3 RESEARCH INFRASTRUCTURE LIFE CYCLE PLANNING

3.5 CONSTRUCTION STAGE AND IMPLEMENTATION PLANNING

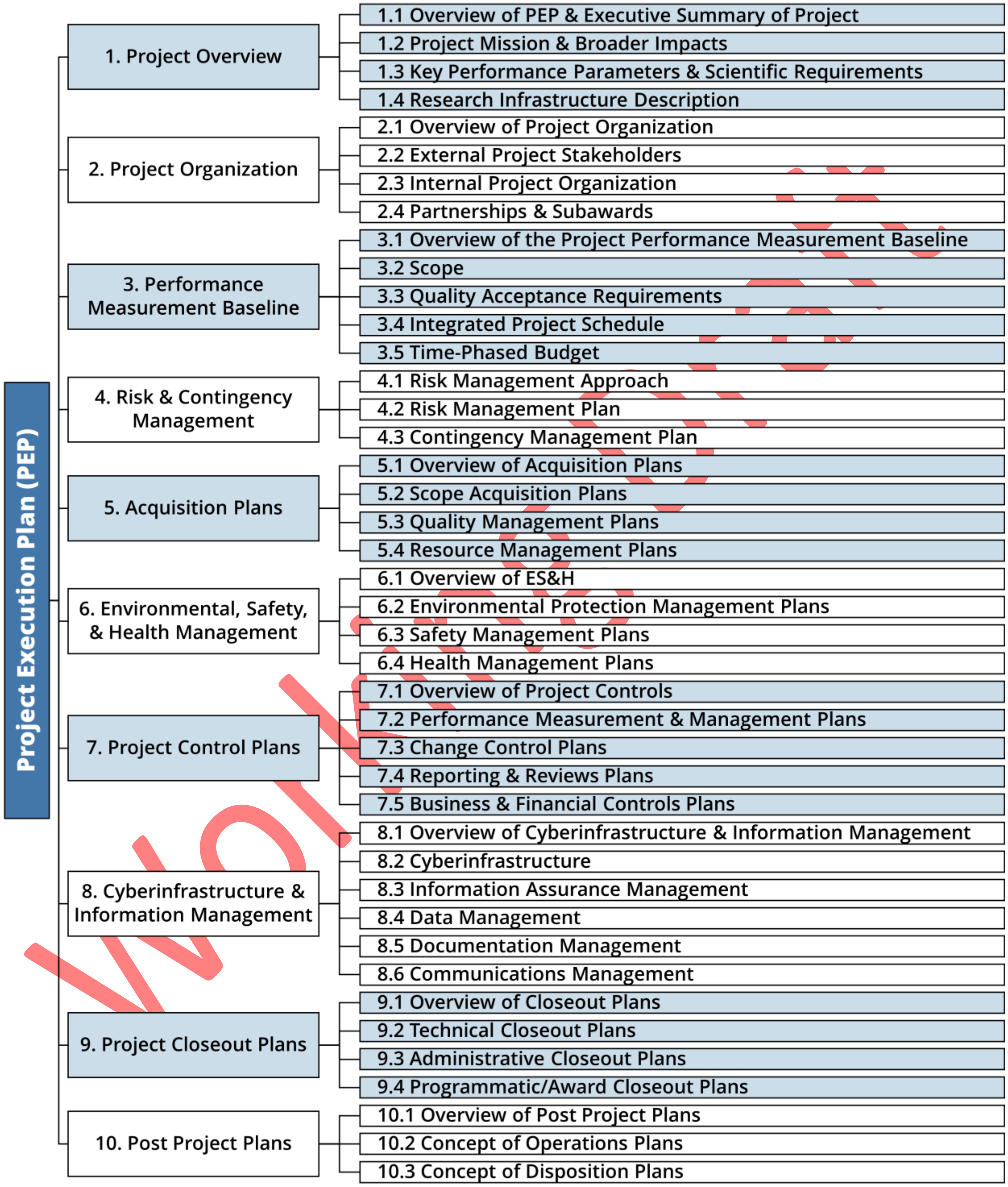
The Project Execution Plan (PEP) is an organized presentation of plans for how a project will be planned, managed, executed, and concluded. The PEP must provide a useful description of the project, what the project will deliver, how performance will be measured and reported, details on who will manage the effort, what resources are required to complete the project, how long the project execution phase will last, and how much risk or uncertainty is associated with the project plans. These PEP requirements are applicable to projects of all scales. However, the details of the plan and associated complexity will vary markedly and should be tailored and scaled to match the project characteristics (see Section 3.2 Tailoring, Scaling, and Progressively Elaborating Plans for further discussion).

The PEP should ideally contain or reference all project-related documents and be the standalone source explaining how and why the project plan meets all requirements. As noted in the detailed guidance sections, some components of the PEP may be detailed or more exhaustively presented in appendices or in separate documents, especially living documents like the Risk Register or lengthy documents like the full Work Breakdown Schedule (WBS) dictionary and detailed design drawings. The PEP should reference these separate documents to summarize the complete scope of the pre-construction planning and allow for effective evaluation of the project plans.

Detailed guidance on PEP structure and content for National Science Foundation (NSF) funded Major Facilities and Mid-scale Research Infrastructure (RI) projects is included in the following sections to ensure proposers understand the *what, why, and how* of proper project planning. Figure 3.5-1 provides an overview map of the PEP components and subcomponents that proposers requesting NSF support for RI projects should follow unless alternate descriptions or content are specified in a program solicitation or at the direction of the program officer(s), who will manage the review of any submitted proposals. Each PEP component is required, regardless of project size, but some subcomponents may not be required for all projects. Preparation and presentation of a rigorous and complete PEP will ensure that proposers can present their ideas in the best possible light, support effective merit review, and serve as a critical resource to manage and complete RI projects.

Figure 3.5-1

PEP Overview Map



3.5.1 PEP Component 1 Project Overview

What Does This Component Describe?

This component provides a succinct, clear, and unambiguous overview of the project. It includes an Executive Summary of the project, including whom the project is intended to serve, the science objectives and purpose of the project (i.e., the driving *why* behind the project), and a summary description of the proposed solution to that purpose. A mission statement for the project is included, along with a brief recap of any scientific and/or broader impacts that will result from the project. Also included is a high-level summary of the deliverables, along with the Key Performance Parameters (KPP) and high-level constraints and assumptions that will be the boundary conditions for the project.

Why Is This Component Important?

First, the overview helps ensure that everyone involved in the project has a shared vision of the goals the project is trying to achieve. A shared perspective can help to avoid misunderstandings and conflicts during project execution. The team and stakeholders gain direction and mission alignment by articulating the *why*. Second, the overview is a guiding beacon throughout the course project, helping with decision-making and prioritization. When issues arise that require a choice between competing solutions, returning to the formal *why* of the project will often provide clear direction and guidance. Additionally, the overview helps to foster better understanding and clarity for external stakeholders as to why particular decisions were made. Finally, the overview can help to motivate and engage the project team by ensuring everyone understands the ultimate goal and the impact it will have.

How To Develop and Write This Component

There are four required subcomponents included in the Project Overview Component, as listed in the table below. The subcomponents provide a high-level summary of the PEP and the project, outline the need and motivation for the project, list the high-level requirements to be met, and finally, describe the RI solution to the needs and requirements. All participants and stakeholders should agree upon the contents of the project description.

Table 3.5-1

Component	Sub-Component	Documents/Products	References
1. Project Overview	1.1 Overview of PEP and Executive Summary of Project		
	1.2 Project Mission and Broader Impacts	Project Mission Statement	In accordance with the award instrument used.
	1.3 Key Performance Parameters and Scientific Requirements	List of Key Performance Parameters Science Requirements Table	
	1.4 Research Infrastructure Description		[Insert Link/Reference to Scope and WBS section in Chapter 4??}

PEP 1.1 Overview of PEP and Executive Summary of Project

This subcomponent serves two primary purposes.

PEP Overview. This should provide a short, high-level overview and understanding of the purpose of the PEP as the project management document, how it is structured and used, and how it will be updated during the course of the project.

Executive Project Summary. The summary includes high-level statements of why the project exists, who it will serve, what the primary science objectives are, and what will be created and delivered to meet those objectives (i.e., the RI). The summary should list the Total Project Cost (TPC) and Total Project Duration (TPD) as well as the major deliverables. A brief description of the key institutions and partnerships should be included. The summary should be contained in a page or less. More specific details on these items are then described below in their respective components and subcomponents.

Good Practices and Practical Considerations

- The primary purpose of the executive project summary is not to sell or market the project; that's the purpose of the project proposal. Instead, it should clearly and unambiguously describe who the project serves, what will be created and provided (i.e., the RI), and why the RI is needed by the scientific community and then act as a manual for implementing the RI.

- This component provides the project description that is fully agreed upon by the key project stakeholders, team members, and other relevant parties. It also serves as a touchstone during project execution to ensure that plans, decisions, and actions align with the project's overarching purpose and mission.

PEP 1.2 Project Mission and Broader Impacts

This subcomponent describes the overall high-level purposes, scientific objectives, and broader societal impacts of the project. Specifically, the following elements should be described in this subcomponent.

Project Mission. This subcomponent includes a more detailed and complete description of the scientific objectives motivating the RI project (i.e., the driving *why* behind the project) and a description of who the project is intended to serve (e.g., the specific scientific community, end users, and benefactors of the RI in operations.)

Broader Impacts. This subcomponent provides a description of any meaningful Broader Impacts that advance scientific knowledge and that contribute to the achievement of societally relevant impacts on research communities, the scientific and technical workforce, and the public and society at large. See the 2011 National Science Board report on Merit Review Criteria for guidance and examples on Broader Impacts.[1]

Good Practices and Practical Considerations

- The best project mission and science objective statements are relatively concise and clearly state the project's goals and purpose. A good rule of thumb is to strive to state the project's mission in one or two paragraphs, maximum. More content often means that the project purpose is not yet fully distilled, understood, or explainable. Quantitative objectives should be reserved for the KPP and Quality Acceptance Requirements.
- There is a common misconception that Broader Impact activities must be a separate add-on to the research activities, but Broader Impacts are integral to the project baseline activities. Development of a diverse, globally competitive science, technology, engineering, and mathematics (STEM) workforce trained in RI design implementation, and commissioning, for example, can be addressed by using project activities as practical training to supplement academic training.
- There is a practical cost to meeting broader societal impact goals. The scope of deliverables, activities, and budget that are related to Broader Impacts should be specifically identified in the project baseline described in PEP Component 3 Performance Measurement Baseline.

[1] https://www.nsf.gov/nsb/publications/2011/meritreviewcriteria.pdf

PEP 1.3 Key Performance Parameters and Scientific Requirements

This subcomponent provides the quantitative descriptions of requirements which provide the basis for determining the attainment of the scientific objectives and, therefore, project completion.

Key Performance Parameters. These should include a descriptive list of the high-level KPP and functional requirements of the RI. Any specific high-level Environmental, Safety, and Health (ES&H) requirements, cybersecurity requirements, and any other high-level specifications, constraints, and/or assumptions that serve to define the RI at a high executive level should be included in the KPP.

Objective KPP describe the optimal or desired technical goals of the project, provided performance is sustained and sufficient resources are available. Objective KPP often enhance operational efficiency or extend science capabilities. Appropriate parameters are those that express performance in measurable terms of accuracy, capacity, throughput, quantity, processing rate, purity, reliability, sustainability, or others that define how well a system, facility, or other project will perform.

Threshold KPP comprise the minimum science parameters against which the project could be considered successful.

The difference between objective and threshold KPP should relate to scope/quality contingency plans. If the project is forced to descope or re-baseline, the threshold KPP may need to be accepted. See Section X.XX TITLE for more detail.

Scientific Requirements. This should include a high-level listing of the primary science requirements to be fulfilled by the RI, derived from the KPP described above. Note that these requirements should in turn serve as a basis for the definition of project scope (deliverables).

Table 3.5-2

Example of threshold and objective KPP (table will be updated to be NSF-centric)

Description of Scope	CD-2 Threshold KPP	CD-2 Objective KPP
Facility Size	175,000 SF	200,000 SF
Brightness	8 KeV	8 KeV
Spatial Resolution	1 nm	1 nm
Energy Resolution	0.1 meV	0.1 meV
Experimental Facilities	2	3

Good Practices and Practical Considerations

- The key science requirements, constraints, assumptions, and other requirements included herein this subcomponent should only include very specific, Level 1 or Level 2 requirements; the complete list of science requirements, flow-downs to engineering requirements, and all quality acceptance criteria are described below in PEP Component 3 Performance Measurement Baseline.

PEP 1.4 Research Infrastructure Description

This subcomponent describes the infrastructure necessary to obtain the research and education objectives. Specifically, the following elements should be described herein in this subcomponent.

RI Description. This subcomponent should include a high-level overview of the NSF-supported RI, i.e., the project deliverables. The descriptions should correlate directly with the Level 2 product scope (deliverables) of the WBS, as described in PEP Component 3 Performance Measurement Baseline below.

Related Infrastructure. If the project deliverables are to be incorporated into or with other infrastructure or deliverables not covered under the funding instrument, the goals of the larger infrastructure should be articulated, along with the relationship of the project deliverables with the wider goals.

Good Practices and Practical Considerations

- This subcomponent does not supplant the WBS described below in PEP Component 3 Performance Measurement Baseline. Instead, this subcomponent provides a high-level overview of the project deliverables, typically described at Level 2 or 3 of the WBS. The WBS and WBS Dictionary provide the formal definition and description of the project scope, while this subcomponent serves as an executive summary and overview of what the project will create and/or provide.
- It is often helpful/useful to describe key exclusions in this subcomponent, that is, items that are aspects of the RI that might reasonably be expected to be part of the project deliverables but that are provided by other means/funding/entities. Examples might include space and site preparations provided by the host institution or spare equipment to be used and provided by operations.

3.5.2 PEP Component 2 Project Organization

What Does This Component Describe?

This component describes the internal and external organizational structure necessary for successful project implementation. It includes a description of the Project Organization and defines key roles, responsibilities, and communication lines for both external stakeholders and internal project staff.

Why Is This Component Important?

A Project Organizational structure that matches the characteristics and needs of the project will facilitate successful management and completion. Well-considered positions and assignments avoid miscommunications and misunderstandings and ensures that all stakeholders and project participants are aware of their respective roles, responsibilities, authorities, and lines of communication during the execution of the project.

How To Develop and Write This Component

There are four subcomponents in Component 2 Project Organization, as listed in the table below. The first three are required of all projects and provide an overview of the organization and detailed descriptions of the external and internal participants and stakeholders. The fourth subcomponent is required only if the Awardee forms collaborations or partnerships with other entities and institutions for the project.

The Project Organization should be structured in a manner tailored and scaled to the type, size, complexity, and characteristics of the project. All participants and stakeholders should be familiar with the organization and agree with its structure, roles, and authorities. The organization is typically developed in a progressively elaborated approach, as described below in X.X.X.X.

Table 3.5-3

Project Organization components, subcomponents, products, and documents that satisfy subcomponent requirements, as well as references to further material and related topics.

Component	Sub-Component	Docs/Products	References
2. Project Organization	2.1 Overview of Project Organization		
	2.2 External Project Stakeholders	Organization Chart Roles and Responsibilities Table	
	2.3 Internal Project Organization	Organization Chart Roles and Responsibilities Table	Section 4.2 Project Scope and Work Breakdown Structure Section 4.6.6 Project Personnel and Competencies
	2.4 Partnerships and Subawards	List of Partners, Agreements, and Contributions	Section 5.9 Partnerships

PEP 2.1 Overview of Project Organization

The overview provides a summary of the Project Organization, including the general Project Organizational structure, key participants, external stakeholders, project partners, and any other important organizational information required to explain and execute the project successfully.

PEP 2.2 External Project Stakeholders

In this subcomponent, key external project stakeholders are identified and described, along with their connection to the project, their expected roles, and their lines of communication and authority. External stakeholders are individuals and entities with relationships to, and interactions with, the project that do not normally involve contributions to day-to-day project activities or deliverables (e.g., the NSF, user groups, host institutions, etc.). The following products are required for this subcomponent:

- **External Organization Chart.** A graphical depiction of how the project structure relates and interacts with all key external stakeholders is required.

- **Roles and Responsibilities List.** A table or list with descriptions of the roles, responsibilities, authorities, and communication links between the project and all identified key external stakeholders is also required.

Examples of a sample external organization chart and example roles and responsibilities descriptions are shown in Figure 3.5-2 and Table 3.5-4 below.

Generally, external stakeholder relationships start to be identified or formed during the Project Definition stage, with communication and interactions initiated well in advance of the start of implementation or Construction Stage. The external organization chart becomes progressively elaborated as planning advances and becomes mature. For stakeholder relationships not yet established, the recipient should explain the plans and steps necessary to set up communications and interactions, including details such as identified contacts, frequency of meetings, charters, intellectual property provisions, along with others.

The types and number of external stakeholders included in the external organization varies from project to project, based on project characteristics and needs. External stakeholders may include but are not limited to, the following.

Funding and Oversight Groups. The NSF is typically the primary funding and oversight entity for projects described in this PEP. For projects that are part of a larger endeavor, there may also be other external entities with oversight and responsibility for the overall project, including the NSF-funded portion.

Institutional Project Sponsors. These are typically leaders or departments in the Awardee organization with an interest in the outcome of the project and organizational authority to provide resources and overcome barriers to the project. Examples: vice president for research, sponsored research offices, facilities providing space and resources, institutional business, and administrative services departments, and so forth.

External Advisory Boards. Some projects may have a group of subject matter experts that provide ongoing consultation for science and technical matters, community engagement, programmatic advice, or other relevant topics. It should be noted that such advisory boards are a project resource but do not generally have any role in actual project oversight. The oversight function is the responsibility of NSF and/or other funders. As a result, the advisory boards cannot formally approve any changes in project scope, schedule, and budget but can advise the project on the development of such requests.

External Technical Review Boards. These are project-instituted, independent technical review and readiness panels that provide advice on advancement to the next stage or phase, composed of subject matter expected external to the project. They can also include ad hoc external subject matter experts who advise on technical issues. These external, technical review boards are in addition to and do not replace, any internal technical or mixed review board review panels used to verify designs or accept quality testing.

Research Community Stakeholder Groups. Projects may maintain communications with representative groups comprised of researchers interested in using the infrastructure or resultant data and who, therefore, have a stake in the project deliverables and future operations. Examples of these may include a Science Working Group (SWG) or a user's group. Relationships with these groups are typically for information exchange only.

Public Community Stakeholder Groups. Projects will likely want to establish relationships with representatives of the public who have an interest in the public impacts of project implementation and who may, therefore, have influence on project activities and outcomes. Examples include individuals, communities, organizations, and anchor institutions such as governments, federal, state, and local agencies, schools, libraries, health and social service providers, tribal and indigenous-serving organizations, non-profits, cultural organizations, and businesses.

The most common structure used for an external organization chart for Mid-scale RI implementation is the traditional, hierarchical layout, as shown in Figure 3.5-3.

Note that relationships between project leadership and external stakeholders are indicated with clear lines of communication and authority shown on the chart. Arrows, dotted lines, and position in the chart can indicate the direction of interactions, oversight and authority versus communications, and primary contacts.

Figure 3.5-2

An example of an External Organization Chart showing clear lines of authority and communications for a project with a traditional organizational structure. DRAFT FIGURE

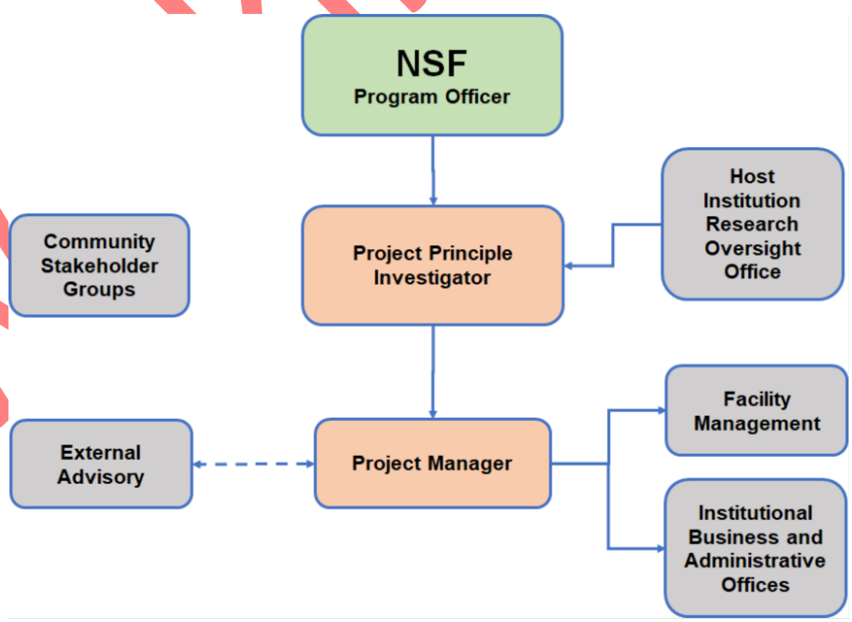


Table 3.5-4

Examples of external roles and responsibilities (DRAFT FIGURE)

External Advisory Board	The Advisory Board is composed of subject matter experts, recommended by the project leads, and appointed by the project Principal Investigator (PI) for the duration of the project. The Board provides advice and recommendations on project management and technical issues to the PI.
User Group Board of Representative	The users' group is an independent, external coalition of researchers and potential users of the completed infrastructure, with a stake in the design requirements, performance, and operations of said infrastructure. A Board of Representatives, comprised of members elected and serving according to the Group's charter, will meet with the project PI. During the meetings, the PI will update the Board on the status and plans of the project, while the Representatives will provide input on the desired usage of the infrastructure and communicate any concerns or issues that may impact the wider research community.

