Project Manager's Guidebook

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Purpose/Introduction

Building the interstate highway system, landing on the moon, detecting improvised explosive devices, and developing the Internet are Federal Government achievements that all required project management. Not every project will have the same scale of impact, but by virtue of being funded by Congress and with involvement by agency leadership and the Executive Office of the President, all projects are contributing in some way to the security, growth, and success of our Nation.

The role of a Federal agency project manager (PM) is so important that it is one of the few positions in the Federal Government with specified qualifications and training mandates. PMs have the responsibility to wisely spend taxpayer dollars to implement programs and projects that lead to better services for the taxpayers and more efficient and effective agencies. It is critical that PMs understand:

- Challenges and risks exist in every direction—projects succeed and fail for a variety of reasons.
- Consequences can be significant—the Nation's resources are at stake. The project is funded with Government dollars and is connected to the agency's mission, which typically has an effect on our overall National Security posture and the daily lives of American citizens.
- The project and program environment is unique and dynamic—no project team faces the exact same circumstances. Technology is ever-changing, acquisition laws and regulations change, leadership and administrations change, industry practices are always evolving, and the user's needs and expectations evolve frequently.
- Intangible human qualities, such as leadership, integrity, perseverance, and tenacity to reach a goal, are often key determinants for success.
- Good planning and decision-making are keys to success—thinking through every step of the project to ensure management of risks, stakeholder support, proper use of tools, innovation, and continuous data-driven decision-making shape every action and reaction.

Civilian agency PMs are critical to the success of agency acquisition initiatives, programs, and projects. Providing both strategic oversight and operational guidance, the PM is responsible for navigating a complex enterprise spanning Federal regulations, Federal and contractor personnel, technological systems, agency policies, and the needs of end users. As a PM, technical and business expertise alone is insufficient. The PM must be a practitioner of ever-increasing technical, management, regulatory, and procedural knowledge and possess the soft skills required to motivate and lead personnel supporting the project.

The goal of this guide is to be a resource tool to PMs, providing practical concepts and useful tools and templates. This guide is not intended to be a comprehensive "how to" guide or an exhaustive authority on project management. Rather, it is designed to provide PMs with best practices and tools to adopt or adapt so that management of projects are appropriate and effective in achieving desired results.

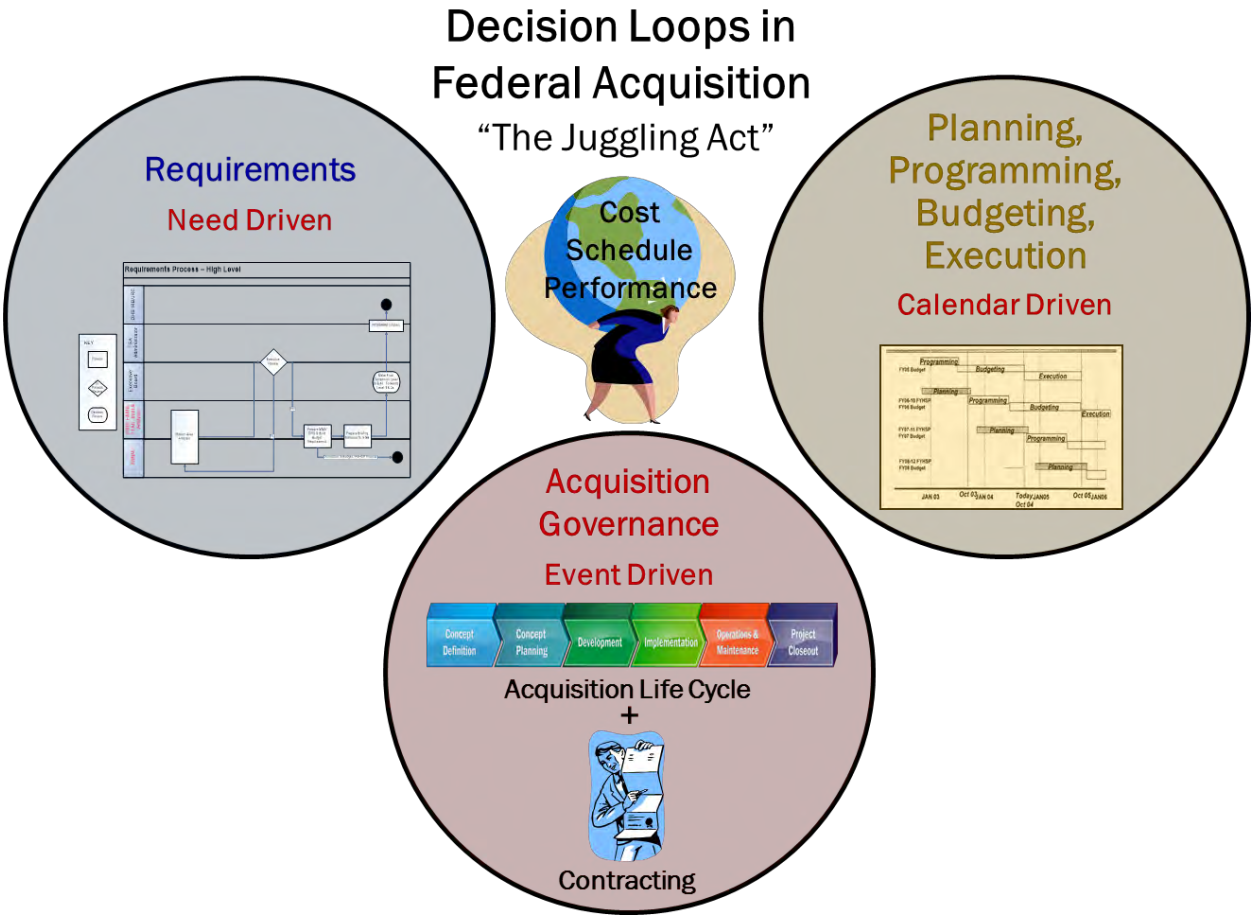
In addition to this guide, the PM can also consult online and resident training through FAI.gov, including:

