
	Headquarters and Program Products
Table I-4	1. FAD [Baseline at MCR] (PP&C requirements in FAD Sections 6.0, 7.0)
Table I-4	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 [Baseline at SRR]
Table I-4	2.c. Documentation of driving mission, technical, and programmatic ground rules and assumptions [Baseline at SDR/MDR]
Table I-4	3. Partnerships and interagency and international agreements [Baseline U.S. partnerships and agreements at SDR/MDR; Baseline international agreements at PDR]

7120.5 Section	PP&C Requirement
Table I-4	4. ASM minutes
	Project Management, Planning and Control Products
Table I-4	1. Formulation Agreement [Baseline for Phase A at MCR; Baseline for Phase B at SDR/MDR] (PP&C requirements in FA Sections 7.0, 11.0, 13.0, 14.0)
Table I-4	2. Project Plan [Baseline at PDR] (PP&C requirements in Project Plan Sections 2.2, 2.3, 2.4, 2.5, 3.1, 3.3, 3.4, 3.10, 3.16)
Table I-4	3. Plans for work to be accomplished during next Implementation life-cycle phase [Baseline for Phase C at PDR; Baseline for Phase D at SIR; Baseline for Phase E at MRR/FRR; Baseline for Phase F at DR]
Table I-4	3. Plans for work to be accomplished during next Implementation life-cycle phase [Baseline for Phase C at PDR; Baseline for Phase D at SIR; Baseline for Phase E at MRR/FRR; Baseline for Phase F at DR]
Table I-4	4. Documentation of performance against Formulation Agreement (see #1 above) or against plans for work to be accomplished during Implementation life-cycle phase (see #3 above), including performance against baselines and status/closure of formal actions from previous KDP
Table I-4	5. Project Baselines
Table I-4	5.a. Top technical, cost, schedule and safety risks, risk mitigation plans, and associated resources
Table I-4	5.b. Staffing requirements and plans
Table I-4	5.c Infrastructure requirements and plans, business case analysis for infrastructure
Table I-4	5.d. Schedule [Baseline Integrated Master Schedule at PDR]
Table I-4	5.e. Cost Estimate (Risk-Informed or Schedule-Adjusted Depending on Phase) [Baseline at PDR]
Table I-4	5.f. Basis of Estimate (cost and schedule)
Table I-4	5.g. Joint Cost and Schedule Confidence Level(s) and supporting documentation [Baseline at PDR]*
Table I-4	5.h. External Cost and Schedule Commitments
Table I-4	5.i. CADRe
	Table I-5 Project Plan Control Plans Maturity Matrix
Table I-5	1. Technical, Schedule, and Cost Control Plan [Baseline at SDR/MDR]
Table I-5	3. Risk Management Plan [Baseline at SRR]
Table I-5	4. Acquisition Plan [Baseline at SRR]
Table I-5	10. Review Plan [Baseline at SRR]
Table I-5	16. Configuration Management Plan [Baseline at SRR]

* Only for projects with LCC >$250M

Appendix L: Partnership Types

Apart from contracts, NASA has authority to enter into a wide range of agreements with numerous entities to advance the NASA mission through its activities and programs. 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. Agreements 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. A project's acquisition strategy may call for the formation of partnership agreements. On occasion, such partnership agreements may be included in the constraints, Ground Rules and Assumptions (GR&A), and/or stakeholder expectations provided to the project.

Partnership agreements may include Space Act Agreements (SAAs), Cooperative Research and Development Agreements (CRADAs), International Space Act Agreements, Interagency Agreements (IAAs), and various other types of agreements. Each agreement type is described below.

Detailed guidance for the formation and administration of agreements is provided in:

- *NPD 1050.1*, *Authority to Enter into Space Act Agreements*. This directive identifies organizational responsibilities, mandatory legal provisions, delegation of signatory authority, and minimum organizational concurrence requirements.

- *NAII 1050-1*, *Space Act Agreements Guide*. This guide explains the NASA agreement practice and provides assistance to those involved in formation, execution, and administration of SAAs.

- *NPR 9090.1*, *Reimbursable Agreements*. This directive establishes financial management requirements for reimbursable agreements related to (1) administrative procedures; (2) determining full cost; and (3) pricing.

- *NPD 1360.2*, *Initiation and Development of International Cooperation in Space and Aeronautics Programs*. This directive describes NASA policy for the initiation and development of international cooperation and provides specific policy and procedural guidelines for entering into international SAAs.