Good Practices and Practical Considerations

- Advisory groups (technical advisors or user groups) have no oversight role, and the PI has no obligation to adjust project requirements and goals. However, the PI should be responsive to requests and concerns as allowed by the constraints of the projects.

PEP 2.3 Internal Project Organization

This subcomponent describes the internal organizational structure of the project. The identification of key internal positions and leadership roles should occur early in the project planning process, along with the selection of an organizational structure that is compatible with the project characteristics. The chosen organizational structure should be matched (tailored) to the characteristics of the project and aligned with the key project deliverables as detailed in the project WBS containing all project scope. The organizational structure will dictate roles and lines of responsibility and authority.

An internal organizational chart and a roles and responsibilities table are required for all implementation and Construction Stage projects in this subcomponent. A graphic representation of the internal Project Organizational breakdown structure (OBS) shows key roles and leadership positions within the project and clear lines of communication and authority. A roles and responsibilities table provides a description of the roles, responsibilities, authorities, and communication linkages between key leadership and management positions in the internal organization.

Internal Organizational Chart. The three most common structures for NSF projects are traditional hierarchical, functional, and matrixed. The traditional Waterfall is the most common method for NSF projects as it avoids some problems with matrix and functional structures (multiple supervisors, less clear lines of authority, and responsibility for scope and deliverables). Non-traditional organizational structures should be explained as appropriate for the project. The chosen organizational structure should be negotiated with and approved by NSF.

Traditional organization structures are hierarchical in nature and match a traditional (often called Waterfall) WBS. Project roles are aligned with the deliverables captured in the project WBS. Lines of authority and responsibility for deliverables in the WBS are one-to-one and flow from the top levels of the WBS down to lower levels. Roles and responsibilities can be clearly and simply defined. An example of a traditional Waterfall and matrix organization chart is shown in Figure 3.4.3-x.

Functional organizations, where leaders and teams are aligned with institutional and support functions rather than deliverables, are allowed but are less common and require agreement from NSF. Functional leaders report directly to the Project Manager (PM) and manage their staff's assignments to work on deliverables across the WBS. The mapping between leadership below the PM and responsibility for deliverables in functional organizations can be less clear than in traditional hierarchical structures since one individual or support group may serve the same function across several WBS elements. In that case, a Responsibility Assignment Matrix (RAM) that assigns individuals or organizations to all tasks and deliverables becomes essential for assuring that all project scope has assigned and responsible oversight. A typical RAM may have four primary assignments: *Responsible, Accountable, Consulted, and Informed* (and therefore is also called a RACI matrix). An example of a functional organization chart is given in Figure 3.5-4.

Projects that are cyclical in nature or that require flexibility and speed, such as software projects based on Agile frameworks, may rely on a matrix or other non-hierarchical organization. A matrix organization can be represented by a grid with functional roles on one axis and hierarchical roles along another. Managers and leaders share authority and responsibility for deliverables with others, and workers may report to multiple bosses. Note that NSF requires a traditional, hierarchical structure down to WBS Level 2 but allows flexibility in organizing below those levels along other, well-justified structures such as Agile-based stories, epics, or other cyclical work packages. An example of such a hybrid organization that includes an Agile structure at lower WBS levels is shown in Figure 3.5-5.

Figure 3.5-3

Example of a hierarchical organization structure for a traditional Waterfall project. Leadership positions are assigned to and aligned one-to-one with the WBS structure, as shown by including the WBS number in the position title. PLACEHOLDER DRAFT FIGURE

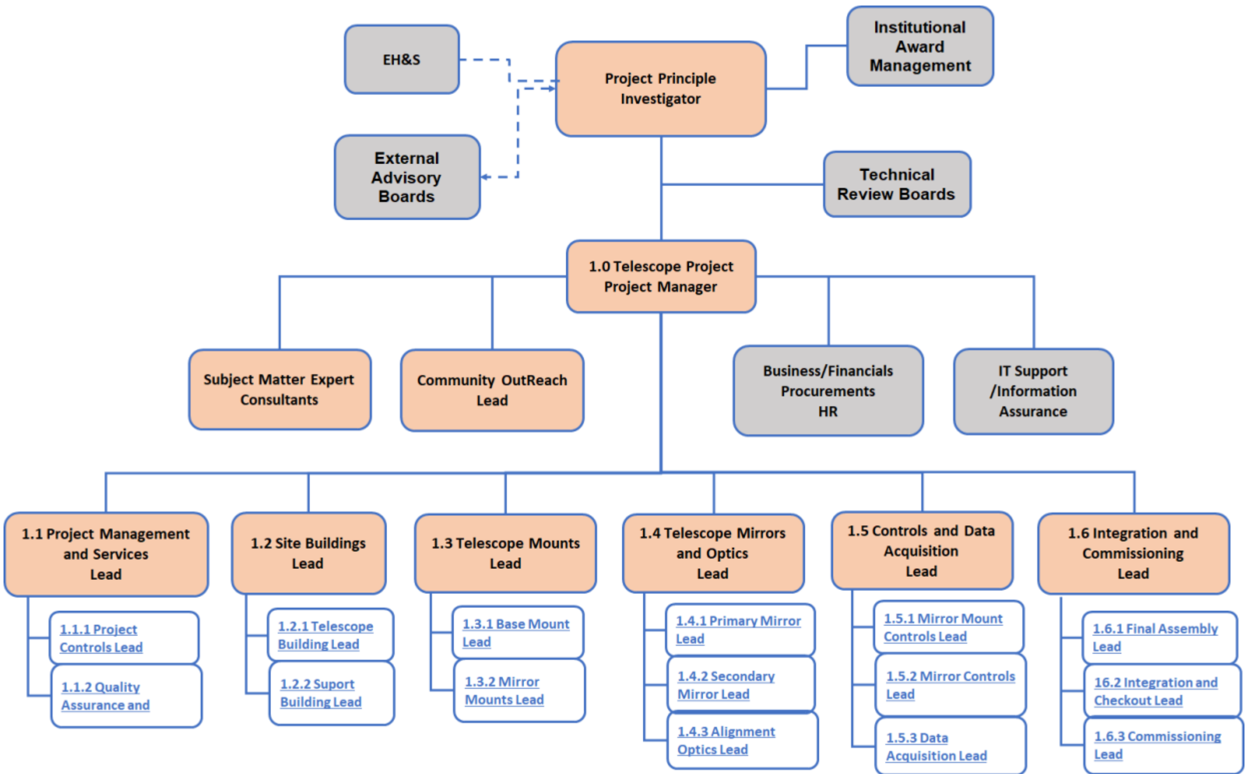


Figure 3.5-4

An example of a functional Project Organization is where leads are assigned to capability areas that report to the Project Manager. Each lead works on multiple deliverables. Responsibility for deliverables is typically assigned in a Responsibility Assignment Matrix. PLACEHOLDER DRAFT FIGURE

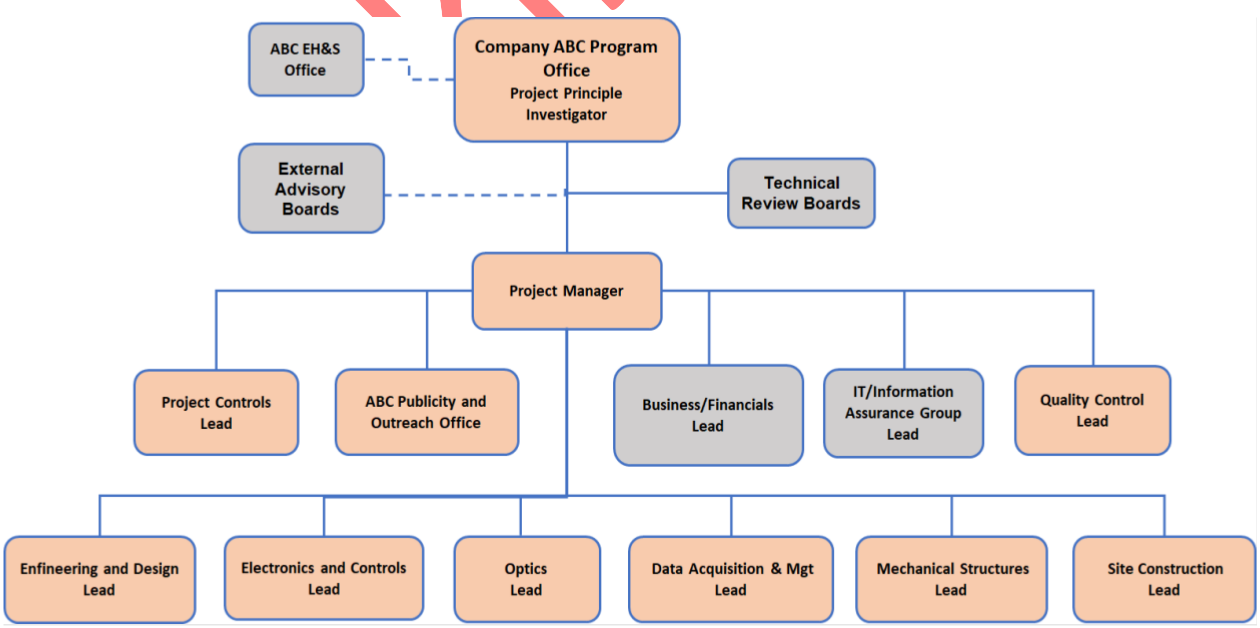
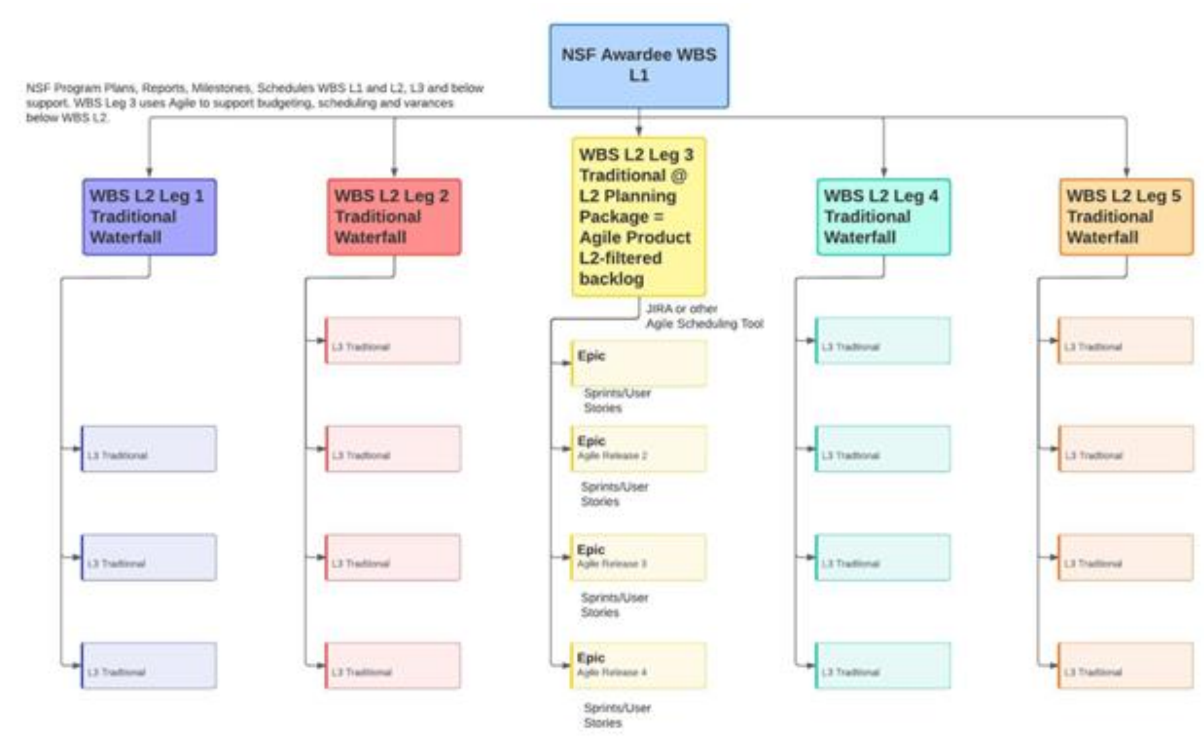


Figure 3.5-5

An example of a hybrid organization is showing a traditional structure to Level 2. Below Level 2, the legs of the organization chart are mixed between traditional and matrixed/Agile structures. DRAFT PLACEHOLDER. Insert one of Blaise's hybrid org charts or create a new, simpler graphic?



Key positions, organizational structure, relationships, and roles and responsibilities should be determined as early as possible in the project. Not all positions may be identified at first, nor will all be filled during early planning. The details of the organization advance in maturity from a rudimentary form to a fully mature organization ready to support implementation at the review for approval to award. As planning matures and approaches the start of implementation and Construction Stage, roles will become better defined, and individuals can be identified and assigned to the positions in the chart. The Resource Management Plan that is detailed in PEP Component 4 Risk and Contingency Management should provide details of how any unassigned key positions will be filled in a timely manner through hiring or other means (for example, hiring plan schedule and actions to ensure that key personnel (such as a PM) are on board by the start of implementation.)

Roles and responsibilities for leadership positions should be aligned with the needs of the position before any consideration of personnel assignments. Personnel selected for leadership and key roles in the project ideally should have all the necessary skills, experience, and qualifications for the assigned position. This includes both scientific and technical qualifications as well as the willingness and ability to provide staff oversight and perform project management tasks such as budgeting and progress reporting. Recipients may want to consult Section 4.6.6 Personnel and Competencies for assistance in defining the roles and responsibilities. Written and tabulated examples of roles and responsibilities are shown below.

Figure 3.5-6

DRAFT EXAMPLE OF RandR

Example of written descriptions of roles and responsibilities

EHS Officer:

An EHS staff member trained in safety and shop operations will provide weekly guidance and oversight on safety and compliance. The EHS Officer will advise on safety-in-design aspects of the design and assembly plans. The EHS Officer will visit and assess the safety plans for the assembly site and review the safety plans for testing.

Project Manager:

The PM reports to the PI and is responsible for the oversight of the budget, schedule, change management, and risk management. The PM oversees the work package leaders and manages the execution of the project to ensure that the project is completed within the approved cost, schedule, and technical scope. The PM is responsible for the development, documentation, and implementation of effective project management systems, cost controls, and schedule milestones to assess project performance. The PM is responsible for risk evaluation and management in accordance with the project Risk Management Plan (RMP). The PM chairs the Change Control Board (CCB) and is responsible for approvals before passing change requests to the PI for final approval.

Example roles and responsibilities in table format

Title	Name and *Institution*	Roles and Responsibilities
Bike Spec and Design Team Lead	**Maria Martinez,** ***Tech Univ. Eng. Department***	• The Bike Spec. and Design Lead reports to the PM and is accountable for meeting designated work package deliverables • Responsible for keeping communications open with the PI, the PM, other team leads, and all Project stakeholders. • Responsible for planning and maintaining the technical design, scope, cost, and schedule. • Supervises the resources and contracts for accomplishing the tasks and adjust schedule to meet stakeholders' needs. • Assures compliance with technical requirements, Project configuration management, and Tech Univ. policies/ procedures regarding procurements and EH&S. • Monitors and controls risks, tracks progress against the plan, and reports status and variances on the defined schedule. • Participates in Change Control Board discussions and follows configuration controls with respect to changes in scope, cost, schedule, and/or performance.

Good Practices and Practical Considerations

- The size and complexity of the organizational chart (the number of leadership roles and layers of authority) should align with the project's characteristics. For example, large complex projects may choose to assign a leader and a deputy for a particular leadership position so that, between the two, both technical and management needs can be met. Smaller and less complex projects may include only one individual for each leadership role, but those individuals may serve in multiple leadership assignments.
- If the organization separates the roles of PI and Project Director (PD), each should be described.
- Generally, there should be no more than five to seven direct reports to any one leader.
- The organizational structure presented in the PEP should be high-level and include leadership and key personnel only, not every individual working on project tasks. Key positions listed in the internal Project Organization typically include the PI and Co-Principal Investigators (Co-PI), the PM, primary Technical Leads and Control Account Managers (CAM), and any other key leads, such as Safety Officers or Systems Engineers. The complete listing of all project positions is developed in the staffing plan described in PEP Subcomponent 5.4 Resource Management Plans.
- For traditional organizations, it is good practice to include WBS numbers in the organization chart to easily tie responsibility and authority to work packages and deliverables.
- In some cases, two people with complementary skill sets may be needed to fill leadership roles. For example, PI and PM roles require different areas of expertise. The project may be better served by selecting two people to fill the roles.
- Technical team leadership may be shared between a Lead and a Deputy, with one assuming leadership in scientific or technical aspects and the other leading day-to-day activities and project management responsibilities.
- The focus for the definition of the organizational roles and responsibilities should be the requirements for the position to be filled. All the experience, positions, and honors of the assigned key and leadership personnel in this section should not be listed.
- If additional project team training is planned, it should be included in the Staffing Plan as described in Component XXX. Examples may include general project management training as well as specific training for CAM performance reporting and tracking.
- RAM and RACI tables are common ways to capture roles and assignments. Many projects expand their RAM with CAM assignments. The essential goal is to ensure that all WBS elements or deliverables have an assigned individual with responsibility and

authority to ensure that all scope is completed within budget and schedule while meeting requirements.

PEP 2.4 Partnerships and Subawards

This subcomponent identifies all partners and Subawardees who are essential contributors to the success of the project, describes their contributions, and identifies the responsible partner contact/lead. Information on funding sources for each partner, the terms and conditions of the partner agreement (Memorandum of Understanding [MOU], subaward, commitment letter, etc.), and details of schedules and interfaces should be provided. This may include discussions of the criticality of the deliverable, along with backup plans if the partner struggles or cannot deliver. For subawards, describe how oversight is to be managed by and through the primary recipient. This includes specific roles of key partner personnel, frequency of oversight meetings, how performance measurement and management will be executed, how financial oversight will be managed, how risk and contingency are managed, and other relevant information necessary to ensure project success. An example of a partnership summary table with relevant partnership information is shown below.

Table 3.5-5

Example of a list of partners, with type of agreement, lead contact, and areas of support/contributions.

DRAFT FIGURE PLACEHOLDER

Partner Type	Partner Institution	Lead	Area of Support
Sub-award	Jim's Custom Bike Builder	Jim Jones	• Provide space, labor, and tools for bike assembly • Develop and Deliver Final Manufacturing and Assembly Plan • Provide staff to work on the bike design team • Work with partner on adapting plans to target audience
In-Kind, MOU	SportMoto Parts Company	Mike Malone	• Donate 8 moto-bike sand tires for design studies and prototype use
Sub-award	Buffalo Bicycles Subsidiary of World Relief Bicycles	Brian Moonkola	• Provide input on target community needs • Provide a team of 5 riders experienced in testing bikes and components in punishing conditions for up to 100 hours of testing in designated terrain • Distribute the final design and Manufacturing and Assembly plan to its network of workshops in appropriate areas in Africa

Good Practices and Practical Considerations

- Key considerations for forming partnerships are given in Section 5.9 Partnerships. International partnerships, for example, require early planning and communication of intent to NSF.
- The body of the section should contain the partnership details in text format, but it is good practice to provide a summary table with key information for easy reference.
- If there are external partners, their project roles and responsibilities should also be described.

3.5.3 PEP Component 3 Performance Measurement Baseline

What Does This Component Describe?

This component describes the Performance Measurement Baseline (PMB) that defines and documents the four objective measures of project success: scope, quality, schedule, and budget. These four elements are captured in a suite of documents, including a Work Breakdown Structure (WBS), WBS Dictionary, Quality Acceptance Requirements, Integrated Project Schedule (IPS), and a time-phased budget. Additionally, this component provides a summary view of the total project definition, which includes the contingency associated with each of the four PMB elements and a yearly funding profile.

Why Is This Component Important?