- FPM 120: Acquisition Fundamentals of Project and Program Management I
- FPM 121: Acquisition Fundamentals of Project and Program Management II
- FAC-COR webpage on FAI.gov
- FAC-P/PM webpage on FAI.gov

A. The Federal Triad

A Project Manager (herein referred to as PM) in the Federal Government must effectively manage three domains to be successful: 1) Requirements; 2) Budgeting and Execution; and 3) Acquisition Governance (these three are often referred to as "Big A"). In the Government, the Federal Triad separates project management and acquisition execution compared to how project management occurs in private industry. It defines the strategic, big-picture approach versus acquisition done solely as a function of the contracting process for specific procurements. In Big A acquisition, the PM must orchestrate and manage all cost, schedule, performance, and project scope risks of a project while simultaneously managing the inputs and outputs of these three strategic decision loops.

Figure 1: The Federal "Triad"



Requirements are driven by acquisition needs. Depending on an agency's core mission and capabilities to perform that mission, agency needs are a reflection of the gaps in those capabilities and are often difficult to forecast. Needs are generated by a myriad of external and internal forces that generate change and affect an agency's ability to contribute to the overall security posture of the United States and well-being of its citizens. New capabilities

are generated out of the necessity to acquire new capital assets and services that make the agency more effective or efficient. Often new capabilities come along to take timely advantage of advances in technology. Typical agency requirements that generate acquisitions include replacement of obsolete or worn-out equipment, upgrades and modification of current assets, countering a threat to National Security, technology advances, industry alignment, workforce demographics, lack of capacity, mission changes, Congressional interest, executive direction, and feedback from customers and users. Of the three decision domains in the Federal Triad, managing requirements is the most dynamic in nature for the PM.

Budgeting and Execution to fund current and future acquisitions are driven by the calendar. All Federal budgets feed into and become part of the President's annual budget submission, which is presented to Congress no later than the first working Monday of February each year. Congress must then pass appropriations or a Continuing Resolution on or before September 30 each year to fund the Federal Government. PMs must not only acquire the funding authority for the project, but they also must keep their budget from being considered for reprogramming to pay for other obligations not associated with the project.

Acquisition Governance is driven by successful completion of acquisition events or milestones. This decision loop includes two processes: (1) compliance with the Federal Acquisition Regulation (FAR) for contracting; and (2) an agency's process, or sometimes the lack of such a process, for managing the project life-cycle. Successful development of a new system and the decision to go into full quantity buys or production, required dates for reports, or a vendor's manufacturing window are all milestone-type events that are decision gates in the acquisition process.

The PM must manage the cost, schedule, and performance risks of the assigned project within the strategic decision environments of the three domains and their competing drivers. Agency requirements are generated when new capabilities are needed or when existing capabilities need to be more efficient, which by chance may or may not coincide with the budget cycle calendar. Further, unplanned agency needs and the budget calendar have no clear linkage to achieving successful events within the governance framework of the FAR and the project life-cycle. The result can be the ultimate juggling act for the PM. This guide provides tools and techniques to help PMs with this dynamic challenge.

This guide is organized around these three domains. Before delving into each domain, the next section establishes a baseline of essential information elements. The guide concludes with best practices and tools to perform various project management tasks and functions.

B. Foundational Information

Project management is an expansive topic. A complete articulation of all aspects and techniques for project management would be voluminous and hard to use. Instead, this section focuses on foundational project management information that any PM should know in order to be successful in the three domains of requirements, budget, and acquisition.