- *NPD 1370.1*, *Reimbursable Utilization of NASA Facilities by Foreign Entities and Foreign-Sponsored Research*. This directive describes NASA policy for undertaking reimbursable use of NASA facilities by, or for the benefit of, foreign entities; or conducting research on a reimbursable basis in collaboration with, or for the benefit of, foreign entities.

- *NPD 1050.2*, *Authority to Enter into Cooperative Research and Development Agreements (CRADAs)*

- *NAII 1050-2, [Cooperative Research and Development Agreement (CRADA) Program Information Package]*

Space Act Agreements

The National Aeronautics and Space Act of 1958 (Space Act), 51 U.S.C. §§ 20101-20164, grants NASA broad discretion in the performance of its functions. Specifically, Section 20113(e) of the Space Act authorizes NASA to enter into and perform such contracts, leases, cooperative agreements, or 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 U.S. state, territory, or possession or with any political subdivision thereof or with any person, firm, association, corporation, or educational institution. Arrangements concluded under the other transaction authority of the Space Act are commonly referred to as Space Act Agreements (SAAs) and can be reimbursable, non-reimbursable, or funded.

Reimbursable Agreements

- NASA enters into reimbursable agreements when it has unique goods, services, and facilities not being fully utilized to accomplish mission needs, which it can make available to others on a noninterference basis, consistent with the Agency's missions.

- All reimbursable agreements are subject to the provisions of NASA's financial management policy.

Non-Reimbursable Agreements

- These agreements involve NASA and one or more agreement partners in a mutually beneficial activity that furthers the Agency's missions, wherein each party bears the cost of its participation and there is no exchange of funds between the parties. Each party funds its own participation.

- Non-reimbursable agreements permit NASA to offer time and effort of personnel, support services, equipment, expertise, information, or facilities.

Funded Agreements

- Funded agreements are agreements under which appropriated funds are transferred to a domestic agreement partner to accomplish an Agency mission. They may be used only when the Agency's objective cannot be accomplished through the use of a procurement contract, grant, or cooperative agreement or a reimbursable or non-reimbursable agreement under the Space Act.

- These type agreements have been used to seed an industry (e.g., commercial crew and cargo). NASA rarely uses this authority.

A Center agreement manager is assigned for each SAA and is responsible for providing guidance and facilitating the overall agreement development process with the project. The Center agreement manager also determines the need for an abstract; ensures that required managerial, financial, and legal coordination has been performed; controls when the draft agreement may be shared with the potential partner; ensures all required information has been entered into the Space Act Agreement Maker (SAAM) system; and coordinates the appropriate review, concurrence, and approval cycle. A list of these individuals can be found at https://inside.nasa.gov/pacop/agreemanagers. A Space Act Agreement (SAA) manager may also be assigned by the project to assist in negotiating and managing the inventory of agreements within the project. Every SAA is assigned a Technical Point of Contact (TPOC), who is responsible for negotiating and managing the assigned agreement. The TPOC is typically the technical representative within the project responsible for the requirement.

Cooperative Research & Development Agreements (CRADAs)

A CRADA is any agreement between one or more Federal laboratories and one or more non-Federal parties under which the Government, through its laboratories, provides personnel, services, facilities, equipment, intellectual property, or other resources with or without reimbursement (non-Federal parties cannot receive funds) and the non-Federal parties provide funds, personnel, services, facilities, equipment, intellectual property, or other resources toward the conduct of specified research or development efforts which are consistent with the missions of the laboratory. CRADAs are treated as fully reimbursable agreements. CRADAs may not provide funding to a non-Federal CRADA collaborating party.

The principal purpose of a CRADA is to transfer federally developed or controlled technology to state and local governments and to the private sector. It also promotes technology transfer and improves access to science and technology.

NASA has statutory authority to enter into CRADAs under the Stevenson-Wydler Technology Innovation Act, 15 USC 3710, but generally does not use this authority when NASA's technology transfer objectives can be achieved through use of an SAA.

A Center agreement manager is assigned for each CRADA and is responsible for providing guidance and facilitating the overall agreement development process with the project. The Center agreement manager also determines the need for an abstract; ensures that required managerial, financial, and legal coordination has been performed; controls when the draft agreement may be shared with the potential partner; ensures all required information has been entered into the Space Act Agreement Maker (SAAM) system; and coordinates the appropriate review, concurrence, and approval cycle. A list of these individuals can be found at https://inside.nasa.gov/pacop/agreemanagers.