The PMB is the pre-defined and documented definition of project success. It is the agreed-upon objective target upon which all project activities should be planned and directed. A successful project should result in the delivery of 100% of the scope as defined in the PMB, meeting all of its quality acceptance criteria, and doing so on schedule and within budget. One cannot fully plan, execute, or close a project successfully without a well-defined and stable PMB.

How To Develop and Write This Component

There are five subcomponents to be included in PEP Component 3 Performance Measurement Baseline, as listed in the table below. All five are required, regardless of project type, size, or complexity. Each subcomponent has several identified documents or products that should be created during the development of this component.

The PMB should be structured in a manner that matches the project characteristics and is agreed upon by the participants and stakeholders. This entire component should be tailored and scaled to the individual type, size, complexity, and characteristics of the project. Further, the subcomponents are typically developed in a progressively elaborated approach, as described in Section 4.4/TBD.

Table 3.5-6

Component	Sub-Component	Documents/Products	References
3. Performance Measurement Baseline	3.1 Overview of the Project Performance Measurement Baseline	TPC and TPD Summary Milestones Summary Budget and Funding Profiles	NSF EVM Gold Card[2]
	3.2 Scope	WBS WBS Dictionary Scope Management Plan	Section 4.2 Project Scope and Work Breakdown Structure
	3.3 Quality Acceptance Requirements	Requirements Documents Specifications Test plans Acceptance criteria	
	3.4 Integrated Project Schedule	Schedule Basis and Estimating Plan Integrated Project Schedule Reporting Milestone Table	Section 4.4 Schedule Development, Estimating, and Analysis Government Accountability Office (GAO) Schedule Estimating Guide
	3.5 Time-Phased Budget	Cost Estimating Plan (CEP) Cost Book and Basis of Estimate (BOE) Time-Phased Budget	Section 4.3 Cost Estimating and Analysis GAO Cost Estimating Guide

PEP 3.1 Overview of the Project Performance Measurement Baseline and Project Definition

This subcomponent serves as an executive summary and overview of the project baseline and project definition, providing all the essential high-level features of the project in one place. The PMB encompasses the four components: scope, quality, schedule, and budget. In

[2] https://www.nsf.gov/bfa/lfo/docs/NSF_EVMS_Gold_Card_July%202019-1.pdf

addition to the PMB, the project definition adds contingencies and fees (where authorized) to obtain the TPC and TPD for the NSF award. It also includes a time-phased budget for the funding required to execute the project, a funding profile for the NSF TPC, and any outside funding necessary to execute the project. The following four subcomponents in PEP Component 3 Performance Measurement Baseline address the four elements of the PMB, while contingencies are addressed within PEP Component 4 Risk and Contingency Management.

The overview should provide a listing of the project scope at WBS Level 2 and state the key elements of the Project Definition: the TPC (i.e., PMB budget + budget contingency + fee), the TPD (PMB schedule + contingency), and the planned start date. The cost and schedule contingency percent of the baseline should also be given. The text should be accompanied by a summary table of the key Project Definition elements, including a list of the Level 2 WBS elements (scope) and associated budgeted costs, schedule dates, and durations. The table should include overall cost, schedule contingency amounts, and baseline percentages in summarizing the TPC and TPD.

Table 3.5-7

Example of a Project Summary Table showing the high-level parameters of the Project Definition: WBS to Level 2 with associated costs and schedule, including summarized TPC and TPD with contingencies. In this example, responsible individuals and institutions are assumed to be known and are included.

WBS #	WBS Element Name	WBS Lead	Lead Institution	Budget	Schedule Dates and/or (Duration)
1	Project Name	PI	INST 1	-	Start / End (Months)
1.1	L2 Element	CAM	INST 2	$$	Start / End (Months)
1.2	L2 Element	CAM	INST 3	$$	Start / End (Months)
1.3	L2 Element	CAM	INST 1	$$	Start / End (Months)
	Baseline Subtotal			$$$$$	Years/months
	Contingency (% of Baseline)			$$ (%)	Years/months (%)
	Fee (if applicable)			$	
	Total Project Amount			$$$$$$$	Years/months

A time-phased funding profile for the financial resources needed to accomplish the project activities is required for this subcomponent. This is typically demonstrated in a table, with accompanying text that explains up and down ramps, along with unusually large peaks and low points. At a minimum, the table should include the time-phased project PMB commitment budget (spending plus obligation), the anticipated yearly contingency allocation amount, and the TPC. Any other funding sources (i.e., non-NSF) should also be included as distinct, separate elements. An example table is shown in Table 3.4-x.

Table 3.5-8

Sample commitment and funding profile table by fiscal year

Item	Year 1	Year 2	Year 3	Totals
Base Budget:	$15,350,650	$8,500,375	$34,560,180	$58,411,205
Contingency:	$2,302,598	$1,700,075	$5,184,027	$9,186,700
Total Project Cost (TPC):	$17,653,248	$10,200,450	$39,744,207	$67,597,905

Good Practices and Practical Considerations

- It is good practice to include the responsible lead partner institutions, if any, and the assigned CAM if known.
- Some projects break the baseline budget in the project summary definition and funding profile tables down into cost categories to enhance understanding of the budget flow. Early project costs may be mostly equipment and materials and supplies (M&S) procurements, while later costs may be labor dominated. Commonly used cost categories include equipment, M&S, labor, and travel, or just labor and non-labor. Some projects may separate indirect and direct costs in the summary funding profile.
- Budgets and funding profiles should include escalation and inflation adjustments for all project costs in *then year* dollars for the planned project spend date, which may be three to five years after a project proposal is submitted.

PEP 3.2 Scope

This subcomponent identifies and describes the baseline scope of the project via two key documents: a WBS and a WBS dictionary. Both of these documents are required for every project. The WBS integrates and relates all project work (scope, schedule, and cost) and is used throughout the project management to identify and monitor project progress. See Section 4.2 Project Scope and Work Breakdown Structure for detailed guidelines on developing a WBS. Every project, regardless of type, size, or complexity, is required to have a WBS that includes at least specific Level 2 deliverables. Below that level, the details will be dependent on the project specifics. Summaries of these two documents are included in this PEP subcomponent.

Work Breakdown Structure. The full scope of the project is identified and listed in a deliverables-based WBS, where the deliverables are comprised of the project's products, results, and services. The project WBS is an organized hierarchical listing by name or title of all scope in the project. If the complete WBS for the project extends to levels below Level 3, it will generally be too large for inclusion in its entirety within the PEP. In that case, the full WBS should be maintained in a separate document or appendix, and only the first few WBS levels should be displayed in the PEP. A statement should be made enumerating the number of levels and providing a reference to the full WBS as a supplementary document.

WBS Dictionary. A corresponding high-level WBS Dictionary summary is also included in this subcomponent. The WBS Dictionary defines and describes each element of the WBS. Like the WBS itself, the full WBS Dictionary is typically created as a supplementary document and referenced within the PEP. The WBS Dictionary that is included in this subcomponent is limited to the Level 2 or Level 3 WBS determined above.

Scope Management Plan. A Scope Management Plan (SMP) should be developed as part of this subcomponent. The SMP should clearly and concisely describe the overall strategy and approach to managing scope. It should describe how scope is identified, defined, described, and documented in the WBS. The SMP should describe specific roles and responsibilities for managing project scope. Further, the SMP should define how scope is to be controlled over the course of the project, including the management of scope creep pressures. Finally, the SMP should describe how both descope and upscope options will be identified, documented, and tracked, as well as how they will be considered and reviewed via Change Control and/or configuration management. Relevant information such as WBS area estimated cost and schedule impacts, time frames in which the de- and upscopes are viable, priorities of these options, and how decision dates will be incorporated in planning (e.g., inclusion in the IPS) should be included.

Additionally, the SMP should be developed and included as part of this subcomponent. The SMP should describe how Scope Options (e.g., time-phased descopes and upscopes) are considered, reviewed, and approved.

A summary table that includes all high-level scope elements through WBS Level 3, along with corresponding dictionary descriptions, should be included in this subcomponent.

Table 3.5-9

WBS #	WBS Element Name	Element Description (Simplified WBS Dictionary Entry)
1	Project Name	
1.1	L2 Element Name	High-level deliverable description, including key subcomponents, significant exclusions, and other relevant high-level information necessary to describe the element clearly and unambiguously.
1.1.1	L3 Element Name	High-level deliverable description, including key subcomponents, significant exclusions, and other relevant high-level information necessary to describe the element clearly and unambiguously.
1.2	L2 Element Name	High-level deliverable description, including key subcomponents, significant exclusions, and other relevant high-level information necessary to describe the element clearly and unambiguously.
1.2.1	L3 Element Name	High-level deliverable description, including key subcomponents, significant exclusions, and other relevant high-level information necessary to describe the element clearly and unambiguously.

Note that the WBS structure should be tailored and scaled to the project and organization characteristics. Most, but not all, NSF projects are usually well matched to a traditional Waterfall framework, with a hierarchy of elements that sum up to higher levels. Traditional frameworks are most common, but NSF allows other frameworks, depending upon the project characteristics. Software developers and other organizations accustomed to cyclical planning and management methods, for example, may be accustomed to an Agile framework.

If a project elects to use a non-traditional WBS and management framework, it needs to present a clear justification and description of the terms and methods to be used. For instance, Agile projects may equate stories or epics with work packages in traditional project frameworks.

Good Practices and Practical Considerations

- While task-based WBS are acceptable in some industries, a product-oriented WBS is preferred for NSF RI projects. That is, the WBS should capture only deliverables: products, services, and results. Associated tasks and activities are captured in the project's IPS, not the WBS. One simplistic way to think of this is that the WBS includes nouns while the schedule includes action verbs.

- The level of detail in the WBS should match the stage, size, and complexity of the project. The lowest-level elements of the WBS on any branch are called work packages. Work packages serve as the focus on corresponding activities in the IPS, that is, the activities in the IPS should be developed and organized around the provision and delivery of the work package scope. Similarly, work packages are used as the lowest level budgeting elements in the time-phased budget, that is, the cost Basis of Estimates (BOE) described below in PEP Subcomponent 3.5 Time-Phased Budget are established at the work package level.
- In a hierarchical WBS, lower-level WBS elements roll up to the higher levels such that each high-level WBS is the sum of the lower-level elements and work packages.
- Acceptance of any non-traditional framework will need to be negotiated with NSF.
- When naming lower-level WBS elements, add identifiers that link to the higher-level WBS, that is, *Procurement* may occur many times in the WBS, but *Periscope Optics Procurement* will distinguish between the various other procurements and avoid confusion when viewing elements out of context.
- Control accounts and CAM should also be identified when constructing a WBS. An accountable person should be identified for each high-level WBS element of scope to ensure proper management and oversight are provided.

PEP 3.3 Quality Acceptance Requirements

This subcomponent describes the processes for determining and documenting the requirements and quality acceptance criteria and plans for the deliverables identified and included in the WBS. It describes how the key parameters and high-level science requirements summarized above in PEP Subcomponent 3.2 Scope flow down to detailed science requirements, engineering requirements, and quality/acceptance requirements and plans. If all requirements or plans are not fully mature, it describes the process the project will follow to progressively elaborating documentation and planning.

Typically, requirements are captured in tabular format. One example of this type of table is shown below in Table 3.5-10; note, however, that the format of the table will depend strongly on the characteristics of the project. For complex projects with many cross-linked requirements, a database or multiple spreadsheets or tables with links to higher-level requirements may be needed. If the actual requirements documents are too large to include in the PEP itself, then this subcomponent should describe the processes and reference them as provided supplementary requirements documents.

Table 3.5-10

A simple table showing the traceable flow down links from key parameters to science and engineering requirements to quality plans and requirements. Complex projects may require separate but linked documents tracing the relationship between high-level requirements and lower, detailed requirements and quality plans.

Key Performance Parameters	Science Requirements Documents	Detailed Science and Engineering Requirements Documents	Quality Acceptance Plans
Key Parameter A	High-Level Science Requirement A High-Level Science Requirement B	Detailed Science Requirements Document XY	Quality Control and Acceptance Plan for Component X Quality Control and Acceptance Plan for Subsystem Y
Key Parameter B	High-Level Science Requirement C High-Level Science Requirement D High-Level Science Requirement E	Engineering Requirements for Subcomponent Y Engineering Requirements for Subcomponent Z	Quality Control Plan for Subcomponent Y Acceptance Plan for Subsystem Z
Key Parameter C	High-Level Science Requirement D	Detailed Science Requirements Document YZ	Testing Plan for Component Z

The quality acceptance criteria and requirements for all other lower-level scope listed in the full WBS should be included as supplementary documents and referenced from within this PEP subcomponent. Note: At the time of award, not all Quality Acceptance Requirements documents, especially for lower-level elements, are necessarily required to be completed. However, a plan for progressively elaborating, completing, and approving these requirements, including a timeline for accomplishing plan elements, should be described.

Good Practices and Practical Considerations

- Note that science requirements are related to the quality of the science, while engineering requirements are related to the details of the particular solution or approach to achieving the science goals.
- A good practice is to follow the SMARTTT criteria in determining requirements and acceptance plans: Specific (clear and unambiguous), Measurable (testable), Achievable (possible within project constraints and parameters), Relevant (suitable

and germane to the project goals), Traceable (derived and flowed down from a higher-level requirement, KPP, or project objective), Tiered (numbered in a hierarchical (flow-down) manner), and Total (complete and standalone). For example, it is not sufficient to simply state that software shall be robust.

- The use of compliance matrices (CMX) is encouraged to track adherence to the acceptance criteria, identify areas that are pending, and highlight specific requirements that have not been met. A good practice is to create a CMX for every requirement document or set of specifications.
- A formalized process using requests for waivers against requirements that cannot be met is encouraged during project execution. The plan for this process is described in PEP Component 7 Project Control Plans. Depending on the magnitude of the scope impacted, some proposed waivers may require NSF review and approval, according to the established Change Control process.

PEP 3.4 Integrated Project Schedule

This subcomponent describes the development of the baseline IPS, a management tool used for planning and executing work during implementation and Construction Stage projects. The IPS addresses both how and when the work is to be performed by identifying the activities needed to accomplish the scope of work and by time-phasing these activities with durations and schedule logic. Logical sequencing involves identifying the key relationships between activities to determine the proper sequence necessary to accomplish the work. The IPS is based on the WBS hierarchy and includes tasks and activities, project start and end dates, review dates, and other critical dates and key milestones. This subcomponent also includes a description of key assumptions, constraints, and other important information used as the basis of the IPS. Refer to Section 4.4 Schedule Development, Estimating, and Analysis for detailed guidance on the development of construction schedules and plans, including the schedule basis document and NSF expectations associated with the GAO scheduling best practices.

The following products are required for this subcomponent:

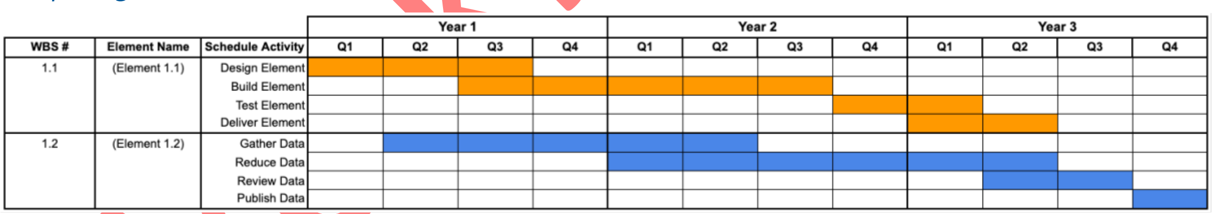
- **Schedule Basis and Estimating Plan.** A description of the methodology, tools, and processes for developing and estimating the project schedule, including key assumptions and constraints.
- **Integrated Project Schedule.** A series of tasks, summary tasks, and milestones based on the WBS hierarchy. For the purposes of the RIG, tasks and activities can be considered equivalent terms.
- **List of Reporting Milestones.** A tiered table or list with the key, high-level milestones that will be used to monitor and report progress.

The Schedule Basis and Estimating Plan describes the methodology, tools, and processes used in developing the schedule of activities that follow the WBS. It describes the estimating techniques, guidelines, and assumptions followed by project estimators. Project team members should consult the detailed guidance on creating schedules given in Section 4.4 Schedule Development, Estimating, and Analysis, considering tailoring and scaling to project characteristics. The plan should include the basis for schedule network logic, the external dependencies, constraints, and key drivers of the critical path. Key dates used in the development of the schedule, such as life cycle dates, decision dates, hand-off dates, and so forth, should be identified. Key assumptions should address topics such as procurement durations, calendars/seasons, operations integration requirements, funding parameters, items excluded from the schedule, and so forth. Assumptions about travel estimating, defined work years, numbers of shifts, and any staffing and resource limitations should be provided. The plan can be included in this PEP section if it is not too long. Otherwise, its key points can be summarized here with a reference to a separate and complete supplementary plan document.

The required IPS should be based on the WBS hierarchy, with each specific deliverable identified in the WBS accounted for in a series of tasks, summary tasks, and milestones. A complete IPS is typically too large to be included in the PEP document itself and is usually included as a supplementary document to the PEP. A summary view of the baseline IPS shall be included in this PEP subcomponent, showing a high-level view of the project that corresponds to the high-level WBS deliverables listed above in 3.4.4.2. The scheduling approach, tools, and documents should be tailored to the project complexity and characteristics. For very simple projects, the IPS may consist solely of a list of key activity and milestone dates or blocking in a spreadsheet or cartoon. For most projects, however, a Gantt-type schedule that is created with commercial scheduling software is preferred. An example of a Gantt chart is shown below in Table 3.5.-11.

Table 3.5-11

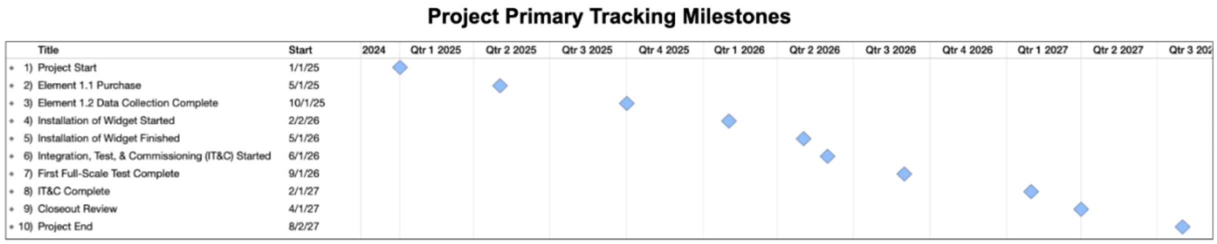
Sample high-level Schedule Gantt chart



Projects are required to produce a list of tiered tracking milestones based on the scheduled activities. At the highest level, this constitutes a short list of milestones that are reported to NSF. The milestones shall be spaced at a frequency that will readily communicate how well the project is tracking the overall plan without being too inclusive of minor details. The second tier is typically used by project management to track progress, while lower tiers are used by CAMs, and work package leads track progress at lower WBS levels. Usually, only the key tracking milestones need to be displayed in the PEP, with lower levels referenced in separate supplementary documents. An example of a list of key milestones in graphical format is shown below in Table 3.5-12 below.

Table 3.5-12

Sample graphical representation of Key Tracking Milestones



Project Primary Tracking Milestones

Title	Start	2024	Qtr 1 2025	Qtr 2 2025	Qtr 3 2025	Qtr 4 2025	Qtr 1 2026	Qtr 2 2026	Qtr 3 2026	Qtr 4 2026	Qtr 1 2027	Qtr 2 2027	Qtr 3 202
1) Project Start	1/1/25												
2) Element 1.1 Purchase	5/1/25												
3) Element 1.2 Data Collection Complete	10/1/25												
4) Installation of Widget Started	2/2/26												
5) Installation of Widget Finished	5/1/26												
6) Integration, Test, & Commissioning (IT&C) Started	6/1/26												
7) First Full-Scale Test Complete	9/1/26												
8) IT&C Complete	2/1/27												
9) Closeout Review	4/1/27												
10) Project End	8/2/27												

A high-level view or description of the project's critical path shall be included in this subcomponent. Ideally, this is represented graphically in the summary schedule (or milestone/task list for very simple projects) using color coding. Again, the full IPS with an identifiable critical path is typically included as a supplementary document to this PEP. The critical path shown in the PEP should be a simplified high-level view that corresponds to the high-level WBS elements described above in PEP Subcomponent 3.2 Scope.

Good Practices and Practical Considerations

- The IPS should be logically driven, with all activities and milestones driven by predecessors and successors. Specific deterministic dates (arbitrary start or stop dates not driven by related activities) are not good practice and should be avoided to the extent possible.
- The baseline schedule should be constructed without built-in buffers or other forms of hidden schedule contingency. Approved schedule contingency is held and managed separately from the baseline schedule, but it can be shown in the IPS as described in Section 4.7 Contingency Estimating and Management.
- The IPS should be resource loaded (labor and non-labor). For simple projects, this may mean assigning budget and staff to key milestones, tasks, or WBS elements. Projects using commercial scheduling software can use internal tools to add resources to the IPS.
- The number of Tier 1 tracking milestones per year will depend upon the project characteristics, but a good rule of thumb is at least one or two but not more than five or six.
- The TPD includes the baseline duration and schedule contingency, and the milestone table should reflect the difference between those dates.
- The project's IPS should adhere to the GAO scheduling best practices as described in Section 4.4 Schedule Development, Estimating, And Analysis.
- The complexity of a schedule typically drives the needed experience level of the person(s) developing and maintaining the schedule and the selection of a scheduling software tool.