1. Programs vs. Projects

Program and project management are often used interchangeably, and while several aspects of program and project management have similar pathways, they require different people, experience, and processes. At the most basic level, the key difference is in what is being managed: a program or project. Program, project, program manager, and project manager are all defined in the Office of Federal Procurement Policy (OFPP) Memorandum for Federal Acquisition Certifications in Program and Project Management, dated December 16, 2013.

Table 1: Office of Federal Procurement (OFPP) Policy Definitions

Term	Definition
Program	Directed, funded acquisitions that provide new, improved, or continuing systems or services in response to an approved need. Programs are divided into levels established to facilitate decision-making, execution, and compliance with statutory and regulatory requirements and may be composed of multiple projects, services contracts, interagency agreements, and other types of acquisitions. With a systems or services capability focus, programs usually tie together an agency's higher-level programming and budgeting process with the agency's strategic plan.
Project	A planned acquisition undertaking with a definite beginning and clear termination point that produces a defined capability. A project is an individually planned, approved, and managed basic building block related to a program. A project is not constrained to any specific element of the budget structure; however, basic research, maintenance of equipment and facilities, and operations are not considered projects.
Program Manager	The acquisition workforce member with the responsibility and relevant discretional authority who is uniquely empowered to make final scope-of-work, capital investment, and performance acceptability decisions on assigned acquisition programs. The program manager is also responsible for meeting program objectives or production requirements through the acquisition of any mix of in-house, contract, or reimbursable support resources. Program managers are responsible to stakeholders for management and oversight of subordinate projects within the scope of the overall program. The program manager is ultimately responsible for effectively managing all business and technical risks of the program to ensure effective systems and services are delivered to the end user on schedule, within budget, and at the required levels of performance.

Term	Definition
Project Manager	The acquisition workforce member assigned responsibility for accomplishing a specifically designated work effort or group of closely related efforts established to achieve stated or designated objectives, defined tasks, or other units of related acquisition effort on a schedule, within cost constraints, and in support of the program mission or objective. The project manager is responsible for the planning, controlling, and reporting of the project and for the management of required functions, including acquisition planning, definitization of requirements, business case development, performance of the schedule as well as formulation, justification, and execution of the budget. The project manager is responsible for effectively managing project risks to ensure effective systems and services are delivered through a total life-cycle approach to the end user on schedule, within budget, and at the required levels of performance. A program manager may also serve as project manager for projects within the scope of the program.

2. What to Manage

The PM manages a project toward its successful completion, but what exactly does the PM manage?

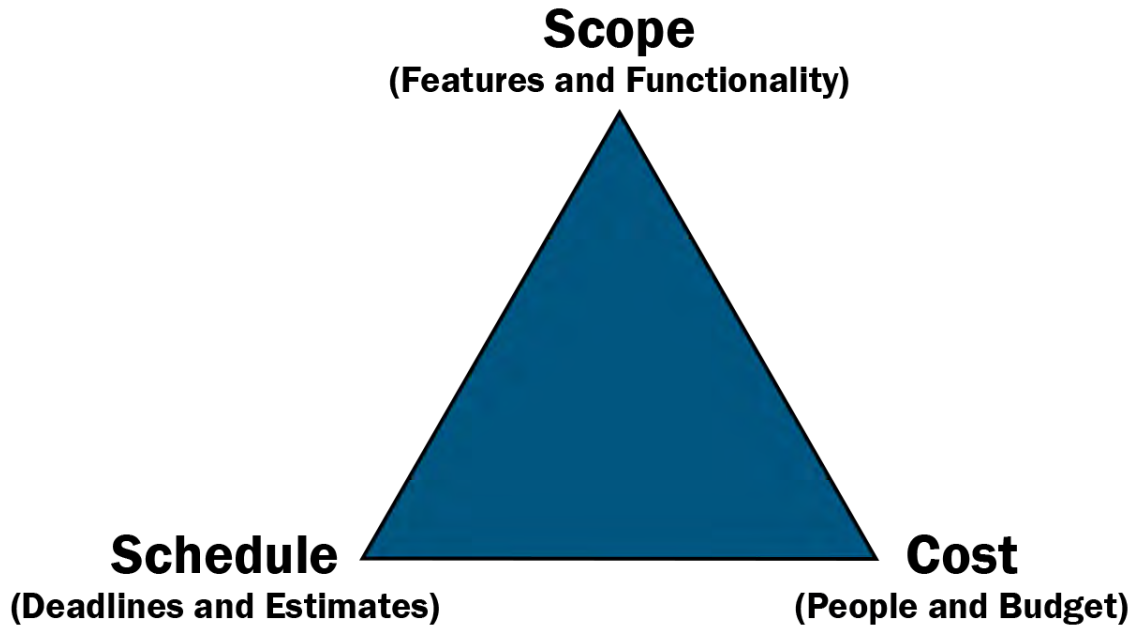
1. **Manage project requirements**. Requirements clearly describe the desired outcome of the project. What must a product do? What specific service must be performed? The PM must facilitate the identification of these requirements and ensure that they are met by the project outcomes.