International Space Act Agreements

In addition to the "other transactions" authority for SAA's granted by the Space Act, the act also provides authority to conduct international cooperative space activities under international agreements. International agreements are those between NASA and a non-U.S. entity where the partner is a legal entity that is not established under a state or Federal law of the United States, including a commercial, noncommercial, or governmental entity of a foreign sovereign or a foreign person. International SAAs can be non-reimbursable or reimbursable. (NASA does not enter into funded international SAAs.) It is NASA policy that activities with, or for the benefit of, foreign entities will normally be conducted through SAAs. (See NPD 1050.1 and NPD 1360.2).

It is NASA's policy to engage in international cooperative projects that provide technical, scientific, or economic benefits to the U.S. Such projects could include foreign participation in NASA activities, NASA participation in foreign activities, and international collaborative efforts. International cooperative efforts should contribute to NASA's overall program objectives and U.S. national policies such as maintenance and enhancement of U.S. industrial competitiveness. These agreements should be within the scientific, technical, and budgetary capabilities of each party. NASA resources committed to a project could include, for example, time and effort of personnel, support services, use of facilities, equipment, information, and, where appropriate, funding. Generally, NASA's cooperative activities with foreign entities are not directed to the joint development of technology or products or processes that are potentially of near-term commercial value.

The Office of International and Interagency Relations (OIIR) at NASA HQ is responsible for the negotiation, execution, amendment, and termination of international agreements. When considering the use of an international SAA, it is essential to seek guidance early in the process from the Center agreement manager and the OIIR.

Interagency Agreements (IAA)

The Space Act provides authority for NASA to enter into Non-reimbursable and Reimbursable SAAs with agencies of the Federal Government and with state/local governments, including state and local colleges and universities (public partners). These agreements constitute a formal statement of understanding between NASA and the public partner requiring a commitment of NASA resources (including goods, services, facilities or equipment) to accomplish stated objectives.

NASA is authorized to enter into IAAs with Federal agencies under the Space Act, and to accept reimbursement for use of its goods, services, facilities, or equipment from another Federal agency.

A widely-available authority for Federal agencies (including NASA) exists in the Economy Act. It authorizes Federal Agencies to enter into mutual agreements to obtain supplies or services by interagency acquisition under a specific set of conditions. (Interagency acquisitions are governed by FAR 17.5 (Interagency Acquisitions) and NASA FAR Supplement (NFS) 1817.5 (Interagency Acquisitions), and are issued by a Contracting Officer (CO).)

Interagency acquisitions for reimbursable work performed by Federal employees (other than acquisition assistance) or interagency activities where contracting is incidental to the purpose of the transaction fall outside the scope of the FAR. These types of agreements are processed by the Office of the Chief Financial Officer (OCFO).

Various Other Types of Partnership Agreements

- Loans of Government Property (POC: Office of the Chief Counsel (OCC) and Property Office)
    - A SAA or a non-SAA type loan is required to loan Government-owned property to outside entities and should include a fully executed NF 893, Loan of NASA Equipment.
- Commercial Space Launch Act (CSLA) (POC: Office of the Chief Counsel (OCC))
    - An agreement to facilitate private sector operation of U.S. expendable launch vehicles and the acquisition by the private sector of launch or reentry property and services that are otherwise not needed for public use.
- Software Usage Agreements (SUAs) (POC: Technology Transfer Office)
    - NASA conducts research and development in software and software technology as an essential response to the needs of NASA missions. Under the NASA software release policy, NASA has several options for the release of NASA developed software technologies.
- Intergovernmental Personnel Act (IPA) Agreement (POC: Human Resources Office)
    - Temporary assignment of personnel between the Federal Government and state and local governments, colleges and universities, Indian tribal governments, federally funded research and development centers, and other eligible organizations.

Appendix M: References Cited

This appendix contains references that were cited in the handbook.

Federal Government Sources

Federal Laws and Regulations

Anti-Deficiency Act (ADA) Public Law 97–258, 96 Stat. 923, 31 U.S. Code §1341. The law was initially enacted in 1884, with major amendments occurring in 1950 (64 Stat. 765) and 1982 (96 Stat. 923)

Chiles Act. See Federal Grants and Cooperative Agreements Act of 1977.