- The use of commercial schedule health evaluation tools, accompanied by explanations of any deviations from standards for quality schedules, is recommended.
- Level-of-Effort tasks should be minimized to optimize the tracking of spending against budget and accomplishments against plan in the project's Performance Measurement and Management (PMM) reports.

PEP 3.5 Time-Phased Budget

The planned, time-phased budget required to execute the project is described in this subcomponent. The budget should be developed and aligned with the WBS deliverables described above in 3.4.4.2.

The following products are required for this subcomponent.

Cost Estimating Plan. A description of the methodology, tools, and processes for developing and estimating the project budget, including key assumptions and constraints. The required CEP describes how the costs are developed, documented, reviewed, approved, and managed. Refer to Section 4.5.2.1 Cost Estimating Plan for detailed guidance on creating a CEP. The CEP should describe the expected cost estimating methodology, maturity, and, if applicable, accuracy range (e.g., expert opinion, analogy, parametric, engineering build-up, historical data). It should also explain any ground rules, assumptions, and exclusions that apply broadly to the estimate, allowances, and other sensitive or significant factors or considerations, including their rationale and any references. The CEP should serve as guidance for the project estimators as well as inform the NSF and reviewers. Planners should also discuss any methods used to validate the estimates, including independent cost estimates and reviews. The CEP should be tailored to the project characteristics and may evolve over time as planning matures. Note that the CEP description within this PEP may only be high-level or an executive summary in nature; reference to and inclusion of a supplementary detailed cost estimating document is usual.

Cost Book and Basis of Estimates. The collection of cost estimate worksheets is supported by detailed information on the basis of how each estimate was established. The Cost Book is the comprehensive and well-documented compilation of budget-related data for the total project scope that organizes, correlates, and calculates project management information. The BOE provides supporting documentation outlining the details used in establishing project estimates, such as assumptions, constraints, and estimating methods, and referencing the technical information used. Consult Section 4.3 Cost Estimating and Analysis for detailed guidelines and requirements for creating a Cost Book and BOE. The Cost Book and BOE must be capable of sorting and filtering to provide the cost estimate in multiple formats and reports in formats compatible with necessary reviews and analyses. The estimate structure must have clear traceability between WBS elements, CEP, and BOEs and correctly roll up to higher WBS levels. Because cost analyses assess the application of fringe, indirect, and escalation rates (among other things), there must be clear traceability in the application of all rates (e.g., with lookup tables and formulas). The budget should map into budget categories, including project defined categories as well as required NSF Budget categories (as defined in the standard NSF budget form). The Cost Book and BOE should be progressively elaborated as project planning matures. For example, early estimates may be based on top-down comparisons to analogous projects, while mature estimates should be based on bottom-up estimates based on vendor quotes and other substantive sources.

Time-Phased Budget. A map of the budget over time as a result of matching the budget estimates to the scheduled activities. Once the baseline budget has been established, it needs to be mapped to the schedule to create a time-phased budget that is the basis of the funding profile request and forms the target for cost performance management as the project is executed. Mapping depends upon the scheduling tools and should be scaled to the project's needs. For example, a simple project may maintain a list of tasks or milestones as the schedule, in which case the budget would be mapped directly to each task or milestone. Most projects use commercial software that allows resource loading into the application, along with various codes and notes for sorting and filtering. Projects can scale the granularity of the mapping by controlling the level to which the budget is assigned: simple projects may map to WBS Level 2, while more complex projects may map at lower WBS levels or even at activity levels.

Table 3.5-13

A sample table of a high-level time-phased budget report with project defined cost categories is shown below in Figure 3.4-x. The budget should also map fully onto lower-level NSF 1030 budget categories for review purposes.

Cost Category	PY 1	PY2	PY3	PY4	Total
Equipment	$ 25,310	$ 4,295,967	$ 4,336,434	$ 2,777,675	$ 11,435,386
M&S	$ 1,238	$ 132,467	$ 130,223	$ 110,552	$ 374,480
Travel	$ 3,500	$ 13,500	$ 13,500	$ 7,000	$ 37,500
Labor	$ 1,403,021	$ 5,598,433	$ 7,610,432	$ 5,229,670	$ 19,841,556
Indirect Costs	$ 257,952	$ 2,108,477	$ 3,992,264	$ 1,462,481	$ 7,821,174
Total PMB	**$ 1,691,021**	**$ 12,148,844**	**$ 16,082,853**	**$ 9,587,378**	**$ 39,510,096**
Contingency	$ 262,108	$ 5,138,961	$ 6,947,792	$ 1,016,262	$ 13,365,124
Contingency %	15.50%	42.30%	43.20%	10.60%	33.83%
Total Project Cost	**$ 1,953,129**	**$ 17,287,805**	**$ 23,030,645**	**$ 10,603,640**	**$ 52,875,220**

Good Practices and Practical Considerations

- The project budget should adhere to NSF and GAO cost estimating best practices as described in Section 4.3 Cost Estimating and Analysis.
- All cost and budget figures shown in the PEP should be in *then year* United States dollars (USD) to include reasonable estimates of inflation, annual staff salary increases, and other escalation effects.
- The project budget should not include built-in buffers or other forms of hidden budget contingency. Budget contingency is addressed separately below in PEP Subcomponent 4.3 Contingency Management Plan.
- The Cost Book and BOE should easily map to the WBS and NSF cost categories to facilitate compliance with 1030 budget forms (which will need to be produced at least yearly) and other reports required by NSF during implementation and Construction Stage.
- Control accounts and the assignment of CAM for managing the budget should be considered both at the creation of the WBS and at resource loading of the schedule. Accounts may need to be readjusted based on the total dollar amount once the budget is established.

- During cost reviews, the application of negotiated fringe benefits, indirect cost rates, or algorithmic methods (e.g., 3% salary escalation) is frequently assessed. Clear demonstration and consistent application of such formulas and factors will greatly facilitate and accelerate the cost analysis.
- Note that control accounts should be assigned to a single WBS element; that is to say, a WBS can contain multiple control accounts, but a control account should be tied to a single WBS element.

3.5.4 PEP Component 4 Risk and Contingency Management

What Does This Component Describe?

This component describes the project risk management and the related Contingency Management Plans (CMP). Risk management includes a high-level overview of the risk management approach in the project Risk Management Plan (RMP), a list of high-level identified risks (Risk Register), and an estimate of the overall project risk exposure. An important aspect of any risk management approach includes the establishment and management of adequate contingencies that can be used to control project risks. Contingency management includes the estimation of those contingency amounts, supported by the project risk exposure estimates. These contingencies are part of the Project Definition that encompasses the Total Project Cost (TPC) and Total Project Duration (TPD). The CMP details how contingencies will be controlled and used to offset project risk and successfully complete the project within the TPC and TPD.

Why Is This Component Important?

A project's risk management approach identifies and analyzes potential risks, both threats and opportunities, that could impact the project's objectives. Identification then allows the project to take steps to minimize the probability and impact of threats, maximize the benefits from opportunities, and plan responses if those threats and opportunities are realized. An essential part of any risk management approach is the estimation of the overall project risk exposure and the establishment of contingency amounts needed to support risk responses. Effective risk management can reduce project delays, avoid cost overruns, and help ensure the technical and scientific objectives of the project are met. Risk management also can lead to better decision-making and improved stakeholder confidence during the project. Performing systematic and effective risk and contingency management will greatly increase the likelihood of project success.

How To Develop and Write This Component

There are three required subcomponents in PEP Component 4 Risk and Contingency Management, as listed in Table 3.5.4-1 below:

- An overview of the risk management approach.
- RMP, Risk Register, and an estimate methodology for total project risk exposure and the results.

- CMP that lays out the methodology to calculate and control contingency amounts.

Note that detailed guidance on creating both risk management and contingency management plans, listed in the references in the table, should be followed when creating the plans.

RMP and CMP are required of all RI implementation projects, but the subcomponent plans and products should be structured in a manner that matches project characteristics and is agreed upon by the participants and stakeholders. It should be tailored and scaled to the type, size, complexity, and characteristics of the project. Further, the plan is typically developed in a progressively elaborated approach, as described below in X.X.X.X.

Table 3.5-14

Component	**Sub-Component**	**Documents/Products**	**References**
4. Risk and Contingency Management	4.1 Risk Management Approach		
	4.2 Risk Management Plan	RMP Risk Register Estimate of Overall Risk Exposure	Section 4.6 Risk Management
	4.3 Contingency Management Plan	Estimates of Cost, Schedule, and Scope Contingency Amounts CMP	Section 4.7 Contingency Estimating and Management

PEP 4.1 Risk Management Approach

This subcomponent provides a high-level overview of the project plans and approach for the management of risk. Include a description of the philosophy, commitment, and approach to risk management on the project, including any specific standards or institutional policies and procedures that will be followed. Summarize how contingencies will be estimated and used to manage risk. Describe the general risk tolerance of the Project Organization.

Good Practices and Practical Considerations

- If the plans and products expected in this component are not fully mature (e.g., still undergoing development before implementation), then explain the steps that will be taken to reach maturity (progressive elaboration).
- Every project is unique, so the plans, approaches, methods, and risk tolerances will vary from project to project. That said, the standard seven-step risk management process described in Section 4.6 Risk Management should serve as the starting point for planning risk management on most projects. If an alternative scheme or method is used, a justification for that approach should be included in this subcomponent.
- Contingency estimation and management guidelines can be found in Section 4.7 Contingency Estimating and Management.

PEP 4.2 Risk Management Plan

This subcomponent includes the RMP that will be used to identify and manage risks. The RMP should identify the responsibilities for risk management and describe the risk management process that will be followed— including roles and responsibilities, procedures, criteria, tools, and techniques to be used to identify, analyze, respond to, and track project risks. The level of detail in the plan, and the scope, timing, and level of risk analysis should be commensurate with the maturity and complexity of the project and may evolve and change over time. An RMP includes the processes that will be used during project execution to control risk. In particular, the RMP should describe the risk identification tool used to capture and document individual risks in a Risk Register. A view of the current Risk Register of the project should be shown, including all identified high-level/key project risks with detailed descriptions and their quantified probabilities and impacts. If the Risk Register is too large to include in the PEP document itself, provide a sample and attach the full Risk Register as a supplemental document. The RMP should also describe the methodology used to estimate the aggregated total project risk exposure from threats. The current value of total project risk exposure in terms of cost and schedule should be supplied. Detailed guidelines and information on creating RMPs, Risk Registers, and overall risk exposure estimates are covered in Section 4.6 Risk Management.

Good Practices and Practical Considerations

- Risk management should be started early in project development and, like budgets and schedules, be progressively elaborated to maturity before project execution. As an example, the creation of an early list of risks in a rudimentary Risk Register will support planning and allow projects to adjust plans to reduce or eliminate them by including mitigation plans in the baseline.
- Risk management includes both threats and opportunities. Projects should include and monitor opportunities in their Risk Registers to enable timely actions to capitalize on and maximize the favorable outcomes opportunities can provide. (Note that most estimates of total risk exposure, however, do not include opportunities in the BOE.)

- On simple projects, the entire RMP can be described within this subcomponent. On larger projects, a summary and reference to an external detailed RMP document should be provided.
- Methods for calculating total risk exposure should be tailored and scaled to the project characteristics. Simple, less risky projects may be able to use algorithmic methods that require less expertise and administrative overhead to be adequate for project needs. Note, however, that risk management requirements for Major Facility Construction projects require the use of Monte Carlo simulation to estimate the aggregated total project exposure. Additional details on tailoring risk management plans are included in Section 4.6 Risk Management.

PEP 4.3 Contingency Management Plan

This PEP subcomponent shall describe the estimation and management of project contingency, which typically comprises of three distinct types: budget contingency, schedule contingency, and scope/quality contingency. Project contingency is a primary resource for managing the negative impacts on project objectives from risks and uncertainties; at least one of the three contingency types—and frequently all three—are required to cover relevant project risk to a sufficient level. The CMP also describes management plans controlling, maintaining, and reporting contingency usage and status. See Section 4.7 Contingency Estimating and Management for detailed guidance on contingency management requirements and considerations. The following additional points for each type of contingency shall be addressed.

Contingency Estimation. The CMP should describe the methodologies for estimating the three types of contingencies and state the estimated amount for each one. An explanation of the BOE and justification of why the calculated contingency is sufficient should be included. The estimation methods should be tailored and scaled to match project complexity and other characteristics. Guidelines on contingency estimating methods can be found in Section 4.7 Contingency Estimating and Management.

Budget Contingency. Budget contingency is an amount of money which, when added to the baseline budget, sums up the TPC or award amount. Budget contingency is held separate from the baseline budget and is used to cover the monetary cost of realized risk. Budget contingency shall be estimated using a method that is appropriate for the type, size, and complexity of the project. Budget contingency can be estimated in a number of ways, depending on the nature of the project, its size and complexity, and the state of the project. Typical methods include simple percentage-based methods, summation of identified risk exposure (as captured in the project's Risk Register), risk-factored technical/cost/schedule methods, and Monte Carlo or other probabilistic methods performed on the Risk Register, the budget, and/or the schedule. Monte Carlo methods applied to combined cost and schedule analyses are required for Major Facility projects and should assume a confidence level between 70-90% for budget contingency.

Schedule Contingency. Schedule contingency is an amount of additional time beyond that of the deterministic (baseline) IPS project end date to obtain the risk adjusted project end date. Budget contingency is held separate from the baseline budget and is used to cover the schedule impacts of schedule overruns from realized risks. Schedule contingency shall be estimated using a method that is appropriate for the type, size, and complexity of the project. Typical methods include expert judgment, comparison to other/similarly scoped projects that have been completed in the past, and statistical and/or probabilistic methods. For Major Facility projects, the amount of schedule contingency is determined by performing probabilistic risk analysis on the baseline IPS and selecting a commitment finish end date with a confidence level between 70-90%. Note that there may be costs associated with estimated schedule contingency. Risk managers should ensure that any such costs (e.g., labor during the extended project duration) are captured in the estimated budget contingency estimate.

Scope/Quality Contingency. Scope/quality contingency is comprised of elements within the WBS and/or Quality Acceptance Requirements that can be removed or reduced without affecting the overall project's objectives but that may still have an undesirable effect on the RI's performance or functionality. They are usually regarded as last resort actions when options that employ budget and schedule contingency while preserving project objectives cannot be used. Scope/quality contingency amounts for each reduction in scope or quality are based on the cost and schedule savings realized by the reduction in the baseline realized by the change that improves the probability of completing the project on budget and schedule. The total amount of cost and schedule savings equals the sum of the individual scope contingency amounts. The total amount of contingency is time sensitive: it declines over time as opportunities pass their use-by dates without being exercised. Scope Options are typically captured in a Scope Management Plan ([SMP], see PEP Subcomponent 3.2 Scope), which may also include scope opportunities that can be exercised when budget and schedule allow. The project's SMP should list all identified scope/quality contingency options, along with the estimated monetary value of each option, time-phased use-by dates, special requirements, and a description of the impact on science, performance, and/or functionality of the RI. For Major Facility construction projects, identified scope/quality budget contingency should have a total value of at least 10% of the project's baseline budget until construction commences.

Good Practices and Practical Considerations

- To provide additional assurance of successful project outcomes, the scope contingency options should equal at least 10% of the Performance Measurement Baseline (PMB) at the start of the project. Major Facility projects have more specific guidelines (See Section 4.7 Contingency Estimating and Management)
- Exercising scope contingency will most often require NSF approval, so proposers should communicate and discuss the change request well before planned implementation dates.

Contingency Management Plan: Contingency Use Profile. In practice, all projects employ some sort of contingency, whether it is related to scope/quality, schedule, budget, or combinations thereof. The project should create and maintain an expected contingency allocation profile that is reported in the funding profile provided in PEP Subcomponent 3.5 Time-Phased Budget. Contingency allocation profiles should track an estimated time-phased risk exposure profile and usually do not track the commitment or spending profiles. For many projects, the highest use of both schedule and budget contingency occurs during procurement and during the final commissioning/integration phases. A contingency allocation curve for such a project would be bimodal, with one peak for procurements activities and another for significant contingency amounts held back until the end of the project, even though the spending curve may be low near the end of the project. Although risk does burn down over time, there may be significant reworking of hardware, for example, needed as a result of knowledge gained during integration and commissioning activities.

Contingency Use and Change Control. The RMP describes how the project uses the Change/Configuration Control Process (CCP) to assign contingency to specific WBS elements when risks materialize and how contingency is de-allocated from WBS elements and returned to the contingency category when underruns occur. The NSF Program Officer (PO) must concur on all change requests exceeding negotiated thresholds for allocation of scope, schedule, or budget contingency. Contingency may only be used to support in-scope work for the approved project baseline or pre-approved scope opportunities in the SMP. See Section 4.2.5.7 TITLE for additional details.

All Change Control actions that affect the use of contingency – cost, schedule, or technical performance and scope – should include a link to an identified and documented risk and indicate the affected WBS elements at the first meaningful level of technical differentiation within the project. The project must keep a log of all change actions such that contingency actions, including puts and takes, can be reported, and summarized. Adjustments to contingency should include taking advantage of opportunities to assign savings and underruns to contingency. Savings should not be left in associated WBS elements if they are above thresholds set out in the RMP, nor should they be shifted to other tasks without going through the CCP for return to contingency and subsequent allocation to a different WBS element. Savings realized through the implementation of planned de-scoping options should also be placed into contingency before being reallocated through Change Control actions.

Liens List: Forecasting and Opportunity Management. The project should maintain a liens list of planned future adjustments to contingency as a forecasting tool that tracks actions that have not yet been incorporated into the budget at completion (BAC) or estimate at completion (EAC). The list may document items such as very high probability risks with trigger points for action, deferred scope held as contingency until a decision date, realized risks needing draws on contingency that require more definition for a Change Control action to be implemented, budget and schedule variances that will not/cannot be mitigated, and anticipated opportunities for returns to contingency. The liens list acts as an escrow or staging account for planned or near-certain contingency allocations.

The list should include a description of the identified risk and the anticipated action, with estimates of budget and schedule impacts, and anticipated decision date for any CCB action. The affected WBS elements should be identified at the second level (or the first meaningfully specific level of scope description), where known.

Maintaining Adequate Contingency Levels. The CMP should describe the process for ensuring that the remaining amounts of cost and schedule contingency are adequate to cover the Risk-Adjusted Estimate at Completion (RAEAC) by periodically updating the EAC and the analysis of overall project risk exposure. As time goes by, risk exposure changes with risk mitigation, new knowledge, and new circumstances. The amount of remaining budget contingency fluctuates over time with assignments to risk mitigation and return of any savings. The remaining available contingency should always equate to at least the difference between the TPC minus the EAC and any liens. If the remaining contingency is judged to be inadequate for project needs, steps should be taken to restore amounts to adequate levels (e.g., exercising descope options or returning underruns to contingency.)

Contingency Status Reporting. The RMP should describe the requirements for reporting contingency status, issues, and adjustments through the CCP in its interim reports (typically monthly reports). NSF generally sets reporting requirements for interim status. These typically include completed and anticipated Change Control actions involving the movement of contingency and a comparison of contingency amounts to the need indicated by the RAEAC.

Good Practices and Practical Considerations

- It is good practice to re-estimate EAC and risk exposure periodically, unless stated otherwise in the award terms and conditions. Specific dates may also be appropriate times for re-evaluation, such as at major milestones dates. The PM should periodically assess the current risk status to identify and address any new risks that arise as the project progresses.
- Contingency is meant to be used. Rather than hoarding or protecting contingency funds until very late in the project, projects can appropriately expend cost and schedule contingency to correct variances as long as the remaining contingency is at least equal to the risk exposure.
- If contingency drops significantly below the remaining risk exposure, the project should take steps to restore contingency (e.g., by exercising scope options, value engineering, implementing efficiencies, or reducing personnel costs where possible).
- Projects may choose not to request cost and schedule contingency but must always have scope/quality contingency plans (e.g., descope options).
- Scope quality/contingency can be used to address the remaining uncertainty between the cost and schedule estimates and the chosen calculated confidence-levels of a risk analysis.

- Descope Options, when exercised, can be moved into upscope (opportunity) options to be brought back into the baseline if resources are available later in the project.

3.5.5 PEP Component 5 Acquisition Plans

What Does This Component Describe?