2. **Manage projects to stay within scope**. The overall scope of a project has two dimensions: (1) Product Scope and (2) Project Scope. Product Scope includes the technical and operational performance requirements and physical attributes of the item or service being acquired. Project Scope includes all of the functional area work that must be completed throughout the total life-cycle of the project.

3. **Manage any change or refinement of project objectives**. During the life of the project, any number of changes may occur. Your agency may have new political leadership or management with a new vision. A public event may change priorities for the agency and the program. The longer the project, the higher the chances of changes external and internal to your project. Managing change also means managing risks since most changes will be generated as a result of external factors.

4. **Manage project constraints.** In project management, the foundational constraints are sometimes referred to as the "Iron Triangle." Within these three constraints, a PM cannot change one constraint without affecting the others. If scope increases, then cost or schedule will also increase. Conversely, if scope remains constant and cost increases, the schedule could fluctuate either way. It's a dynamic that is unique to each project.

Figure 2: The Iron Triangle



Within the bounds of the three constraints are additional management requirements for PMs. Cost, for example, contains resources such as people, budget, and facilities. People resources may be direct employees or personnel assigned partially to the project in a matrix project environment, or they may be contractors. The PM must manage the efforts of the various people resources assigned to the project, including regular meetings and communications to maintain the project's direction and focus. For the budget, the PM must manage cost from an affordability perspective. Within Scope, the PM must manage what the product or service much achieve (features and functionality) and the quality level (utility, affordability, and value) of the product or service required for success. Within Schedule, the PM must manage to when the product or service is needed.

3. Managing and Leading

As a PM, management, communication, and leadership skills are required to ensure the project successfully meets its objectives and requirements. Leadership and management address, from different perspectives, three key aspects of a project:

- Technical requirements
- Constraints
- Team management

A manager's responsibilities focus on implementation and efficiency. This comes in the form of managing requirements through development, implementation, change, and refinement as the project moves through its life-cycle, ensuring that the project solution meets the requirements. It also comes in the form of managing a team and project stakeholders.

Leadership, on the other hand, looks beyond implementation of a project to motivating individual talent to achieve high expectations willingly as well as project teams to tackle project challenges and find opportunities for innovation within the project. Project leaders introduce change and innovation to technical requirements and challenges, and they influence, motivate, and persuade the project team to work toward a common objective through consensus.

Table 2: Key Differences between Managers and Leaders

Manager – "Do Things Right"	Leader – "Do the Right Thing"
● Administer project activities ● Ensure quality ● Regulate and enforce ● Focuses on day-to-day efforts and overall project timelines ● Asks, How? When?	● Develops ideas and innovates ● Provides high-level oversight ● Empowers, motivates, and supports ● Focuses on the long-term ● Asks, Why?

4. Roles

The following roles are common to project teams. Not all roles will appear in every program or project team based on the size and complexity of the project.

Table 3: Key Roles and Responsibilities in Programs and Projects

Roles	Responsibilities
Project Sponsor	Responsible for funding and authorizing the project.
Program Manager	Cross-project oversight to achieve a common programmatic goal; allocates funding and prioritizes projects.
Project Manager	Responsible for the project; authors key project documents, assigns resources, and monitors budget and performance.
Project Team	Executes project tasks through integrated teaming.
Stakeholders	Provides positive or negative feedback on the direction and outcomes of the project.
Contracting Officer	Only person with the authority to commit the Government by awarding funding to contractors; makes any necessary changes to the contract once awarded.
Contracting Officer's Representative	Designated by the Contracting Officer to oversee the performance of the contractor and ensure the Government is receiving products or services as stated in the contract; does not have the power to make changes to the contract.
Business/Financial Manager	Manages the linkages between cost estimates, programming and budgeting, funds execution, and value management.
Technology Manager	Manages the technical management processes, systems engineering, and design related facets of the project.

* See Integrated Project Teams in Section G of this guidebook, Tools for Managing the Project.

5. Relevant Laws and Regulations

A myriad of laws and regulations apply to a Federal PM's day-to-day efforts. While the following list is not extensive, it contains some of the key laws and regulations that apply across programs, specifically with regard to managing Federal programs and the acquisition process. Agency- or subject matter-specific laws, regulations, and policies should be researched and known by PMs to ensure that programs/projects are and remain in compliance.