Commercial Space Launch Act (CSLA) of 1984 as amended, Public Law 98-575, 98 Stat. 3055, 51 U.S.Code National and Commercial Space Programs Ch. 509: Commercial Space Launch Activities § 50901 et seq.

Economy Act of 1932 as amended, Public Law 72–212, 47 Stat. 382, 31 U.S.Code §1535.

Export Administration Regulations (EAR) determined by the Department of Commerce 15 CFR Parts 730 through 774.

Federal Acquisition Regulation (FAR) 48 CFR Chapter 1, divided into Subchapters A-H, which encompass Parts 1-53.

_____ FAR Part 1 Federal Acquisition Regulations System

_____ FAR 4.804 Closeout of contract files.

_____ FAR 6.3 Other Than Full and Open Competition

_____ FAR 7.105 Contents of written acquisition plans.

_____ FAR Part 10 Market Research

_____ FAR 13.302 Purchase orders.

_____ FAR 15.3 Source Selection

_____ FAR Part 16 Types of Contracts

_____ FAR 16.103, Negotiating contract type.

_____ FAR 16.104, Factors in selecting contract types.

_____ FAR 16.401 Incentive Contracts. General.

_____ FAR 16.404 Fixed-price contracts with award fees.

_____ FAR 16.5 Indefinite-Delivery Contracts

_____ FAR 16.6 Time-and-Materials, Labor-Hour, and Letter Contracts

_____ FAR 16.603 Letter contracts.

_____ FAR 17.5 Interagency Acquisitions

_____FAR Part 42 Contract Administration and Audit Services

_____ FAR 42.302 Contract administration functions.

_____ FAR 42.5 Postaward Orientation

_____ FAR 42.15 Contractor Performance Information

_____ FAR 49.5 Contract Termination Clauses

Federal Grants and Cooperative Agreements Act of 1977 (also referred to as the Chiles Act), Public Law 95-224, 92 Stat. 3.

Federal Insurance Contributions Act (FICA), 26 U.S. Code Chapter 21.

Intergovernmental Personnel Act (IPA) of 1970, Public Law 91-648, 84 Stat. 1909 (42 U.S. Code §4701 et seq. and 5 U.S. Code §§ 3371-3375)

International Traffic in Arms Regulations (ITAR; 22 CFR §§120-130) as indicated by the U.S. State Department implements

_____22 U.S. Code §2778 of the Arms Export Control Act as amended (22 U.S. Code §2751 et seq.) ("AECA"; see the AECA Web page); and

_____Executive Order 13637 of March 8, 2013, Administration of Reformed Export Controls.

National Aeronautics and Space Act of 1958 (Space Act) as amended, Public Law 85–568, 72 Stat. 426-2, 51 U.S. Code §§20101-20164; specifically, §20113(e) for Space Act Agreements

Stevenson-Wydler Technology Innovation Act of 1980 as amended, Public Law 96–480, 94 Stat. 2311, 15 U.S. Code §3710

Federal Agency Sources

FedBizOpps, the Governmentwide Point of Entry (GPE) for business opportunities with the Federal Government.

Defense Acquisition University (DAU), "Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management Framework chart (v5.2)," 2008, as reproduced in the International Cost Estimating and Analysis Association (ICEAA), *Cost Estimating Body of Knowledge (CEBok®), Module 2*, and reproduced in this handbook as Figure 3.5-3.

Department of Defense (DOD), DI-MGMT-81861A, *Data Item Description: Integrated Program Management Report (IPMR)* (16-SEP-2015). This document supersedes DI-MGMT-81466A (CPR) and DI-MGMT-81650 (IMS).

Government Accountability Office (GAO)

_____GAO *Principles of Federal Appropriations Law (The Red Book)*

_____GAO-09-3SP, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs (Supersedes GAO-07-1134SP)*

_____GAO-13-276SP, *Assessments of Selected Large-Scale Projects*

_____GAO-16-89G, *GAO Schedule Assessment Guide: Best Practices for Project Schedules*

_____GAO-16-309SP, *NASA: Assessments of Major Projects (Quick Look Book)*

Office of Management and Budget (OMB) Circular A-11, *Preparation, Submission, and Execution of the Budget*, 2016 or current version

National Research Council (NRC) of the National Academy of Sciences (NAS), Committee on the Planetary Science Decadal Survey, Space Studies Board, Division on Engineering and Physical Science. "*Sea Change: 2015-2025 Decadal Survey of Ocean Sciences*," 2015 Decadal Survey. The National Academies Press: Washington, D.C., 2015.