This component describes the planned processes and methods that will be used on the project to acquire (i.e., create and provide) the scope, as defined in PEP Component 3 Performance Measurement Baseline. Additionally, it refers to plans for acceptance testing of the scope against the quality acceptance requirements that are also specified PEP Component 3. Finally, it includes plans for determining, acquiring, and managing all the labor and non-labor resources required for acquiring and testing the scope.

Why Is This Component Important?

Pre-defining the expectations and approaches to creating the scope, testing it, and resolving non-compliance issues is required to understand the resources needed to carry out these plans and approaches, which is necessary for complete and thorough planning. Without a priori and complete consideration of acquisitions, accurate schedule development and cost estimation are impossible to achieve. A well-considered Acquisitions Plan also provides for the anticipation of potential challenges and bottlenecks, allowing for a complete review and assessment of risk. Finally, a complete and accurate Acquisitions Plan improves communication, minimizes misunderstandings (both with external stakeholders and project team members), and fosters a shared understanding of resource needs and procurement plans.

How To Develop and Write This Component

There are four required subcomponents to be included in Component 5 Acquisition Plans, as listed in the table below. All four are required, regardless of project type, size, or complexity.

The scope Acquisition Plan should match the project characteristics and needs and should be agreed upon by the participants and stakeholders. The plans should be tailored and scaled to the individual type, size, complexity, and characteristics of the project. Further, the subcomponents are typically developed in a progressively elaborated approach, as described in X.X.X.X.

Table 3.5-15

Component	Sub-Component	Documents/Products	References
5. Acquisition Plans	5.1 Overview of Acquisition Plans		
	5.2 Scope Acquisition Plans	Scope Acquisition Plan	
	5.3 Quality Management Plans	Quality Management Plan	GAO APQA (?)
	5.4 Resource Management Plans	Resource Management Plan	

PEP 5.1 Overview of Acquisition Plans

This subcomponent provides a brief, high-level description of the approach for acquiring the scope and ensuring it meets its Quality Acceptance Requirements. Acquisition Plans may include the approaches to any or all the following activities: development, design, analysis, site selection and permitting, prototyping, procurement, purchasing, construction, coding, assembly, integration, testing, commissioning, verification, and/or validation of the scope as defined in the WBS. For example, the project must decide whether to build in-house, pursue subcontracts, or purchase commercially available components. The Acquisition Plan should also describe the high-level resource requirements (labor and non-labor) necessary to carry out the overall project plan and create, provide, and deliver the scope. Specific details of these topics are described in more detail below in the relevant subcomponents.

Good Practices and Practical Considerations

- When possible, sourcing from commercially available products or offerings can reduce project risk and increase confidence in cost and schedule projections.

PEP 5.2 Scope Acquisition Plans

This subcomponent describes the plans for acquiring all of the scope listed in the WBS and described in the WBS Dictionary. Elements to highlight in these plans should include the following.

Acquisition Approaches. All significant acquisitions should be listed, along with procurement approaches, subawards, and contracting strategies (e.g., vendor selection and management plans). This should be time-based and include explicit milestones for creation and provision of the scope. Also include the planned approval process for all significant acquisitions (e.g., those that require NSF review), with a year-by-year plan of approvals.

Remaining Development and Design Work. All remaining Research and Development and/or Design Completion Activities necessary to achieve readiness for implementation and Construction, Stage including a time-phased plan for performing this work (i.e., schedule), should be listed. This may include specific engineering and design work, prototyping, manufacturing validation, vendor qualification, modeling and simulation, creation of specialized management plans, formation of partnerships, and the like, that are required for project success. Also, provide any estimated budget required to perform the development and design work, including specific NSF funding and any contributions from partners or outside sources.

High-Risk Acquisitions. Identify all high-risk acquisitions, including new or evolving technologies, single-source vendor situations, unique procurement concerns, and so forth. Describe the management approach to minimize risk of these s and identify elements in the project Risk Register that are related to these acquisitions.

Site and Environment. Identify all required and/or special site selection criteria, provide a description of the selected site(s) for the RI, and provide a plan to manage the associated site-related work. Provide a detailed list of all required site permitting, Environmental Impact Statements (EIS), site assessments, and any others that are required. The cost and time frame for performing the site selection and permitting activities should be described (and captured in the project budget and IPS).

Good Practices and Practical Considerations

- Within the Acquisition Plan, a defined list of major procurements (purchased items or services) with expenses and projected timelines can be included to facilitate award oversight and review. The list should include details of the procurement (e.g., sole source, fixed price, competitive bids).
- Every deliverable element included in the WBS should have a clear and unambiguous acquisitions approach identified and described herein this subcomponent. Often, the Acquisition Plans for so-called child elements in the WBS are contained at a higher parent level. Make note of these situations to ensure clarity of the plans.

PEP 5.3 Quality Management Plans

This subcomponent describes the management plans and processes that will be used to ensure that all acquired scope will meet all specified Quality Acceptance Criteria. Plans and processes for reviewing and addressing non-compliant scope should be described herein. Quality Management includes both quality assurance (QA) processes related to preventing quality issues and quality control (QC) processes related to products and deliverables assessment, testing, or evaluation.

Relevant plans for the Integration, Test, and Commissioning (IT&C) of the RI should be described, including the following.

System Integration. How the various sub-elements and lower-level WBS items will be brought together and tested as a collective whole. Included in this is the identification of all physical and performance interfaces within and external to the RI deliverable components, including how they will be identified, combined, verified, and coordinated.

Testing. How compliance and fitness for the purpose of the deliverable will be assessed (i.e., verification testing) and documented (e.g., via CMX) using the criteria established and documented (above in PEP Component 3 Performance Measurement Baseline) to measure acceptable performance. Also, how non-compliance will be addressed and managed (e.g., via request for waivers).

Commissioning. How the capability of the RI to function and perform will be verified and validated, including how the various system components will be brought online sequentially and in simultaneous operations to study and affirm the interaction among subsystems.

Conditions for Acceptance. Specifying the expected condition of the facility, its performance attributes, the tests the recipient will perform, and the data it will consider prior to accepting the facility or components of the facility and declaring it ready for operations and maintenance. In some cases, a phased approach to acceptance will be required.

Good Practices and Practical Considerations

- In some communities, the IT&C activities are referred to as Assembly, Integration, and Validation/Verification (AIV).
- The ultimate goal of Quality Management is to ensure the RI is capable of performing/delivering the high-level science that is described above in PEP Component 1 Project Overview, and that it is ready for handover to operations at the appropriate time. All activities and plans, from low-level scope production through high-level IT&C activities, should be focused on achieving this goal.
- System IT&C activities are an essential aspect of most complex RI projects. Failure to plan or perform them well can lead to project cost and schedule overruns. Therefore, this Quality Management subcomponent should describe a clear, straightforward, achievable, and robust plan for IT&C.
- The Quality Management subcomponent should describe the plans for specifying the expected condition of the RI at the project conclusion, its verified performance attributes, all tests that will be performed, and the data that will be provided prior to accepting the RI and declaring it ready for the next life cycle stage (e.g., Operations). In some cases, a phased approach to acceptance may be required. For example, for distributed-but-integrated facilities or for facilities with complex instrumentation and equipment, it may be necessary to demonstrate performance and perform acceptance procedures for parts of the system prior to proceeding with construction and/or acquisition of other systems.
- Systems engineering is a fundamental key to the most successful Acquisition Plans. This Quality Management subcomponent should, where relevant, describe the project's Systems Engineering Management Plan, including roles and responsibilities and how requirements are to be developed, flowed down, tracked, and managed

from high-level mission and science requirements through lower-level requirements. Additionally, this plan should describe how all internal WBS, and external interfaces are to be specified, documented (e.g., in Interface Control Documents [ICDs]), communicated, tracked, and managed.

- On longer, more complex projects, it is common for some Quality Management Plans to change, evolve, or adapt as the project progresses. Further, some IT&C activities may overlap with the start of the next life cycle stage, such as the Operations Stage. How these adaptations and overlaps are to be managed should be described in this subcomponent as required. Typical questions that may be applicable to address include:
  - Will the project have parallel periods of Construction/Acquisition and Operations, with some components coming online earlier than others?
  - What is the project's strategy for facility acceptance, operational readiness review, site safety and security, and training of operational staff and members of the research community utilizing the facility?
  - What are the project plans for transitioning staff from Construction to Operational support activities? Is there a plan to bring in personnel with the requisite technical skills to operate and support the facility at appropriate times? Have training needs been addressed?
  - What risks to the project might result from contractor interference during periods of beneficial use or occupancy as construction activities conclude?
  - What risks to the project might result from operations delays?
  - What contracting strategies are employed to ensure that priority tasks are completed in a timely way and do not delay operational readiness?
  - What are project plans for obtaining use and occupancy permits or satisfying other local regulatory criteria?
  - Do the budgets reflect a proper allocation between Construction/Acquisition and Operations?
- Even if limited operations are undertaken during implementation and Construction Stage, the changeover from construction funding to operational funding does not have to occur until the facility has been accepted. Where operational funding will be used for phased transitions to operations prior to project closeout, the project must ensure that the budget justification clearly describes the changeover and that the earlier changeover is estimated and budgeted accordingly, per the Segregation of Funding Plan (PEP Subcomponent 6.5, below).
- Projects should carefully consider issues of warranty, repair, and segregation of funding, especially when phased transition to operations results in operations activity overlapping with the implementation and Construction Stage of a project.

PEP 5.4 Resource Management Plans

This subcomponent describes the Resource Management Plans necessary to successfully carry out both the Acquisitions Plans and the Quality Management Plans.

Staffing Plan. The project's Staffing Plan should include time-phased plans and expectations for project-specific job categories and correlation to scope deliverables. The required expertise and qualifications of key staff should be included. Hiring and transition plans should be included that clearly describe the schedule and requirements for hiring, training, onboarding, managing staff resources, and ultimately transitioning resources off the project of all project staff.

Non-Labor Resource Plan. A non-labor resource plan should include the identification and time-phased Acquisition Plans for key materials, tools, workspaces, equipment, and other non-labor resources required to successfully perform the Scope Acquisition and Quality Management of the project.

Good Practices and Practical Considerations

- Full Resource Management Plans for small, simple projects may be correspondingly simplified, e.g., the details of hiring and transition plans may be omitted if all staff are already employed by the Awardee organization.
- There are often risks associated with resource acquisitions (e.g., hiring for specialist roles with exacting technical or professional qualifications may require long lead times in the hiring process); these risks should be identified within the project's Risk Register as appropriate and included in the project schedule.
- Staff retention, especially towards the end of a project, can be difficult. Awardees should consider and plan for appropriate incentives to improve retention.
- Resource loading planning for the temporary transition of staff onto and off the project can help to avoid *standing army costs* but can create challenge in retaining staff unless alternate assignments are available for those resources.

3.5.6 PEP Component 6 Environmental, Safety, and Health Management

What Does This Component Describe?

PEP Component 6 Environmental, Safety, and Health Management outlines the strategies, plans, procedures, protocols, and responsibilities for managing environmental, safety, and health risk aspects throughout the project's life cycle. It typically includes an assessment of potential environmental impacts, strategies for mitigating these impacts, and compliance with relevant environmental regulations. It outlines safety procedures, hazard assessments, and measures to ensure the physical safety of personnel and equipment during the execution of the project. The health subcomponent describes measures for promoting the physical and mental well-being of individuals involved in the project, such as access to medical resources, acceptable ergonomics, and mental health support during project execution. The ES&H section also includes reporting mechanisms, emergency response plans, and ongoing monitoring to ensure that the project operates in a manner that is environmentally responsible, safe, and supportive of the health of all involved parties.

Why Is This Component Important?

Incorporating ES&H considerations into project planning is of paramount importance. It helps ensure the protection of human life and well-being by systematically identifying and mitigating potential safety hazards and health risks. The ES&H Plan safeguards the project team and demonstrates an organization's commitment to its employees and stakeholders. Integrating environmental aspects into project planning helps mitigate negative impacts on the environment, fostering sustainability and compliance with environmental regulations, helping to prevent costly fines, legal issues, and damage to the project's reputation. Addressing ES&H concerns from the outset of a project leads to better cost management by reducing the likelihood of accidents, rework, and delays, ultimately enhancing project efficiency and its probability of success. It also promotes a culture of responsibility, sustainability, and ethical practice. The inclusion of ES&H considerations in the PEP is not just a legal or moral imperative; it's a strategic move that contributes to project success, risk reduction, and the long-term well-being of both people and the environment.

How To Develop and Write This Component

There are four required subcomponents to be included in this component, as listed in the table below. All four are required for a PEP, regardless of project type, size, or complexity.

The ES&H Plans should match the project characteristics and should be agreed upon by the participants and stakeholders. The plans should be tailored and scaled to the individual type, size, complexity, and characteristics of the project. Further, the subcomponents are typically developed in a progressively elaborated approach, as described in X.X.X.X.

Table 3.5-16

Component	Sub-Component	Documents/Products	References
6. Environmental, Safety, and Health Management	6.1 Overview of Environmental, Safety, and Health Management		
	6.2 Environmental Protection Management Plans	Environmental Protection Management Plans	Chapter 5
	6.3 Safety Management Plans	Safety Management Plans	(Something from OSHA?)
	6.4 Health Management Plans	Health Management Plans	

PEP 6.1 Overview of Environmental, Safety, and Health Management

This subcomponent provides a high-level description of the overall project approach to the management of ES&H. It describes over-arching policies and objectives, including a statement of the project's commitment to ES&H. A description of the ES&H management structure is described, including roles, responsibilities, and the reporting structure of all personnel involved in managing ES&H on the project. Communications plans as they relate to ES&H are described. Finally, ES&H emergency response plans should be discussed. Specific details of ES&H management topics are provided and described in more detail below in the respective subcomponents.

Good Practices and Practical Considerations

- For simple projects, these plans may be aggregated into a single document. But, for larger, complex, or more specialized projects, there may need to be separate (larger) supplemental documents that are referenced from within the PEP.
- The project's ES&H Plans and approaches should adhere to relevant local, state, and federal regulations. It is the Awardee's responsibility to identify and adhere to all such requirements and regulations.
- The project's ES&H Plans and approaches should be scaled and tailored to the needs of the project but should also follow industry best practices as much as reasonably possible.
- If applicable, the project's ES&H Plans and approaches should refer to and draw upon any approved home/parent institution's ES&H Plans and policies.

- As a good practice and to minimize conflicts of interest, a project's safety management structure should be accountable to and report outside of the normal project management organizational breakdown structure (OBS), that is, to avoid even the appearance of pressure from project management to maintain schedule and budget performance at the expense of ES&H. For example, on many projects, safety reports should be made to a level above the PM (e.g., directly to a PD, PI, or other entity).
- As a good practice, a project's ES&H Plans should explicitly empower all project team members to identify and report safety issues, extending to the point of being able to stop work that they deem unsafe.

PEP 6.2 Overview of Environmental, Safety, and Health Management

This subcomponent describes specific plans and approaches for managing environmental concerns during the execution of the project. NSF's proposed funding for the construction or modification of RI facilities may constitute a federal action that triggers compliance with several federal environmental statutes designed to consider the proposed action's impacts on environmental, cultural, and historic resources as part of the federal decision-making process. Awareness of and strict adherence to all relevant environmental laws are extremely important considerations in the Planning, Construction, and Operation Stages of RI. These statutes include, but are not limited to, the National Environmental Policy Act (NEPA), the National Historic Preservation Act (NHPA), and the Endangered Species Act (ESA). While NEPA and the NHPA typically focus on proposed activities that take place within the United States, proposed activities that take place outside of the United States may also be subject to these federal statutes. In addition, there are international agreements and treaties that require consideration of potential environmental impacts. It is the responsibility of NSF to identify and comply with all relevant statutes, regulations, and laws prior to making a funding decision. If the project is funded, the project team may also have responsibilities during the Construction and Operation Stages to comply with applicable state, federal, tribal, and international legal authorities.

Typical topics covered in an Environmental Management Plan (EMP) may include:

- **Environmental Regulations.** A list of all relevant environmental regulations and standards that the project is subject to follow and will adhere to during execution.
- **Impact Identification.** Plans and approaches for the identification, assessment, and tracking of all relevant significant environmental impacts of the project, both positive and negative.
- **Mitigation Plans.** Plans and approaches for minimizing or mitigating all identified negative environment impacts, including measures to protect local ecosystems and biodiversity, habitat preservation and restoration, reduction of the project's overall carbon footprint, reduction of electricity and other energy source usage, and the reduction of the overall greenhouse gas emissions of the project. Also include waste management plans, including recycling and disposal methods as appropriate.

- **Reporting.** Plans and approaches for reporting on environmental performance throughout the life of the project.

Good Practices and Practical Considerations for Environmental Management

- The primary goal of a project EMP is to protect the environment during and after the execution of the project; this should be emphasized in all planning, procedures, and policies.
- For large and complex projects with significant environmental management concerns and implications, an external EMP document with all details defined and described may be required. For smaller and simpler projects, the EMP can be fully described within the PEP.
- It is common for projects to use a parent institution's environmental policies, plans, procedures, and protocols as a basis for ensuring environmental protection on a project. Every project is unique, with specific needs and requirements that will require modification, adaptation, and extension of any higher-level institution’s policies.

PEP 6.3 Safety Management Plans

This subcomponent describes specific plans and approaches to managing personnel and equipment safety during the execution of the project. Typical topics covered in a Safety Management Plan (SMP) may include:

- **Safety Regulations.** A list of all relevant safety regulations and standards that the project is subject to follow and will adhere to.
- **Hazard Identification.** Plans and approaches for the identification, assessment/analysis, and tracking for all relevant safety hazards on the project.
- **Hazard Mitigation.** Plans and approaches for minimizing and mitigating all identified hazards and safety concerns.
- **Safety Facilities.** Plans for medical facilities, first-aid stations, emergency response protocols, and communication and transportation plans for injured personnel. Include plans for and usage of personal protective equipment (PPE).
- **Documentation and Reporting.** Plans and procedures for monitoring, documentation, and reporting of safety status, including reporting of all safety incidents and responses. Plans and procedures for post-incident investigations and implementation of corrective actions as required.
- **Training.** Plans for safety training and awareness education of project personnel.

Good Practices and Practical Considerations for Safety Management

- The primary goal of a project SMP is to ensure the safety of workers and the protection of equipment during the execution of the project; this should be emphasized in all safety-related plans and procedures.

- For multi-site projects, the project lead may need to review, verify, and monitor ES&H the local plans and implementation at remote sites or partner organizations.
- It is common for projects to use a parent institution's safety policies, plans, procedures, and protocols as a basis for ensuring safety on a project. Every project is unique, with specific needs and requirements that will probably require modification, adaptation, and extension of higher-level institution’s policies.
- The PEP should also address plans for critical maintenance and inspection procedures that ensure the safe and efficient operation of RI elements during the project.
- For Design Stage proposed projects, the SMP should address safety-by-design approaches to incorporate into the design and analysis process.
- If the project is subject to periodic reviews, the SMP should ensure that safety is always discussed and included as a standalone topic during these events.
- Serious safety incidents, problems, or near-hits may need to be reported to NSF, depending on the specific terms and conditions of the award.
- Documented and shared lessons learned from the execution of the project can inform and improve ES&H Plans over time.

PEP 6.4 Health Management Plans

This subcomponent describes specific plans and approaches to managing personnel health during the execution of the project. Typical topics covered in a Health Management Plan (HMP) may include:

- **Health Regulations.** A list of all relevant health regulations and standards that the project is subject to follow and will adhere to.
- **Identification, Assessment, and Mitigation.** Plans and approaches for the identification, assessment/analysis, and mitigation approaches for all relevant health risks on the project, including both occupational and environmental hazards. Include exposure control plans for hazardous materials.
- **Health Monitoring.** Plans and approaches for the ongoing assessment of the health of project personnel during the execution of the project, including ergonomic considerations, pre-project health screenings, and ongoing monitoring. Include protocols and procedures for managing occupational illnesses and injuries of project personnel.
- **Documentation and Reporting.** Plans and procedures for documentation and reporting, including reporting of health-related incidents and responses.

Good Practices and Practical Considerations for Health Management

- The primary goal of a project HMP is to protect the health and well-being of workers during the execution of the project. This includes both physical and mental health and well-being. Therefore, stress management, work-life balance initiatives, and access to mental health resources and support should be considered and implemented as required.
- It is common for projects to use a parent institution's environmental policies, plans, procedures, and protocols as a basis for ensuring environmental protection on a project. Every project is unique, with specific needs and requirements that will probably require modification, adaptation, and extension of higher-level institution's policies.
- Projects being implemented in remote areas or extreme environments should pay particular attention to health management and monitoring plans.

3.5.7 PEP Component 7 Project Controls Plans

What Does This Component Describe?