Table 4: Key Laws and Regulations and High-Level Summaries

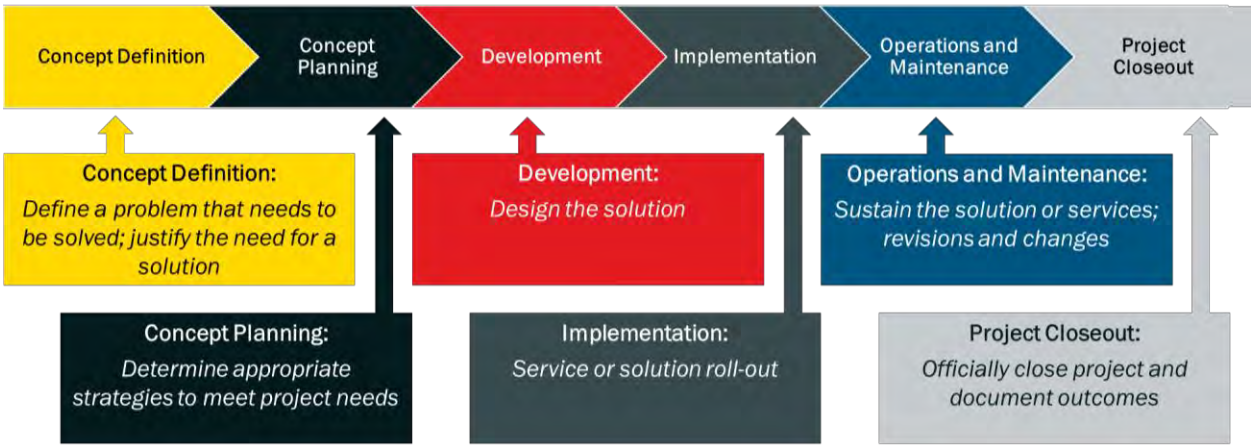
Law/Regulation	High-Level Summary
Acquisition Focused or Related	
Federal Acquisition Regulation (FAR)	Governs Federal acquisition. The FAR is divided into "Parts" on specific topics.
Agency-Specific FAR Supplementals	Provide agency-specific acquisition policies and processes.
Procurement Integrity Act	Places certain restrictions on Federal employees who serve as procurement officials, as defined in the Procurement Integrity Act, when involved in the conduct of a procurement.
Competition in Contracting Act (CICA)	Requires, with limited exceptions, that Contracting Officers promote and provide for full and open competition in soliciting offers and awarding U.S. Government contracts over the simplified acquisition threshold.
Performance of Inherently Governmental and Critical Functions	Guidance on determining which functions must be performed by a government employee versus a contractor.
E.O. 13693: Planning for Federal Sustainability in the Next Decade	This Executive Order mandates Federal executive leadership in energy, environmental water, fleet, buildings, and acquisition management to drive national greenhouse gas reductions and support preparations for the impacts of climate change. Through a combination of more efficient Federal operations, this Order directs reducing agency direct greenhouse gas emissions by at least 40 percent over the next decade while at the same time fostering innovation, reducing spending, and strengthening the communities in which Federal facilities operate.
Budget Focused	
Antideficiency Act	Prohibits Federal employees from making or authorizing an expenditure from, or creating or authorizing an obligation under, any appropriation or fund in excess of the amount available in the appropriation or fund unless authorized by law; prohibits Federal employees from accepting voluntary services and other prohibitions about obligation or authorizing unavailable funds.
Information Technology (IT) Focused	
Federal Information Technology Acquisition Reform Act (FITARA)	Reform initiative implemented in FY2015 to further centralize decision making and oversight of Information Technology (IT) and IT personnel with the Chief Information Officer (CIO).
Clinger-Cohen	1996 law to improve the Federal Government's acquisition of IT, including the creation of the CIO.

Law/Regulation	High-Level Summary
Federal Information Security Management Act (FISMA)	Requires agencies to develop, document, and implement information security for IT assets, including those provided or managed by contractors. The National Institute of Standards and Technology (NIST) is the lead for FISMA standards.
Section 508 of the Rehabilitation Act	Requires Federal agencies to make their electronic and information technology (EIT) accessible to people with disabilities.
Program and Project Focused	
Government Performance Results Act (GPRA) Modernization	Increases accountability for project results by requiring agencies to document their project goals and performance. Each fiscal year, agencies must submit a strategic plan consisting of goals and agency plans to achieve the goals.
OMB Circular A-131, Value Engineering	Guidance to support the sustained use of value engineering by Federal departments and agencies to reduce program and acquisition costs, improve performance, enhance quality, and foster the use of innovation.
OMB Circular A-123, Management's Responsibility for Internal Controls	Provides guidance to Federal managers on improving the accountability and effectiveness of Federal programs and operations by establishing, assessing, correcting, and reporting on internal control.
OMB A-11	Guides budget development for programs and projects. Section 300 requires documentation and justification for certain funding requests over an established threshold, referred to as the Exhibit 300.
Federal Travel Regulation	Governs domestic travel and accommodations for Federal government employees and contractors, including rules on reimbursements.
Federal Advisory Committee Act	Defines how Federally created committees can be established and operated. The law has special emphasis on open meetings, chartering, public involvement, and reporting.
Paperwork Reduction Act	Required Office of Management and Budget (OMB) clearance before using more identical questions to collect information on 10 or more persons who are not Federal government employees.