National Security Presidential Directive (NSPD) NSPD-49, U.S. National Space Policy. The President authorized a new national space policy on August 31, 2006 that establishes overarching national policy that governs the conduct of U.S. space activities. This policy supersedes Presidential Decision Directive/NSC-49/NSTC-8, National Space Policy dated September 14, 1996.

NASA Sources

NASA Guidance

NASA FAR Supplement (NFS)

_____ NFS 1801 Federal Acquisition Regulations System

_____ NFS 1807.105 Contents of written acquisition plans.

_____ NFS 1815.3 Source Selection

_____ NFS 1815.404-2 Data to support proposal analysis.

_____ NFS Part 1816 Types of Contracts

_____ NFS 1817.5 Interagency Acquisitions

_____ NFS 1832.7 Contract Funding

_____ NSF Part 1834 Major System Acquisition

_____ NFS 1834.203 Solicitation provisions and contract clause.

_____ NFS 1842.1503 Contractor Performance Information Procedures

_____ NFS Part 1852 Solicitation Provisions and Contract Clauses

_____ NFS 1852.234-1 clause: Notice of Earned Value Management System

_____ NFS 1852.234-2 clause: Earned Value Management

NASA Strategic Programming Guidance (SPG). The approved annual SPG is posted to the NASA eBudget Clearinghouse.

NASA Reports

2010 Interim Results of the NASA Program Planning and Control (PP&C) Study

NASA Office of Inspector General, Report No. IG-12-021, *NASA's Challenges to Meeting Cost, Schedule, and Performance Goals*, September 2012

NASA Center Standards and Handbooks

NASA Goddard Space Flight Center (GSFC) GSFC-STD-1000, *GSFC Rules for the Design, Development, Verification, and Operation of Flight Systems (Gold Rules)*

NASA Jet Propulsion Laboratory (JPL), *Program Business Management Practices* (aka "Green Book") is available at JPL

NASA Marshall Space Flight Center (MSFC), MSFC-HDBK-3684, *MSFC Project Planning and Control Handbook*

NASA Forms

NASA Form (NF) 533M, Monthly Contractor Financial Management Report

NASA Form (NF) 533Q, Quarterly Contractor Financial Management Report

NASA Form (NF) 893, Loan of NASA Equipment

NASA Form (NF) 1707, Special Approvals and Affirmations of Requisitions

NASA Directives

NPRs and NPDs on NASA Online Directive Information System (NODIS) library

NPD 1000.0, NASA Governance and Strategic Management Handbook

NPD 1001.0, 2014 NASA Strategic Plan

NPD 1000.5, Policy for NASA Acquisition

NPD 1050.1, Authority to Enter into Space Act Agreements

GUI 1050.1, Space Act Agreements Guide (NAII 1050.1)

NPD 1050.2, Authority to Enter into Cooperative Research and Development Agreements (CRADAs)

GUI 1050.2, Cooperative Research and Development Agreement (CRADA) Program Information Package (NAII 1050.2)

NPD 1360.2, Initiation and Development of International Cooperation in Space and Aeronautics Programs

NPD 1370.1, Reimbursable Utilization of NASA Facilities by Foreign Entities and Foreign-Sponsored Research

NPD 1440.6, NASA Records Management

NPD 7120.4, NASA Engineering and Program/Project Management Policy

NPD 7330.1, Approval Authority for Facility Projects

NPD 8820.2, Design and Construction of Facilities

NPD 9501.1, NASA Contractor Financial Management Reporting System

NPR 1441.1, NASA Records Management Program Requirements

NRRS 1441.1, NASA Record Retention Schedules

GUI 1441.1, NASA Records Retention Schedule (NRRS 1441.1)

NPR 1600.1, NASA Security Program Procedural Requirements

NPR 2810.1, Security of Information Technology

NPR 7120.5, NASA Space Flight Program and Project Management Requirements

NPR 7120.7, NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements – See NID 7120.99

NID 7120.99 NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements

NPR 7120.8, NASA Research and Technology Program and Project Management Requirements