This component describes the plans for Project Controls, the integrated system of tools and processes that collect, organize, and analyze project data to support understanding and control of the key project parameters: scope, quality, budget, schedule, contingency, risk, and resources. Through comparison of actual status against plans, analysis of trends and variances, and forecasting of future project requirements, Project Controls give managers the information needed to support decision making. Four major areas of Project Controls planning are addressed in this component:

- **Performance Measurement and Management.** Methods and approaches for assessing the state of the project during execution.
- **Change Control.** Methods for implementing modifications and changes during the course of the project.
- **Reporting and Documentation.** Ways of capturing and communicating the project state to key project stakeholders.
- **Business and Financial Controls.** Methods and approaches that will be used to manage all project-related finances and accounting.

Why Is This Component Important?

Managing a RI project requires regular and accurate assessments of project status and predictions of future trajectory; it is impossible to successfully manage and guide a project unless one knows the current state and can forecast the path forward. Adherence to a defined control process also protects the plan against unauthorized and unplanned changes (e.g., gold-plating or scope creep) that have unanticipated demands on resources, budget, and schedule. The use of an integrated Project Controls Plan has been demonstrated to significantly improve a project's ability to successfully meet its objectives. When adjustments to the plan are necessary to keep a project on track, a transparent and systematic means of making appropriate decisions about the project baseline and/or the adjustment approach is required. Further, a consistent, clear, and accurate means of documenting and reporting the state of the project (i.e., current status, recent changes, outstanding risks, and forecasted trajectory) to the key stakeholders (e.g., the NSF) ensures maximum transparency and minimal surprises. Finally, the means by which the project will formally provide financial and business functions and perform oversight must be fully adhered to throughout the course of the project. Without sound, responsible, and appropriate Project Controls that address these factors, projects may miss goals, requiring unplanned time, money, and effort to return to the plan. In a worst-case scenario, a project may fail to achieve its objectives.

How To Develop and Write This Component

There are five required subcomponents to be included in PEP Component 7 Project Control Plans. These five are shown in the table below. All five are required for a PEP, regardless of project type, size, or level of complexity.

Project Controls Plans should be structured in a manner that matches the project characteristics and is agreed upon by the participants and stakeholders. This entire component should be both tailored and scaled to the type, size, complexity, and characteristics of the project. Further, the component is typically developed in a progressively elaborated approach, as described below in X.X.X.X.

Table 3.5-17

Component	Sub-Component	Documents/Products	References
7. Project Controls Plans	7.1 Overview of Project Controls	Project Management Control Plan (PMCP)	
	7.2 Performance Measurement and Management Plans	PMM Plan: Process and Tools	Section 4.6 Performance Measurement and Management PEP Component 4 Risk and Contingency Management
	7.3. Change Control Plans	CPC Change Log	
	7.4 Reporting and Reviews Plans	Reporting Template(s)	Section 4.9 NSF Performance … Reporting Requirements
	7.5 Business and Financial Controls Plans	Institutional Policies Project-specific financial plans Segregation of Funding Plan	Section 5.6 Financial Management

PEP 7.1 Overview of Project Controls

This subcomponent serves as an executive summary and overview of this entire Project Controls component. The overview should briefly summarize the methods chosen for the other four Project Controls subcomponents: Performance Measurement and Management (PMM), Change Control, Project Documentation and Reporting, and Business and Financial Controls. The overview should describe how the plans will be used to manage the project. It should also describe the tools (e.g., spreadsheets, databases, commercial software products) that will be used for the various Project Controls functions.

It should be noted that Project Controls form a subset of all project management functions; the two are not the same. Project Controls tools and processes focus on metrics, tracking, comparisons to plan, analysis of deviations, change management, and predictions of future needs and events. Project management serves a broader purpose that includes functions such as directing work, meeting scope and quality requirements, balancing resources, making decisions to keep the project on track and managing stakeholder interactions and expectations. Effective Project Controls are closely tied to all aspects of project management so that they can inform and support these broader project management functions.

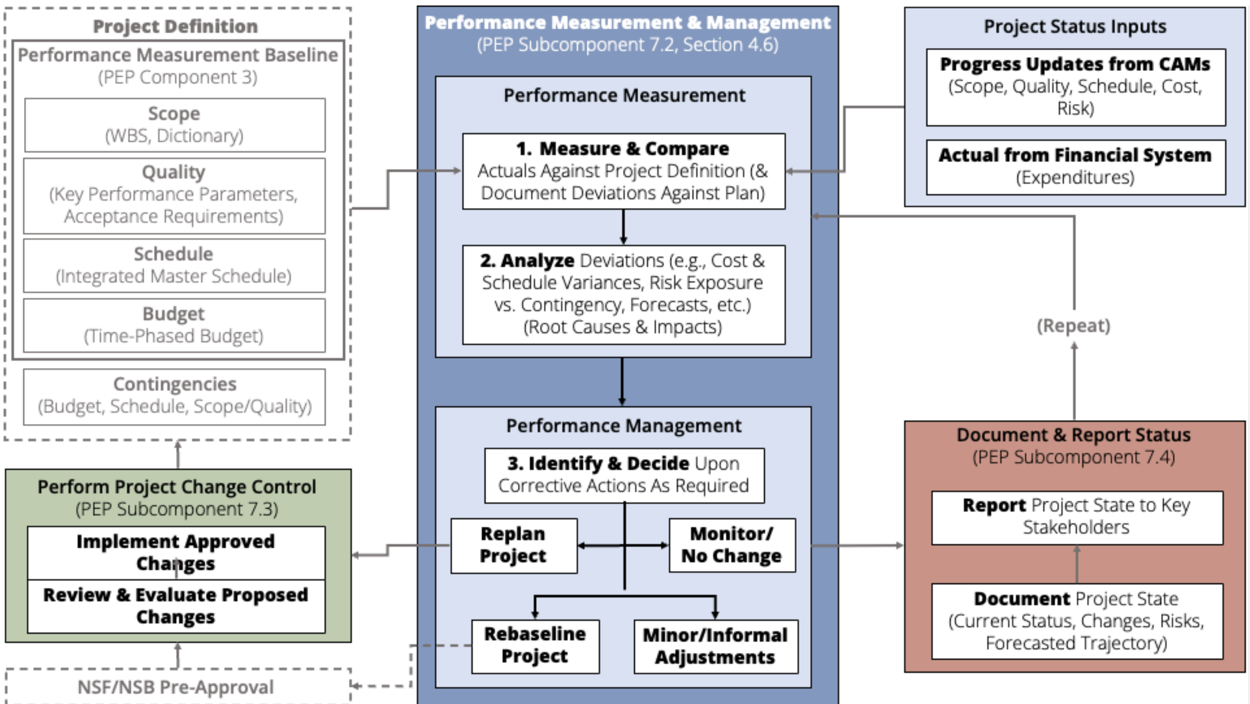
A flow chart of typical Project Controls elements and how they are connected is given in Figure 3.4.7-x. The figure shows how Project Controls are used during execution to compare actual project Status Inputs against the planned Project Definition and to inform management decisions and actions. The Project Definition includes the Performance Management Baseline (PMB) described in PEP Component 3 Performance Measurement Baseline and the contingency amounts established in PEP Component 4 Risk and Contingency Management. The Project Definition is established during pre-execution planning, using the appropriate tools used to create and document the elements of the definition (e.g., WBS, BOE, IPS, etc.). During execution, project Status Inputs are updated and compared to the plan using the PMM tools and methods. Variances and identified issues are analyzed and used to inform management decisions and actions taken. Changes to the PMB or contingency amounts are managed according to the project Change/Configuration Control Process (CCP). Project status, variances, and changes are then documented and reported to stakeholders, and the entire process is repeated for each reporting period. Although not shown on the chart, the institutional Business and Financial Controls ensure that funds are properly managed and that data on obligations and actual expenditures are correctly transmitted to the project as Status Inputs.

Good Practices and Practical Considerations

- Project Control execution and management requires dedicated time from project team members to report and update status, analyze the data, support decision-making, and carry out actions. The time and skills to perform various roles and responsibilities must be included in the consideration of assignments to project roles and in the calculation of hours and money spent in carrying out Project Controls functions. These costs must be folded into the budget and staffing/hiring plans.
- Care must be taken in making sure that the project chooses tools to match its needs. Many commercial project software available for Project Controls (schedule platforms, PMM programs, risk managers, etc.) require expertise and experience to run the software as well as costs for licensing. Expert hire(s) may also be required to support these applications.
- For large, complex projects, a supplementary standalone Project Management Control Plan (PMCP) document that describes all plans and expectations for Project Controls may be created and referenced from within this PEP. For less complex projects and/or nascent projects still under development, all details and plans for the PMCP can be contained within the PEP document itself.
- An illustration of standard operating procedures for the implementation of Project Controls is helpful in communicating the process used for monthly comparisons, analysis, management, and reporting in a format that speaks to the project team members and emphasizes project-specific details of the steps involved during each reporting period.

Figure 3.5-7

Project Controls Process Flow Chart, showing the interactions and connections between the various sub-components of the Project Control Plan. The Project Definition, comprised of the Performance Measurement Baseline and the approved contingency amounts, is shown in grey to indicate that it was established before the Project Controls processes were implemented.



PEP 7.2 Performance Measurement and Management Plans

This subcomponent presents the project Performance Measurement and Management (PMM) tools and methods that describe how the project will be managed and controlled during execution using information from quantitative comparisons of status to the planned project. There are two major processes in a PMM Plan that need to be addressed, as shown in the PMM and Status Input boxes in Figure 3.4.x above:

- **Performance Measurement.** Comparing and analyzing collected Status Inputs against the plans in the Project Definition.
- **Performance Management.** Making management decisions on actions to pursue based on the comparison analysis.

The selection of Project Controls tools depends upon the chosen PMM method, which should be tailored and scaled to meet project needs. For example, Major Facilities construction projects are required to use verified Earned Value Management (EVM) as the PMM method, which entails the use of tools such as EVM software applications and involves adherence to NSF EVM system guidelines. Simpler projects may find that scaled, non-verification EVM, or even simple spreadsheet comparisons of cost versus actual expenditures and milestone tracking, are adequate methods for comparison of plan to actual status. Further guidance on creating a tailored and scaled PMM Plan is given in Section 4.5 Monitor Progress Against Plan.

The PMM Plan should describe how the following functions will be addressed:

- **Scope and Quality Assessment.** Describe how the delivery of scope will be formally assessed, compared to the WBS and the Quality Acceptance Requirements, and how variances will be documented. This should include how requests for technical configuration changes will be created, evaluated, implemented, and documented.
- **Schedule Progress Assessment.** Describe how schedule activity progress inputs will be collected and formally assessed against the IPS and how variances will be documented.
- **Budget Assessment.** Describe how expenditure inputs (actuals) will be regularly collected (at the work package level) and assessed against the time-phased budget, as well as how variances will be documented.
- **Variance Assessment.** Describe how the project management team will evaluate cost and schedule variances and determine what corrective actions will be required, if any.
- **Contingency Management.** Describe how total project risk exposure will be periodically reassessed, compared against contingency, and documented.
- **Project Risk Management.** Describe how the monitoring of individual risks and determination of any risk responses, as described in PEP Subcomponent 4.2 Risk Management Plan, will be applied during the Project Control reporting cycle.
- **Forecasting.** Describe the methods and frequency of updates to EAC and Variance at Complete (VAC) for cost and schedule.
- **Performance Management Process.** Describe processes, roles, and authorities for reviewing the performance measurement analysis and making decisions on which actions to take to keep the project on track.

Good Practices and Practical Considerations

- EVM is a commonly used PMM methodology for comparison and analysis of status to plan. If EVM is selected as the PMM comparison method, the project should scale the processes and tools used to match project characteristics.
- A means of qualitative assessment of project performance is also strongly encouraged; looking at quantitative metrics alone without context and discussion can lead to misunderstandings and misinterpretation of the data. A good practice is for project leadership to regularly visit the work sites, talk to the staff doing the work, and assess progress first-hand, correlating it to the quantitative metrics gathered in parallel. Similarly, conducting both formal and informal status meetings with lead staff, control account managers, and others doing the work is also a good practice.

- The PMM Plans should note at what cadence PMM functions will be performed. Most quantitative PMM functions are conducted monthly. If the proposed cadence is longer or shorter than one month, explain why this is appropriate for the project.
- Some project managers feel impelled to address or fix every variance. Identified variances by themselves are neither good nor bad; they are simply a form of information that requires analysis and interpretation. An appropriate means of systematically evaluating and assessing the significance of variances before corrective action is applied should be part of the PMM process.
- All variances, both positive and negative, should be communicated to stakeholders to ensure a comprehensive and realistic understanding of project status and prospects.

PEP 7.3 Change Control Plans

This subcomponent describes the project Change Control Plans (CCP), which addresses how the project manages, controls, and reports changes to the Project Definition. There are two types of project changes addressed in CCP:

- Change Control, which typically refers to changes to the PMB and movements/usage of contingencies (budget, schedule, and scope contingencies).
- Configuration Control, which applies to changes to the technical details (i.e., requirements and design).

Due to the unique and innovative nature of many NSF-funded projects, change is expected during the RI implementation and Construction Stage. Besides normal adjustments that occur with all implementation projects that involve future planned work, RI projects typically carry significant risks that require adjustments to the plan if realized. When project performance begins to significantly deviate from the plan due to a risk occurrence that affects project objectives or the plan needs to change for other reasons, project management exercises the Change Control process to maintain the overall project trajectories. Once reviewed and approved, Change Control actions may involve adjustments as simple as the documentation of a straightforward schedule reorganization or as complex as a scope change involving changes to design and requirements, cost, schedule, scope, performance/quality, and contingency amounts.

Change Control Process. The Change Control Plan in the PEP should trace the path from submission of a change request, through the evaluation and approval processes, and end with implementation and reporting. It should be detailed enough that it can serve as guidelines for training and directing project team members responsible for delivering the project scope as planned and who are responsible for determining and implementing changes to the plan when necessary.

The CCP should include details on the following:

- The composition of the CCB and the roles and responsibilities assigned to change request (CR) submitters, reviewers, and approvers.

- The process for preparing and submitting CR for evaluation.
- The process for analysis and review of benefits and impacts (e.g., review by a formal CCB).
- The thresholds and authorities required for approval.
- Change documentation and archiving of change materials (CRs, supporting documents, approvals, etc.).
- Reports and notifications to project team members, stakeholders, and NSF.

An example flow diagram for a Change Control process is shown in Figure 3.4.7-x below, tracing the path through the process for both Change Control and configuration change requests. In this example, a single request form is used for both configuration and Change Control requests, but they follow separate evaluation processes. A CCB (e.g., comprised of project managers and work package leads) evaluates changes to the Project Definition: baseline and contingency. A Technical Review Board (e.g., comprised of technical leads and subject matter experts) evaluates changes to project configuration: technical scope, requirements, and design. The CCB make recommendations on changes based on impacts versus benefits. If a recommended technical change involves changes to scope or requirements or affects cost, schedule, and/or contingency, it is transferred to the CCB for evaluation of the impacts on the PMB and continency. If it is a request for a waiver of non-compliance for a completed part so that it can be accepted as still useful, it goes to the technical approver.

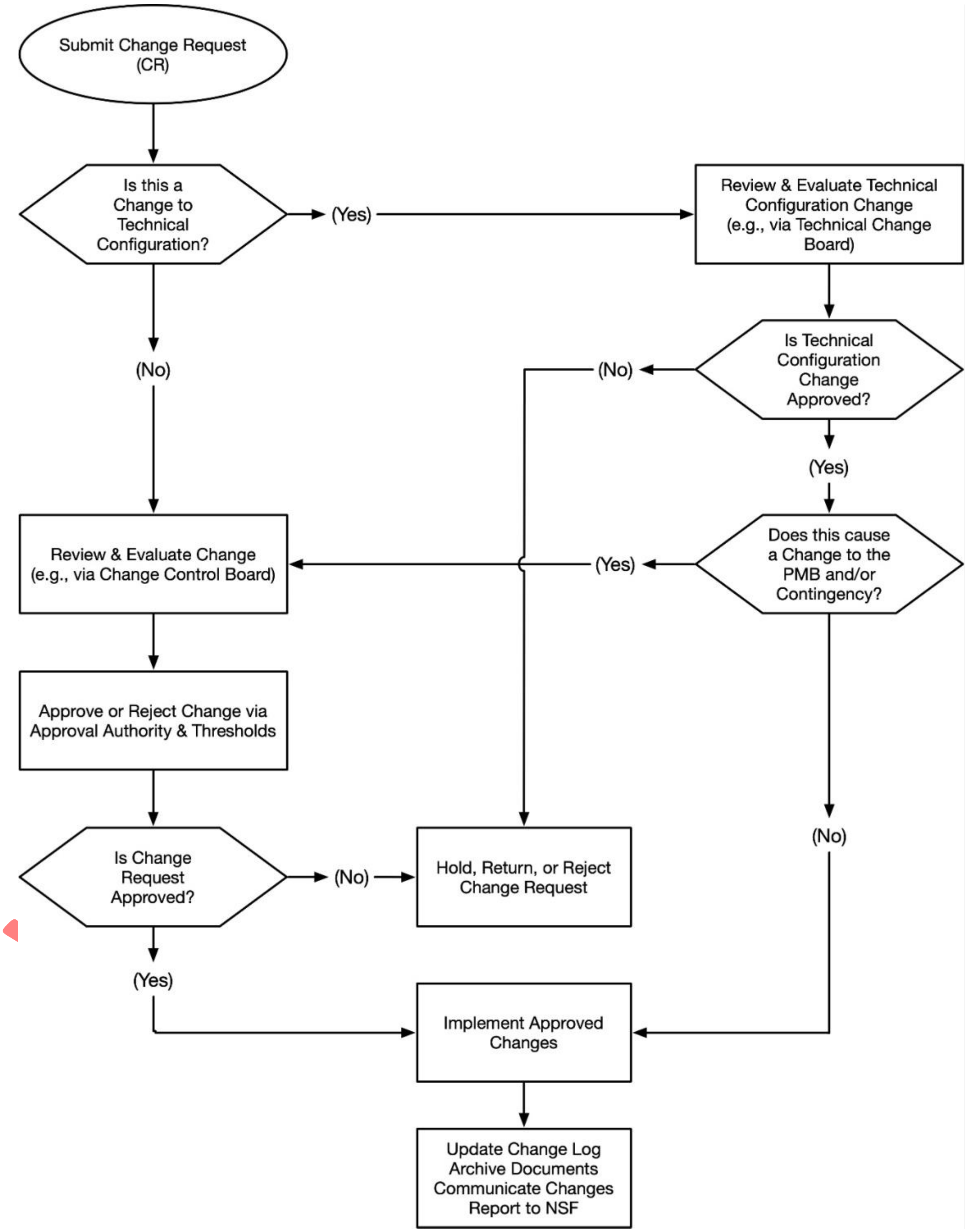
The CCB assesses the CR and makes a recommendation to approve or reject a CR based on the project-specific approval thresholds and authorities. The authorized approvers make the formal decision to approve, reject, return for adjustments, or place the request on hold. Generally, approvals progress from the lowest threshold level for CAM approval through higher levels in the project to the PM as the final approver. Others who may be included as approvers are ES&H officers or systems engineers. If NSF thresholds on project parameters apply, then NSF approval must be sought.

If approved, the changes are implemented. Regardless of the approvers' decision, the CR form is finalized and archived, and the Change Log is updated. The decision is communicated to stakeholders who may be impacted (including other work package leaders who may lose the opportunity to use remaining contingency or whose work may need to be adjusted). Finally, the outcomes of change requests are reported to the NSF in interim progress reports and periodic submission of the Change Log.

The example process illustrated here should be modified by each project, keeping scaling in mind to match project needs. For example, on very simple projects with few WBS levels, the PM may act as CR evaluator and approver without the use of a CCB. For more complex projects with many WBS levels, a deep hierarchy of leadership from CAMs up to the PM and /or PD, and a wide range of technical capabilities areas, CCBs and Technical Change Board (TCB) contribute a necessary depth of knowledge to the evaluation process.

Requirements and guidelines on creating and scaling CR forms and Change Logs are described below. Guidance on setting approval thresholds and the NSF requirement for approval of changes above specific thresholds is also described.

Figure 3.5-8



Change Request and Change Control Log Formats. NSF requires projects to document and archive CR and maintain a Change Log capturing all requests and outcomes for changes to project parameters. It does not have a specified format or template for a CR form, but it does have requirements on the contents. Changes must be linked to WBS elements and schedule IDs, and all control accounts must be specified as impacted by budget or schedule changes. Any contingency adjustments must be linked to an identified WBS and/or risk ID in the Risk Register. In addition to these requirements, projects are encouraged to include the basis of estimate data and calculations itemized by cost element (i.e., labor, materials, supplies, etc.) as well as before and after copies of the affected schedule and/or milestones. The final format for CR, as well as the process and threshold approval levels for implementation, may be negotiated with NSF at the time of award.