6. The Project Life-Cycle Model

The process through which a project develops from start to finish is called the project life-cycle. Although project life-cycles vary among Federal agencies, all project life-cycles encompass the facets of the sample six-phase life-cycle model used in this guidebook.

Figure 3: The Six-Phase Project Life-Cycle Model



1. **Concept Definition.** Analyze organizational objectives and identify where gaps in capability exist to meet those objectives.

2. **Concept Planning.** Determine the specific solution and its requirements to meet the objectives of the project, and develop the project plan for the execution of the project work, including schedule, resources, and quality control.

3. **Development.** Follow the project plan to create the product or solution, and evaluate if the outcome meets project objectives and product requirements.

4. **Implementation.** Deploy the fully functional product or service in what is called the rollout or fielding. The rollout pushes the product or service to the end-user.

5. **Operations and Maintenance.** Sustain the product or service through a support system. This is the longest and most costly phase of a project in the long term, making it important that the product or service be cost-effective and meet performance requirements.

6. **Project Closeout.** Project Closeout includes two sets of activities. First, the project team documents against the required deliverables how the project has or has not met the project goals and objectives as well as lessons learned for future programs and projects. Second, the system or item acquired has reached the end of its useful life, and the project team must dispose of it with the least amount of cost and potential impact on the environment.

7. Functional Domains

The following functional domains are common among Federal projects. Domain expertise in the functional domains is typically resident in management staff and technical experts within the agency or its support contractors.

a. Systems Engineering

Systems engineering in project management is more of a disciplined technical management process than actual engineering in the academic context. Systems engineering (SE) is the recognition and application of scientific, management, engineering, and technical skills used in the performance of system planning, research, and development with an emphasis on the technical management process. This includes application of the requirements development process, decision analysis methods, technical assessment, configuration management, and interface management.

SE processes are applied by the project manager and the systems engineer on the project team throughout the project lifecycle to iteratively determine what the solution design or system will be, evaluate the system iteratively as it is developed to meet requirements, and document this iterative development of the system. The end goal is a balanced system design delivered within cost and schedule constraints. Getting to a balanced system design requires making trade-off decisions among technical performance, cost, and schedule constraints. The project SE management approach is often documented in a technology management or SE management plan.

b. Life-Cycle Logistics

Life-cycle logistics involve the early planning, development, implementation, and management of a comprehensive, affordable, and effective performance-driven product-support strategy. It plays a key role during all phases of the life-cycle.

Early in the life-cycle, product support strategies and plans lay out how the product will be supplied and maintained up to and including disposal. Another upfront consideration is to keep supportability in mind during SE to ensure supportability considerations are part of a balanced systems design. “Designing in” supportability during the design of the system will return great benefits in terms of product readiness and reduced operating costs during the operations and support phase of the life-cycle. Finally, during operations and support, executing and adjusting the product-support strategy keeps the product ready for use at the lowest possible cost.

To ensure the end-user can realistically operate and maintain the system, identify product support considerations by answering the following questions:

- How reliable must the system be?
- When the system requires maintenance, how easy to repair, and affordable to repair, must the system be?

Product support refers to the products and services needed to sustain the project solution throughout its life. A Product/Service Support Plan should be developed to document and answer the following questions:

- What products or services are needed to sustain the solution throughout its life?
- Who will be responsible for executing product support tasks?

- How long will the solution be operational and need product support services?
- When will support tasks occur?
- How much will product support services cost?

When possible, the Federal Government prefers commercially available solutions or commercial solutions with minimal customization or configuration to meet agency-specific needs. This approach helps reduce the long-term operations and maintenance costs of a unique system.

c. Manufacturing and Producibility

Producibility refers to how easy a product design is to manufacture, and how easy it is to sustain an effective and affordable rate of manufacture that meets cost and schedule constraints. Manufacturing aspects that constrain system design include:

- The level of complexity the manufacturer's production facilities and processes can accommodate;
- The number of systems or components the manufacturer can produce while maintaining quality; and
- The limitations of current manufacturing techniques and technology.

d. Test and Evaluation

Test and evaluation (T&E) is the application of efficient and cost-effective methods for planning, monitoring, conducting, and evaluating tests, followed by evaluating the test results. This includes system prototypes, new or modified equipment or material, support equipment, and system components. T&E is a primary means of managing and reporting the technical risk of a system and validating system performance through measurable methods that relate directly to requirements and metrics that demonstrate system success or failure.