NPR 7123.1, NASA Systems Engineering Processes and Requirements

NPR 7500.2, NASA Technology Transfer Requirements

NPR 8000.4, Agency Risk Management Procedural Requirements

NPR 8000.4, Agency Risk Management Procedural Requirements Appendix A

NPR 8705.4, Risk Classification for NASA Payloads

NPR 8715.3, NASA General Safety Program Requirements

NPR 8820.2, Facility Project Requirements (FPR)

NPR 9090.1, Reimbursable Agreements

NPR 9420.1, Budget Formulation

NPR 9470.1, Budget Execution

NPR 9501.2, NASA Contractor Financial Management Reporting

NASA Special Publications

NASA/SP-2010-3403, NASA Schedule Management Handbook

NASA/SP-2010-3404, NASA Work Breakdown Structure (WBS) Handbook

NASA/SP-2011-3422, Risk Management Handbook

NASA/SP-2012-599, NASA Earned Value Management (EVM) Implementation Handbook

NASA/SP-2013-3704, Earned Value Management (EVM) System Description on the NASA internal EVM website https://nen.nasa.gov/web/pm/evm

NASA/SP-2014-508c NASA Strategic Plan at http://www.nasa.gov/sites/default/files/files/FY2014_NASA_SP_508c.pdf See also NPD 1001.0.

NASA/SP-2014-3705, *NASA Space Flight Program and Project Management Handbook*

NASA/SP-2007-6105 Rev 1, *NASA Systems Engineering Handbook*

_____A more recent version of the *NASA Systems Engineering Handbook* may soon be available. Check the Systems Engineering Community of Practice (SECoP) internal website or NPR 7123.1 on the public NODIS website for a link to the newer version after it is posted.

NASA/SP-2016-3406, *Integrated Baseline Review Handbook*

NASA *Standing Review Board (SRB) Handbook*

NASA *Cost Estimating Handbook* *(CEH)*, Version 4.0, February 2015

_____ *Appendix E: Models and Tools*

_____ *Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis*

NASA Websites and Tools

NASA Project Cost Estimating Capability (PCEC) tools

NASA Instrument Cost Model (NICM) tools

Models are often housed within standard platforms like the Polaris (Photochemistry of Ozone Loss in the Arctic Region In Summer) and Joint Analysis of Cost and Schedule (JACS) tools, both found on the One NASA Cost Engineering (ONCE database portal

NASA's external and internal EVM websites at http://evm.nasa.gov/ or https://nen.nasa.gov/web/pm/evm for more information on EVM

NASA Engineering Network (NEN) EVM Community of Practice, https://nen.nasa.gov/web/pm/evm

NASA Engineering Network (NEN) Systems Engineering Community of Practice (SECoP), https://nen.nasa.gov/web/se

Non-Government Sources

Box, George E. P. and Norman R. Draper. 1987. *Empirical Model-Building and Response Surfaces*. Wiley-Blackwell: U.S. and Canada

International Cost Estimating and Analysis Association (ICEAA), *Cost Estimating Body of Knowledge (CEBok®)*, Module 2.

Wolfram MathWorld (see also Eric Weisstein at Wolfram Research), Bernoulli distribution explanation at http://mathworld.wolfram.com/BernoulliDistribution.html

Industry Standards

American National Standards Institute (ANSI)/ Electronic Industries Alliance (EIA), ANSI/EIA-748-B-2007 *Earned Value Management Systems (EVMS).* Arlington, VA: Government Electronics and Information Technology Association (GEIA), 2007. See "SAE" below for the newer 748C (2013) version.

Government Electronics Information Technology Association (GEIA), GEIA-HB-649 *Configuration Management Standard Implementation Guide*, 2005.

(NBN) International Organization for Standardization (ISO), ISO 10007:2014, *Quality Management Systems – Guidelines for Configuration Management (CM)*

Society of Automotive Engineers (SAE)

_____ANSI/EIA-649B, *Configuration Management Standard*, 2011.

_____ANSI/EIA, SAE EIA 748C-2013 (SAE EIA748C-2013), *Earned Value Management Systems*. 2013.

_____EIA 649-2-2016 (or current revision) *Configuration Management Requirements for NASA Enterprises.*

TechAmerica/American National Standards Institute (ANSI), ANSI GEIA-859-A, *Data Management* (Standard), 2012. This product replaces TechAmerica/ANSI GEIA-859-2009 - Data Management (ANSI Approved August 9, 2009).