The following is a list of the typical elements included in a CR form:

- CR ID, Title, Owner/Proposer, Date of submission.
- Summary of Motivation and Change Description, including change in risk to project objectives and any contingency adjustments.
- Links to impacted WBS elements and identified risks.
- Impacts on elements of the project PMB.
- Budget and schedule impacts, including proposed adjustments to contingency.
- Signatures of reviewers, if required.
- Acknowledgement of communication to impacted project leaders.
- Project approvals according to authority and thresholds, with NSF approval if required.
- Project Controls acknowledgment of completed change implementation.
- Attachments: expanded schedules, BOE for impacts, technical reports, and any other pertinent information.

Figure 3.5-9

Sample Change Request

Change Request #	**Date**
Change Request Title	
Impacted WBS Elements	
Associated Risk ID #s	
Award #	
Originator Name	**Originator Signature**
Other Personnel	

Summary change description and justification, and impact if change does not occur (Include potential alternatives as appropriate)	
NSF Approval Required?	
Scope or Technical Impact	
Budget Impact	
Schedule Impact	

Project Acknowledgement and Concurrence

Title/Name	Signature (or Attached Email Approval)	Date

Budget Impacts by WBS and Control Account

WBS Element Level 2	Control Account (WBS Level 3)	Current Budget	Revised Budget	Change Amount	Change Description
WBS L-2 Sub-Total					
Total					

CCB Review Date (Can be bypassed for budget changes <$25K)	**Date**
CCB Review Results	
Change Approved or Rejected by PD?	
Project Director Signature (Or attached email approval)	**Date**
Disposition	**Originator Signature**
NSF Program Officer Signature (required if >$75K) (Or attached email approval)	**Date**
Comments	
Project Controls Implementation (Description)	
Project Controls Staff	**Implementation Date**
Additional Documentation	

The project is also required to keep a complete list of all formal CR, regardless of whether the CR was approved, rejected, or placed on hold, in a summary Change Log. The Change Log is submitted to the NSF on a specified schedule. A list of the typical elements in a Change Log includes the following:

- Change Control document reference number, title, review date, and approval dates.
- Amounts of change in scope, schedule, and budget, labeled at WBS Level 2 or at the first meaningful level of technical differentiation within the project.
- Adjustments to contingency, both draws and returns.
- Running totals for baseline cost, contingency usage to date, and remaining contingency.
- Running totals for project baseline duration, contingency usage to date, and remaining contingency.
- NSF approval date if applicable.

Each project should tailor the CR form and Change Log formats to the project needs. Projects may choose, for example, to use two separate forms for change and configuration requests, where the information collected for configuration changes may be based more on test results and requirements compared to CR focused on cost and schedule.

Change Reporting. It is essential that historical information be logged and maintained in a manner that allows NSF to systematically track the evolution of the PMB and the science objectives from the initial definitions at award through all subsequent changes. In other words, PMB budgets, for example, must be traceable through historical records to the initial PMB release.

- All CCB change requests are to be documented and archived by the project, regardless of outcome.
- Change Logs and CR documentation must be provided on a periodic, pre-determined basis to NSF for review.

Approval Thresholds and Authorities. In addition to internal approval authorities, the defined Change Control process must include a provision for seeking prior written approval from NSF (PO or higher, depending on the magnitude) for all actions that exceed the thresholds specified in the award instrument or NSF policy. The approval thresholds are negotiated with the cognizant PO and award official before award. In particular, the NSF PO must concur on all change actions exceeding thresholds defined in the award instrument for allocation of scope, schedule, and budget contingency. Contingency may only be used to support the scope included in the approved Project Definition. See Section 4.2.5.7 TITLE for additional details.

An example of a Change Control threshold table is shown in Figure 3.4.7-x.

Figure 3.4.7-x. Sample Change Request with negotiated approval thresholds and authorities for a Major Facility project with medium complexity.

Table 3.5-18

Type of Change	NSF	PM	CAM
Key Science Objectives	Impact on KPP	Changes to science requirements	Changes to engineering requirements
PMB Budget	Budget changes above $250,000	Budget changes between $50,000 and $250,000	Budget changes between $5,000 and $50,000
PMB Schedule	Change in project end date	Change of two months or less to Tier 1 or 2 milestones	Change of one month or less to Tier 2 Milestones
Contingency	Greater than $100,000 or two months of schedule Exercising any scope option	Less than $100,000 or two months or less to project end date	Less than $25,000 or one month or less to Level 2 milestones

The CCP should include descriptions of considerations for managing scope, schedule, and budget contingency, including approval and notification thresholds, and how contingency will be added to/subtracted from the Project Definition. When a project approves a Change Control action that results in allocating or returning contingency to the pool of contingency funds, the PMB budget will also change. Similar change control actions affect the PMB schedule; they revise the project PMB schedule and the available schedule contingency or float time - that is, the difference between milestones on the schedule's critical path and the expected completion dates for activities that lead to the accomplishment of those milestones. When a project exercises up- or down-scopes listed in the SMP (see PEP Subcomponent 3.2 Scope), the PMB budget and schedule will change, and the contingency pools will either increase or decrease as a result. The SMP will also change, with descopes removed from the PMB and the Scope Options Plan. Up-scope options will involve adding to the PMB scope, schedule, and budget and deleting the option in the SMP. All contingency requests must be supported by analysis demonstrating that the proposed amounts and changes to be allocated are considered reasonable and allowable and must reference the associated WBS elements and/or the previously identified risk.

Good Practices and Practical Considerations

- Modifications to the PMB that are within the defined scope and do not change the TPD or TPC are referred to as replanning. Replanning may be due to adjustments or reorganization of the project plan and/or may signify that contingency is being expended in an expected manner.
- Re-baselining occurs when the changes involve increases in the National Science Board (NSB)-authorized TPC, an extension beyond the TPD, and/or major changes in scope or science goals. When the proposed changes reach the re-baselining level, the approval process involves NSF and may involve the NSB.
- Replanning exercises are not required to address minor cost or schedule variances but may be warranted if there are substantive changes to the PEP during implementation or Construction Stage.
- Projects should include both threats and opportunities in the Risk Register from the very beginning of the project to allow both up- and down-scope actions during the implementation or Construction Stage.
- A single combined Change Log with both CR information and summary log inputs may be adequate to meet NSF requirements for simple projects and those with few or simple anticipated changes.
- NSF may request submission of native file formats (e.g., spreadsheets, not PDF files) to facilitate oversight.

PEP 7.4 Reporting and Reviews Plans

This subcomponent describes how project status and progress will be periodically documented and reported. This description should address:

Project Status Report. At an interval that is specified in the project's award instrument (e.g., cooperative agreement), the project will create and submit to the NSF a regular status report. At a minimum, the status report should typically include:

- The current technical status of the project, including progress of scope production and adherence to quality acceptance criteria.
- Schedule status, including the current project's critical path, reportable milestones, and other significant information related to the schedule.
- Financial status, including the percentage complete, TPC, BAC, ETC, and EAC (if applicable).

Risk status, including current total risk exposure, realized risks, new/changed/retired risks, contingency status, and any other relevant information. The interim report format will be negotiated with NSF.

Annual/Final Project Report. As required by the project's cooperative agreement, an annual report will be created and submitted to the NSF. This report will generally contain the same type of information that is included in regular project status reports, but with a focus on the entire year's progress and upcoming longer-term trajectory. Additional content may be requested by the cognizant PO or negotiated as part of the terms and conditions for the award.

Good Practices and Practical Considerations

- The specific plans for progress reporting should be elaborated over time, starting with a summary of expected reporting elements based on information generated in the Project Controls Plan and ending with the actual details negotiated with NSF at the time of award.
- In addition to supplying regular status reports required in the terms and conditions of the award instrument, it is essential that project staff inform the NSF in a timely manner of significant issues or significant changes in project status, such as a potential re-baselining, problems with partnerships, or surprising research and development results.

PEP 7.5 Business and Financial Controls Plans

This subcomponent describes the award management and business and financial procedures, policies, processes, and controls employed in executing the project. Detailed guidance is given in Section 5.6 Financial Management For projects involving partner institutions and/or other Subawardees, the host (award institution) acts as the central financial and accounting system for the project, collecting accounting information and invoices from the partners' financial systems.

The following elements should be described in this subcomponent:

- Identification of the roles and responsibilities for financial oversight, including decision authority, of proper allocation of expenditure if a question should arise during execution.
- Description of financial controls, including accounting practices, business controls, software tools, and/or award management practices.
- Stated references to institutional policies for subawards, procurements, and so forth.
- Description of accounting practices for collection and handling of financial data and actual expenses from internal and external subaward sources for input to the project PMM applications.
- Description of methods and responsibility for collecting various rates (salary, fringe, indirect costs, etc.) from the host and any partner institutions, including the process for incorporating rate changes and updates into Project Controls.
- System assessments and validations, such as audits passed and certifications.
- If relevant, a Segregation of Funding Plan describing accounting procedures used to properly delineate and separate expenses for construction activities from concurrent

or related activities supported by other funding (e.g., Construction Stage awards from Operations or Design Stage awards).

Segregation of Funding Plan. A Segregation of Funding Plan is intended to establish internal guidelines to be used by the recipient and to inform a mutual understanding between NSF and the recipient of the recipient's practices and responsibilities to determine the appropriate award when allocating expenses, particularly when construction and design or operations activities overlap in time.[3] The plan describes the procedures the recipient will use to ensure that costs and activities are expensed to the proper award by clearly defining the separation between the different sources of funding. Funds used on research facilities often come from sources such as existing ongoing operations, construction awards, operations start-up awards that include select commissioning activities, research grants, partner funds, etc. The Segregation of Funding Plan should include the following:

- Description of how work scope is defined and segregated according to funding source (e.g., project WBS, operations Annual Work Plan (AWP), design scope of work, etc.).
- Description of any contributions to the project from other funding sources and how these contributions are financially managed (i.e. separate job/cost accounting records).
- Provide a description of how the guidance in the plan will be articulated to all stakeholders and workers.
- Description of materials/services that benefit more than one award (i.e., Construction and Operations Stage awards) and methodology used to allocate expenses to the awards.

Various aspects of the Segregation of Funding Plan may be addressed in the recipient's internal policies and procedures or addressed in other parts of the subject PEP. In these cases, the Segregation of Funding Plan should address these aspects by reference in lieu of duplicating internal documents or text from other components of the PEP.

Good Practices and Practical Considerations

- Typically, projects utilize the award or host institution's existing business offices (e.g., purchasing and contracting) and financial (e.g., accounting) services to execute the project. This subcomponent should describe any such frameworks or relationships, including how the project will be managed within the larger institution, roles and responsibilities, authorities, and other relevant information.
- A description of the institutional entities that provide oversight within the Awardee organization should be included. For universities and laboratories, this usually involves an Office of Sponsored Research, Grants, and Awards, a Vice President of

[3] 2 2 CFR 200.413 "Direct Costs" describes the criteria recipients must use when direct charging costs against a federal award.

Research, etc. For consortia or collaborative projects, representatives from several such groups may be managed as a committee.

3.5.8 PEP Component 8 Cyberinfrastructure and Information Management

What Does This Component Describe?

This component describes the project's Cyberinfrastructure and Information Management (CIM) plans, which refer to the planned methods and processes for identifying, generating, gathering, organizing, storing, and sharing information within and external to the project. CIM plans consist of five key areas of focus: cyberinfrastructure (CI), information assurance (IA), data management, documentation management, and communications management. CI, in this instance, is designed to efficiently connect facilities, data, firmware, software, computers, and people, with the goal of supporting project execution during the implementation and Construction Stage. CI is distinct from any major computational equipment or resources that might be developed as a project deliverable. IA includes cybersecurity and other methods to safeguard digital assets and project information during the planning, execution, and closeout of the project. Data management involves the handling of data produced during the project, including testing and prototype data, code development, and related matters. Documentation management involves the creation, tracking, storage, and retrieval of project documents such as contracts, plans, drawings, specifications, reports, and project control documents. Lastly, communications management involves the planning, execution, and monitoring of information flow and project communications.

The CI described in this PEP component is distinct from any major computational equipment or resources that might be developed as a project deliverable.

Why Is This Component Important?

Effective CIM ensures that needed information is available to the appropriate people at the right time. It enables informed decision-making using accurate, up-to-date information. It helps PMs identify potential risks and issues early, which can prevent costly delays and rework. Effective CIM promotes collaboration and coordination while simultaneously preventing duplication of work, overlooked work, and general misunderstandings. It also helps maintain institutional knowledge both beyond the life of the project and with the departure of individual team members during the project. Effective CI ensures that project data is stored, available, reliable, and backed up. Effective IA (also called cybersecurity) protects against cyber threats, such as hacking, data breaches, and unauthorized access, ensuring confidentiality, integrity, compliance, and availability of project-related information. Effective documentation management ensures that project documents are accurate, up-to-date, and accessible to all relevant and appropriate stakeholders. Effective communications management ensures that information is routed to the correct people and that stakeholders are properly informed about project progress and issues.

How To Develop and Write This Component

There are six required subcomponents to be included in PEP 8 Cyberinfrastructure and Information Management, as listed in the table below. All six are required for a PEP, regardless of project type, size, or complexity.

The information management plans should be structured in a manner that matches the project characteristics and is agreed upon by the participants and stakeholders. This entire component should be tailored and scaled to the individual type, size, complexity, and characteristics of the project. Further, the subcomponents are typically developed in a progressively elaborated approach, as described in Section 3.2 Tailoring, Scaling, and Progressively Elaborating Plans.

Table 3.5-19

Component	Sub-Component	Documents/Products	References
8. Cyberinfrastructure and Information Management	8.1 Overview of Cyberinfrastructure and Information Management		
	8.2 Cyberinfrastructure	Cyberinfrastructure Plan	Section 5.2 Cyberinfrastructure
	8.3 Information Assurance Management	Information Assurance Plan	Section 5.3 Information Assurance
	8.4 Data Management	Data Management Plan	
	8.5 Documentation Management	Documentation Management Plan	
	8.6 Communications Management	Communications Management Plan	

PEP 8.1 Overview of Cyberinfrastructure and Information Management

This subcomponent provides a high-level description and overview of the plans for the management of project information, which includes CI, IA, data management, documentation management, and project communications management. This subcomponent describes the overarching CI and information management policies and objectives, the management team structure, key roles and responsibilities, and other relevant high-level information. It serves as an introduction for the remainder of this CIM component, with specific details for each sub-area provided below in the relevant subcomponents.

Good Practices and Practical Considerations

- Projects are expected to maximize access, sharing, and transparency of project data while simultaneously safeguarding privacy, confidentiality, intellectual property, and security. Striking the correct balance between these two competing goals should be jointly planned with the project team, the relevant science community that the project will serve, and the NSF.
- Project budgets should include adequate resources for CI and IA and management activities, including personnel, infrastructure, services, and storage costs. Project team members should also be trained in resource planning and budgeting.
- In the interest of transparency and as a general good practice as a steward of taxpayer-funded work, projects should report on and share project activities and findings regularly via public outlets like websites, publications, conferences, etc.
- Projects should consult the NSF Brand Identity Portal[4] for updated guidance on logos, signage, and acknowledgment of NSF support.

PEP 8.2 Cyberinfrastructure

This subcomponent describes the requirement that all proposals for new Major Facilities and Mid-scale RI include a CI Plan that outlines the strategy and approach for CI during implementation or the Construction Stage. The CI Plan provides a structured approach for planning, implementing, and managing the CI aspects of the RI. Typical topics for a CI Plan include:

- Enabling the Scientific Mission
- CI Elements and Requirements
- External CI, Facilities, and Resources
- Information Assurance (Cybersecurity)
- CI Implementation Approach
- CI Operational Approach

The CI Plan described in this PEP component is relevant only to implementation or the Construction Stage. However, a CI Plan is required for each life cycle stage of new Major Facilities and Mid-scale RI. See Section 5.2 Cyberinfrastructure for detailed information on CI and the CI Plan.

Good Practices and Practical Considerations

[4] https://mediahub.nsf.gov/portals/dnmqqhzz/NSFBrandingPortal

- RI projects should consider options for geographically separated duplication of critical project data, documents, and other information resources to mitigate data loss resulting from catastrophic incidents.
- Training materials to support proper usage of project-related CI should be developed for use by relevant internal or external stakeholders.
- Wherever possible, project CI elements should be designed for rapid redeployment across different platforms or service providers if necessary.
- Project CI resource utilization assessment and benchmarking tests should be conducted regularly to ensure that system capacity matches workload and does not impede progress or waste resources.

PEP 8.3 Information Assurance Management

This subcomponent describes specific plans and approaches for the management of project cyber-security during the Construction Stage or implementation. Topics covered in this subcomponent's plans typically include:

Institutional Policies and Procedures. Reference to and compliance with a parent institution's cybersecurity management policies and procedures, if available. Include compliance with NSF requirements and relevant laws and regulations.

Roles and Responsibilities. Include organizational framework, roles, and responsibilities for planning and implementing the cybersecurity plans. Include roles and responsibilities for responding to cybersecurity events.

Data and System Security. Plans, framework, and processes for data security, encryption, access controls, reporting, risk assessments, and security audits for all project websites, databases, servers, and other IT infrastructure. Include plans for passwords, data encryption, multi-factor authentication (MFA), access control, and other security implementation practices. Include guidelines for software updates and security patching. Policies for the use of institutional and personal devices and accounts for project work.

Response Plans. Plans and protocols for identifying, reporting, and responding to cybersecurity events. Include business continuity plans for critical systems, resources, and project activities. This includes identified individual team member responsibilities and response hierarchy.

Training. Policies and plans for cybersecurity awareness and implementation training for project staff. This includes training on phishing, password security, social engineering, and other means by which nefarious entities may gain access to the RI CI and data.

Good Practices and Practical Considerations

- For guidance on building or creating a rigorous IA Plan, see Section 5.3 Information Assurance.

- Some NSF-funded institutions and projects have come under serious denial of service, ransomware, and other related attacks. It is the project's responsibility to ensure that all appropriate means are applied to deter, minimize the likelihood of, and otherwise mitigate these attacks and ensure the integrity, security, and appropriate level of confidentiality for project systems and data.
- Projects utilizing cloud computing or third-party services must review all relevant security provisions, agreement terms, and potential risks posed by these entities.
- The cybersecurity plans should be informed by risk analysis, emphasize data management best practices, include robust safeguards and regular vulnerability testing, and include software updates. Training is also very important, but where possible, direct, hardware-controlled means of preventing data breaches or other attacks should be employed as a first line of defense.
- Cybersecurity risk management and incident recovery costs should be included in the project RMP.

PEP 8.4 Data Management

Plans and approaches for managing software development during the project are included in this subcomponent. Topics covered in this subcomponent's plans typically include:

Institutional Policies and Procedures. The plan should reference and describe compliance with a parent institution's CI, IT, and/or data management policies and procedures, if available.

Roles and Responsibilities. Include plans for all IT support, including roles, responsibilities, and training to support project needs. Plans and processes for training and support to ensure project personnel are well-versed in using the project's CI, IT systems, and data management tools should be included.

Project Data. Policies, plans, and protocols for the organization, QA and control, documentation, and long-term preservation and archiving of project-produced data and models. Include plans for sharing and access to these data. Standards and meta-data requirements and expectations should be described.

Software and Code Data-Management Deliverables. Specific plans for software selection or development, deployment, coordination, benchmarking, documentation, code repositories, quality testing, version control, release, and issue tracking. Plans and expectations of key software and data analysis tools to be used during project execution should be included, along with details on licensing, installation, and other requirements.

Backup. Plans and methods for backup, reporting, and disaster recovery in the event of data loss or system failures during the execution of the project.

Good Practices and Practical Considerations

- Where possible, projects should utilize existing and proven CI, repositories, archives, and community standards rather than developing custom solutions that are new and/or untried. Open licensing is also encouraged where applicable.
- Data governance and ownership need to be clearly defined and stated, including intellectual property rights and data rights for all relevant parties.
- Data QA and control are key aspects of a DMP. Careful consideration, the implementation of best practices, and other means should be employed to ensure data quality, accuracy, and reliability throughout the execution of the project.
- Projects should have a comprehensive plan to manage digital assets, including code, software deployment recipes, hardware and network architectures, 3D designs, and the like. Management, access, and distribution of these project execution-related assets needs the same consideration as applied to scientific data and project deliverables.
- A digital asset inventory and associated points of contact can facilitate efficient management and oversight of all resources.

PEP 8.5 Documentation Management

This subcomponent describes specific plans and approaches for managing project documentation. The project is responsible for ensuring that a document management system is in place that provides for the retention and retrieval of essential and significant documentation related to the project. A robust document management system will help prevent miscommunications and misunderstandings and will ensure that future facility operators have the information required to maintain the facility. This plan should provide organized and straightforward access to project records as required for NSF oversight, audits, and post-award monitoring.

Topics covered in this subcomponent typically include:

Institutional Policies and Procedures. Reference to and compliance with a parent institution's policies and procedures, if available, for document management, open access, intellectual property, and other relevant document control policies.