Depending on the level of technical risk on a project, the project's T&E approach may be documented in a T&E management plan. T&E ensures that the product meets technical and operational requirements. T&E can reveal design, product support, training, and other concerns that can be resolved through systems engineering by changing the solution design accordingly. T&E provides data required to make informed project management decisions, such as impacts on schedule and cost that result from product design changes.

e. Contracting

Contracting encompasses the supervision, leadership, and management processes and procedures involving the procurement of capital assets, supplies, and services, including construction, research and development, and science and engineering technical services as governed by the FAR and associated agency-specific additions to the FAR. Contracting involves acquisition planning to include performance-based considerations; cost and price analysis; solicitation and selection of sources; preparation, negotiation, and award of contracts; all phases of contract administration; termination options and processes for closeout of contracts; and legislation, policies, regulations, methods used, and business and

industry practices. Contracting is covered in detail in the Acquisition Governance, Part 2, section of the guidebook.

f. Business, Cost Estimating, and Financial Management

Business, cost estimation, and financial management is a capstone domain integrating cost estimation and analysis; reconciliation of cost estimating; Government and industry financial planning; formulating financial metrics, reports, and budgets; budget analysis/execution; cost-benefit analysis; Earned Value Management (EVM); business case analysis; and other methods of performance measurement.

g. Leadership

Leadership and professional acumen includes those attributes targeted toward leading and managing a multi-functional project team toward satisfactory achievement of program goals as well as influencing both horizontal and vertical stakeholder relations. Leaders take a long-term view and build a shared vision with others, acting as a catalyst for organizational change. Leaders influence others to translate vision into action and inspire team commitment, spirit, pride, and trust. Leaders develop networks and build alliances while collaborating across boundaries to build strategic relationships and achieve common goals. Leaders foster an inclusive workplace where diversity and individual differences are valued and leveraged to achieve the vision and mission of the organization. Leaders hold themselves and others accountable for measurable high-quality, timely, and cost-effective results. Leadership is covered in more detail in Section G of this guidebook, Tools for Managing the Project.

h. Information Technology

Information Technology (IT) is an increasingly important component of projects. Even if the project is not an IT project, it will likely have some intersection with the agency's software or IT systems. The Chief Information Officer (CIO), a role created by the Clinger-Cohen Act, and strengthened by the passage of FITARA, has oversight over Federal agency IT investments. Citizen-centric and secure IT are dominant initiatives within the Federal space.

IT investments must clearly demonstrate that the investment is needed to help meet the agency's strategic goals and mission. The agency must demonstrate how the investment supports a business line or enterprise service performance goal as documented in the agency's Enterprise Architecture and annual Enterprise Roadmap submission to OMB. Agency IT investment business cases (and other documents), the IT Capital Asset Summary (Exhibit 300A), and Agency IT Investment Portfolio (Exhibit 53A) must demonstrate the agency's management of IT investments and how governance processes are used to plan, select, develop, implement, and operate IT investments.

Agencies are required to submit Exhibit 53A and Exhibit 300A submissions to OMB, and are used by OMB to create an overall "Federal IT Investment Portfolio," which is published as part of the President's Budget. Agency and OMB portfolio reviews and budget processes will ensure the selection of IT investments that support the agency's strategic goals, as captured

in the agency's High Priority Performance Goals and Strategic Plan. The PM may be responsible for completing or for assisting the CIO's office with the completion of the OMB-300A and 53A reports which are required for all IT investments. Please see OMB's Guidance on Exhibits 53 and 300 for more information about reporting.

C. Requirements Development

Government Accountability Office (GAO) and Inspector General (IG) reports are consistent in their findings of Federal programs: requirements are too often not properly assessed, captured, and conveyed, leading to program challenges and failures as the result of increased cost, schedule, and performance risks. This section focuses on requirements development for the project and how PMs can plan and initiate efforts to develop thorough and accurate requirements.