Documentation Development Plans. This should include plans and processes for document creation, review, approval, and version control. Specify who is responsible for document generation, who reviews them, and the approval hierarchy. Include guidelines for document formats, templates, naming conventions, and styles to ensure consistency.

Document Storage Systems. Document management system(s) to be used for secure storage, retrieval/access, sharing and archiving documents, records, and data. Include repository retention, archiving, and backup plans.

Document Security Plans. Document security and confidentiality plans, including access and distribution permissions and restrictions for confidential or sensitive documents. These plans should be coordinated with and integral to the overarching cybersecurity plans described in PEP 8.3 Information Assurance Management.

Document Control Plans. Description of version control, access and permission management, responsibilities, approval processes, and archiving of all relevant project-related documentation.

Good Practices and Practical Considerations

- Projects are encouraged to implement a document management system that is accessible via the Internet rather than paper-based, though some paper records may be necessary on certain projects. The documentation management system should not only aid in identifying the types of documents to retain but should also contain appropriate controls over official documents such as drawings to ensure that only the most recent drawings are being used and that only authorized personnel are able to access and modify them.
- NSF has specific requirements and expectations for documentation retention on projects they fund. It is the responsibility of the Awardee to determine the applicability and specific requirements for their project. This may include requirements for retention of financial, programmatic, and equipment records and documents post project. The project is encouraged to work with representatives at the NSF to determine and implement these requirements.

PEP 8.6 Communications Management

This subcomponent describes specific plans and approaches for managing project communications. Communications can take a variety of forms, including regular all-hands meetings, regularly updated project websites, and team newsletters and blogs. Successful communication plans depend strongly upon interactions with project stakeholders, including NSF and other governmental representatives, project team members and partners, and the public. Awardees are recommended to put in place a stakeholder management plan that provides for the identification, analysis, and periodic review of project stakeholders, including an analysis of their needs and expectations. Topics covered in this subcomponent's plans typically include:

Institutional Policies and Procedures. Reference to and compliance with a parent institution's communication policies and procedures, if available.

Roles and Responsibilities. Plans for management and responsibilities for overseeing and implementing project communications, including any required approval hierarchies. Any single point of contact requirements (e.g., for press interactions, crisis management, etc.) should be identified.

Communication Strategies and Methods. The overarching strategies and specific methods planned for both internal and external (e.g., NSF) project communication. Specify items such as the goals, target audiences, communication frequencies, formats, and other planned methods of formal and informal communication. The communication channels and methods to be used should be identified, such as emails, regular meetings, software, and social media platforms. Explain how each channel will be utilized.

Archiving. Plans for how project communications will be documented and archived, including the retention of emails, messaging apps, meeting minutes, website content, and other communication records, should be described.

Accessibility. Projects should ensure that they support accessibility standards for publications, events, and information releases.

Good Practices and Practical Considerations

- Awardees are recommended to put in place a stakeholder management plan that provides for the identification, analysis, and periodic review of project stakeholders, including an analysis of their needs and expectations.
- The project should strive for clear, transparent, and unambiguous communications, both internal and external to the project.
- Project should avoid siloing and compartmentalization of information within a project. Successful projects usually have systems in place to ensure vigorous and clear flows of information internal to the project to prevent issues related to siloing. Team members also should be encouraged to ask for project information, and project leadership is encouraged to freely disseminate such information to the maximum extent possible.
- Projects are encouraged to create websites, social media, signage, etc., to communicate project activities and outcomes to the general public during the course of the project. Projects must acknowledge NSF support in all such communications, publications, presentations, and press releases about the project using the language provided in the project agreement.

3.5.9 PEP Component 9 Project Closeout Plans

What Does This Component Describe?

This component describes the plans for closing out the project. Closeout is the last phase of a project, when the project team verifies the completion of all scope contained in the WBS, completes all the necessary tasks to validate the technical performance of the RI, transitions all deliverables to owners/operations, and shuts down the project. This component is comprised of three elements that need to be considered when closing out a project: technical closeout activities, administrative closeout activities, and programmatic/award closeout activities.

Why Is This Component Important?

The closeout process is an essential part of any project. It ensures that all deliverables have been completed, key parameters have been met, major stakeholders are satisfied, and all unused resources have been returned to the funding agencies as required. The closeout process also provides an opportunity to evaluate the project's success and identify areas for improvement in future projects. By following a systematic and structured closeout process, the project can be assured that all work has been completely addressed and all project objectives met.

How To Develop and Write This Component

There are four required subcomponents to be included in this component, as listed in the table below. All four are required for a PEP, regardless of project type, size, or complexity. Project closeout planning starts early in the project Design Stage and is factored into the baseline scope of work. Each specific closeout activity should be considered and incorporated into the IPS and included in the project budget as necessary. The project team should review and iterate plans with key project stakeholders (e.g., the NSF and operations teams) early in the planning process to ensure all required activities are identified, planned, and budgeted. The key is to minimize surprises and to manage all stakeholders' expectations early and effectively.

The closeout plans should match the project characteristics and needs and should be agreed upon by the participants and stakeholders. The plans should be tailored and scaled to the individual type, size, complexity, and characteristics of the project. Further, the subcomponents are typically developed in a progressively elaborated approach, as described in X.X.X.X.

Table 3.5-20

Component	Sub-Component	Documents/Products	References
9. Project Closeout Plans	9.1 Overview of Closeout Plans		In accordance with the award instrument used.
	9.2 Technical Closeout Plans	Technical Closeout Plan Transition to Operations Plan Lessons Learned Document	In accordance with the award instrument used.
	9.3 Administrative Closeout Plans	Administrative Closeout Plan	In accordance with the award instrument used.
	9.4 Programmatic/ Award Closeout Plans	Programmatic/Award Closeout Plan	In accordance with the award instrument used.

PEP 9.1 Overview of Closeout Plans

This subcomponent serves as an overview of the entire closeout component plans. It provides a brief description of the overall closeout approach and processes. It describes the high-level approaches for each of the three categories of closeout activities (technical closeout, administrative closeout, and programmatic/award closeout). Specific guidance and details for each of these individual closeout categories should be covered in the three other sub-components included in this PEP component.

Good Practices and Practical Considerations

- While closeout in this PEP guidance is described in terms of three distinct categories of closeout (technical, administrative, programmatic/award), it's important to recognize that many closeout activities are typically performed simultaneously.
- The process of closeout activities often begins well before the end of the project, particularly with respect to performance testing and verification of compliance with requirements.
- A project closeout checklist or CMX can be a valuable component of the Technical Closeout Plan.
- Ideally, the details, procedures, documentation, and criteria for closing the project should be discussed and negotiated with the NSF at the time of a received award.

PEP 9.2 Technical Closeout Plans

This subcomponent describes the plans and approaches for the completion of all project scope. Its primary goal is to demonstrate how the project will formally complete, verify compliance, prepare for, and complete transitions, and document all final project deliverables, ensuring that they have been completed, meet their required quality acceptance criteria, and are ready for delivery/transition. Note that final stakeholder (NSF) validation and formal acceptance of the product scope is not part of this subcomponent, that is, stakeholder approval and acceptance are included as part of the programmatic closeout plans below.

While every project is unique, these technical closeout considerations typically include:

Product Scope Completion and Verification Plans. Describe the plans for completing, testing, verifying, documenting, and handing over all scope deliverables that are included in the WBS. This may include activities such as plans for performing final acceptance tests, writing quality control reports, capturing test results, creating compliance matrices (CMX), processing requests for waivers against requirements, and creating, capturing, and processing all required as-built drawings and specifications. Specific procedures to accomplish the work for commissioning could be included as an appendix or separate document.

Project Scope Completion Plans. Describe plans for completing and documenting compliance with all other non-product-type project scope (e.g., services like project management, systems engineering, safety management, etc., or a result such as the creation of a user group)

Transition to Operations Plan. Describe the plans for determining operational readiness and completing the transition of the deliverables from construction to operations. This may include elements such as conducting an operational readiness review and/or operations demonstration. The plan should address verification of deliverables such as the provision of operations and maintenance manuals, staff training, and other appropriate elements such as transfer of title/ownership, as well as operational readiness of the RI.

Project Lessons Learned Plans. A lessons learned document is often included as part of the technical closeout deliverables of a project. The plans for creating and delivering this document should be described here if applicable.

Completion and Archival of Project Documentation. Describe the plans for completing and filing/storing all relevant project documentation and communications.

Good Practices and Practical Considerations

- Commissioning verifies that the substantially complete facility operates over its full range of intended capabilities as specified in KPP and science requirements. Once the commissioning planning is complete, an operations readiness review may be held to examine and comment on the plan. This can be conducted separately or as a component of one of the required project reviews.

- Projects should plan to gather, assess, and incorporate lessons learned during the entire course of the project, as well as analyzing and documenting those identified at project closeout. Feedback from the NSF (e.g., the PO) at the closeout should be included in the lessons learned document.
- Completing and archiving all project documentation and communications is often an overlooked project deliverable. It should be specifically addressed in PEP 8.5 Documentation Management. Systematically and regularly, using a well-structured and organized repository for key documentation during project execution will simplify the effort necessary to archive documents at project closeout. Note that financial records, supporting documents, statistical records, and all other records pertinent to the NSF award must be retained by the recipient as described in accordance with the award instrument used, except as noted in the Uniform Guidance 2 CFR §200.334.,used, except as noted in the Uniform Guidance 2 CFR §200.334.

PEP 9.3 Administrative Closeout Plans

This subcomponent describes the plans and approaches that the Awardee institution will use to complete the closeout of all institutional administrative activities. Depending upon the characteristics of the project, this typically includes but is not limited to:

Closeout of Project Contracts, Agreement Commitments, and Legal Obligations. Describe plans for ensuring all project obligations, contractual agreements, and other commitments are addressed and completed.

Financial Reconciliation and Return of Unspent Money. Describe plans for reconciling all financial control accounts, including both budget and contingency. Describe plans for the return of any unspent/unused monies.

Release or Transfer of Labor Resources. Describe plans for the release of project staff at the end of the project and/or transfer to another role (e.g., Operations). This may include the application of existing HR plans and policies but also may include project-specific plans and methods.

Return, Release, or Transfer of Non-Labor Resources. Describe plans for the return, release, or transfer of non-labor resources (e.g., tools, equipment, computer hardware/software, office space, etc.). Specific property management policies and procedures should be addressed as applicable.

Good Practices and Practical Considerations

- Awardees must liquidate all obligations incurred under their awards as specified in accordance with the award instrument used (e.g., 120 days).
- NSF does not allow Awardees to keep any unspent money at the end of an award.
- Contractual obligations and commitments may not be considered fully complete until lien releases and/or over waivers have been received from external entities like contractors. The project is encouraged to research and review specific requirements

necessary to ensure that no persistent obligations, liens, or other commitments extend beyond the period of performance of the project.

- Project obligations on some RI projects may include environmental and regulatory commitments and requirements that must be formally completed, agreed to, documented, and closed out with all relevant parties. Formal documentation in these situations is critical to gather and include in the closeout documentation.
- The end of a project usually requires the release or transfer of key project personnel and staff from the project. This should be planned for in a professional, systematic, and graceful manner. It's also a good practice to celebrate success with the project team and recognize their contributions and hard work before the disbursement of these personnel.

PEP 9.4 Programmatic/Award Closeout Plans

This subcomponent describes the processes and approaches for obtaining formal affirmation from the NSF that all project work has been successfully completed such that the project award may be closed. At an appropriate time approaching or following construction completion, NSF will typically conduct a Final Construction Review. This review is intended to assess the extent to which the required scope was delivered in accordance with the PEP and award terms and conditions. Depending upon the characteristics of the project, programmatic/award closeout usually includes but is not limited to:

- **Validation of Project Deliverables.** Describe the process for working with the NSF to validate acceptance of the product scope delivery and formally acknowledge that all deliverables are complete and available, with no further action required on the part of the project.
- **Validation of Title/Ownership Transfer.** Describe the process to validate readiness to transfer title/ownership of deliverables to the appropriate entity and verify completion of the transfer.
- **Validation of Transition to Operations.** Describe the process to verify readiness for operation and validate completion of the transition.
- **Final Report(s).** Describe what final project reports are required and will be provided by the project to the NSF at the conclusion of the project. These typically include but may not be limited to the Final Project Report and Project Outcomes Report for the General Public.
- **Closeout Review.** Describe the plans for conducting a close-out review (e.g., a Final Construction Review) with the NSF at the conclusion of the project.
- **Agreement of Project Completion.** Describe the process for working with the NSF to obtain formal written recognition that all project work is completed, project financials have been reconciled, and that the project award may be closed.

Good Practices and Practical Considerations

- In addition to the Final Project Report and Project Outcomes Report for the General Public, there may be other requirements contained in the original solicitation, the award agreement terms and conditions, Federal Acquisition Requirements (FAR), and/or Uniform Guidance (2 CFR 200 Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards the *Proposal and Award Policies and Procedures Guide*, and other oversight and requirements documents. The project management team should work with the NSF to identify all such requirements and ensure they are appropriately addressed.
- It is good practice to create an award terms and conditions CMX that tracks and ensures all requirements have been met or achieved in order to facilitate the NSF Closeout Review.

3.5.10 PEP Component 10 Post Project Plans

What Does This Component Describe?

This component comprises the conceptual Post Project Plans that describe the expected activities and plans for deliverables after project completion and addresses the feasibility and reasonableness of those plans. Such post project activities typically include those undertaken during the operations and maintenance, and those adopted for the transition or closeout of the facility operation during a Disposition Stage. These plans are high-level, conceptual estimates of the expected key activities, considerations, and costs that define the characteristics of these future life cycle stages. Note that these conceptual plans are not the same as the detailed operations Annual Work Plan (AWP) described in Section 3.6 Operations Stage Planning or Section 3.7 Disposition Stage Planning. NSF has separate proposal review and acceptance procedures for these life cycle stages. The creation of the final detailed life cycle proposals and plans for operations and disposition is the responsibility of the future life cycle operators/owners and is not the intention of these conceptual plans.

Why Is This Component Important?

There are a number of reasons a PEP includes the consideration of post project activities. These include:

- Ensuring the feasibility and reasonableness of proposed operations, maintenance, and disposition programs and that the programs are not difficult or too expensive to accomplish.
- Ensuring that the operating plans take advantage of the RI capabilities and that access to the scientific capabilities and output of the RI meet stakeholder expectations.
- Alerting stakeholders, including NSF, to the expectations and assumptions that determine the necessary level of future support and responsibilities for the remainder of the RI lifetime.

- Raising awareness of any special considerations, including environmental, handling of human subjects' data, or other regulatory requirements that may impact the achievement of expectations and goals.

How To Develop and Write This Component

There are three required subcomponents to be included in this component, as shown in the table below. All three are required for a PEP, regardless of project type, size, or complexity.

The Post Project Plans should match the project characteristics and needs and should be agreed upon by the participants and stakeholders. The plans should be tailored and scaled to the individual type, size, complexity, and characteristics of the project. Further, the subcomponents are typically developed in a progressively elaborated approach, as described in X.X.X.X.

Table 3.5-21

Component	Sub-Component	Documents/Products	References
	10.1 Overview of Post Project Plans		
10. Post Project Plans	10.2 Concept of Operations Plans	Concept of Operations Plan (ConOps)	
	10.3 Concept of Disposition Plans	Concept of Disposition (ConDisp)	

PEP 10.1 Overview of Post Project Plans

This subcomponent serves as an overview of the two plans included in this component, providing a brief, high-level description of each plan. It should describe how the plans will be created and elaborated during planning and how and under what circumstances they will be modified after project start. Specific guidance and details for each of these individual Post Project Plans are covered in the two remaining subcomponents, below.

PEP 10.2 Concept of Operations Plans

This subcomponent describes the Concept of Operations (ConOps) Plan, which contains plans and expectations for the post project Operations Stage of the implementation and Construction Stage. The ConOps Plan is created early in project planning and is a high-level, conceptual view of expectations. The ConOps Plan is ideally matured by the time of award and does not need to be revised or modified unless new understanding or issues regarding key elements of operations and maintenance arise during project execution. The ConOps Plan are not the same as the Operations Stage AWP (See Section 3.6 Operations Stage Planning). The AWP is not the responsibility of the project unless the entity executing the construction project or implementation is also the operator and NSF has approved AWP as deliverables within the project scope. In that case, AWP are treated as any other deliverable in the WBS and follow the requirements in Section 3.6 Operations Stage Planning. They are not included in the ConOps Plan.

The ConOps Plan should:

- Describe how and by whom the RI will be operated and maintained,
- Describe who has access to the scientific capabilities and output of the RI such that operation plans satisfy stakeholder expectations.
- Give high-level estimates of the resources and budget needed for annual operations and maintenance (space, utilities, staffing, services, material/supplies, etc.), with analysis or justification for the Basis of Estimate (BOE) and reasonableness of assumptions.
- State the expected lifetime of the facility or operations.
- Include a listing of expected funding sources and contributors that will support operations activities and how much support each is expected to give (including any user's fees).
- A key part of a ConOps for RI is a discussion of expected costs, cadence of major expenditures, and plans for future upgrades to instrumentation (e.g., next-gen instruments).
- Include a description of any transition activities and costs that are not the responsibility of the implementation and Construction Stage (i.e., staff training, initial start-up).
- Describe any post project shake-down activities required to bring the facility to full science capability after the transition to the Operations Stage.

Good Practices and Practical Considerations

- If the plans for operations and maintenance include support and/or contributions from the operating or other institutions, then letters of collaboration from those institutions, stating the nature, duration, and level of support, are encouraged for creating a credible BOE.
- In some cases, particularly with distributed facility projects, the transition to Operations may be staggered, with some deliverables moving to operations while others are still in the Construction Stage. Thus, the availability of operations and project funding will overlap in time. ConOps Plans must address how Operation responsibilities will be managed during the staggered transfers and how costs will be managed following the segregation of funding requirements covered in PEP 6 Environmental, Safety, and Health Management.
- For Major Facilities, the ConOps Plan, along with the Transition to Operations Plan (see PEP 9 Project Closeout Plans) and Segregation of Funding Plan (see PEP 6

Environmental, Safety, and Health Management) are reviewed during Conceptual, Preliminary, and Final Design Reviews. The plans are updated as needed during the Construction Stage. The plans must be updated and provided to NSF for review in a timely manner before commissioning activities commence.

- ConOps Plans for Mid-scale RI implementation projects are typically reviewed during the proposal and award process before commissioning or transitions to operations.
- For Design Stage proposed projects, separate guidance for follow-on plans for further design or implementation is described in the Design Execution Plan (DEP) outlined in Section 3.4 Design Stage Planning.

PEP 10.3 Concept of Disposition Plans

This subcomponent describes the Concept of Disposition (ConDisp) Plan, which provides a high-level description of the expectations during the Disposition Stage, the last stage in the RI life cycle. Disposition options may include the partial or complete transfer of a facility to another entity's operational and financial control, mothballing the facility so that operations can be restarted at a later date, or decommissioning. Decommissioning may include complete removal of the infrastructure and site restoration and remediation. The ConDisp Plan is created early in project planning and is a conceptual view of expectations for divestment or disposition after NSF funding support is terminated. It typically reaches maturity by the time of the implementation and Construction Stage award and does not need to be revised or modified unless new understanding or issues regarding key elements of disposition arise during project execution. ConDisp plans are not as detailed or complete as the Facility Disposition Plan described in Section 3.7 Disposition Stage Planning. Facility Disposition Plans are usually produced after a period of operations, well after project closeout. They are not the responsibility of the project.

The ConDisp Plan should:

- Describe the liabilities, expectations, and plans for transfer of the RI to another institution or entity, demolition and removal, site remediation, decontamination, and so forth.
- Provide a high-level estimate of financial liabilities and costs of disposition activities at the end of its Operational life or end of NSF support. List assumptions used in supporting the estimated costs.
- Describe plans, costs, and assumptions for all potential pathways if more than one is likely.
- Note any known regulations, laws, permitting, or other requirements that are expected to be followed and/or adhered to during the Disposition Stage.

Good Practices and Practical Considerations

- The ConDisp Plan is a pre-cursor to the Disposition Stage Facility Disposition Plan and should not include full and specific details, plans, and expectations for disposition;

instead, it's a high-level, top-down overview that provides enough detail to ensure a broad but accurate understanding of the requirements by all stakeholders.

- For Major Facilities, the ConDisp Plan is reviewed during Conceptual, Preliminary, and Final Design Reviews. The plans are updated and reviewed as needed during the Construction Stage.
- The ConDisp Plan for Mid-scale RI Implementation projects are typically reviewed during the proposal and award process as well as one year before commissioning or transitions to operations.
- An explanation of the impacts of site or equipment contamination on disposition planning is essential for a full understanding of the costs and administrative burdens.
- Awardees should be aware of any legal liabilities for site restoration, remediation or other obligations that attend final asset disposition.