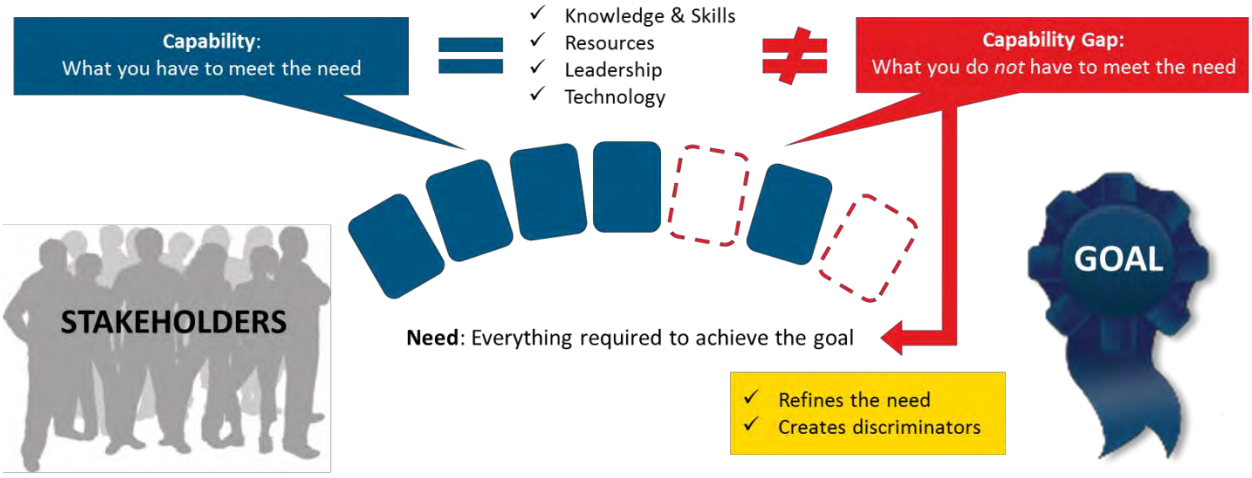
1. Requirements Start with Strategic Planning

The Government Performance and Results Act (GPRA) of 1993 and its update, the GPRA Modernization Act of 2010, requires each Federal agency to do strategic planning and provide to Congress and the general public their published Strategic Plans each year. During this continuous planning process, agencies review their specific missions, goals, and objectives and compare these planning tenets with their current capabilities to execute their strategic plans. When agencies discover deficiencies or the inability to perform their agency mission with the capabilities they have at hand, the agency has a capability gap in their ability to perform the mission or achieve their goals. Capability gaps lead to agency needs, and filling those needs results in developing requirements, exploring concepts, and selecting a solution.

Capability gaps and needs arise from a myriad of sources, including:

- Threats to National Security
- Changes in operational doctrine or procedures
- Industry practices
- Workforce demographics
- Lack of operational capacity
- Changes in agency mission, structure, or leadership
- Stakeholder interests
- New technology
- Obsolete systems
- Worn-out equipment
- Customer and end-user demands
- Executive direction
- Congressional interests
- Training deficiencies

Figure 4: Capability Gap



a. Bottom Up, Top Down, or External Goals

Stakeholders are groups or individuals who exert influence over the project, or whose interests may be positively or negatively affected by the project. These affected interests include how their organization's functions change as a result of the project, the effect of the project on their goals and objectives, and the allocation of their resources. The need bridges the separation between stakeholders and the goal by framing the interests and resources of stakeholders into an approach for achieving the strategic goal.

Different goals originate from either senior leadership, middle management, front-line personnel who perform an organization's day-to-day processes, and external stakeholders or customers, such as Congress. Needs driven from the top down include senior leadership goals, which often result from trying to implement a strategic mission or objective. This kind of need filters from the top of an organization down to the individuals who must support achieving the strategic mission or objective. Middle management goals often result from trying to resolve an inability to manage and execute effectively, due either to a lack of information or insufficient resources. Front-line personnel goals often result from trying to correct a flawed or obsolete process, function, or system currently in use.

Middle management and front-line personnel goals filter from the bottom of an organization up to the individuals with the authority to decide on pursuing those goals and objectives. Goals driven by external stakeholders often result from customer demands or legislation and policy. External stakeholder goals can affect an organization at different levels, and consequently they can filter from the top of an organization down, or from the bottom of an organization up.

b. Material or Non-Material Solutions

Solutions that address capability gaps and meet an agency's needs are expressed as either material or non-material. Material in this context is defined as the aggregate of things used

or needed in any business, undertaking, or operation (distinguished from *personnel*). A material solution fills a capability gap with new systems or assets, resulting in the requirement to procure durable assets of both IT and non-IT type equipment items, hardware, software, facilities, some types of services, and other capital assets. A non-material solution fills a capability gap through update or modification of agency operating procedures, personnel changes, training, organizational structure, or leadership. A non-material solution usually does not result in procuring a durable material asset but could result in buying a service, such as a new training program for employees.

Filling capability gaps with non-material solutions is usually less expensive in terms of funds and other resources when compared with procuring new material. Material needs eventually lead to developing requirements, which in turn initiates projects requiring life-cycle management. Project managers should understand how their agencies go from strategic planning to identifying capability gaps and needs to high-level requirements to concept development and then finally to a specific solution's performance requirements. Understanding this cycle of requirements development gives the PM insight into an organization's culture and preference toward material or non-material solutions to fill its capability gaps.

2. Gap Determination and Prioritization

Determine the purpose and goal of the program or project by first starting with the need.

a. Identify the Need

Table 5: Questions and Guidance for Identifying the Need

Initial Questions	Guidance
What is the need?	Define a problem statement.
What will the program accomplish?	Define the purpose of the program in relation to addressing the problem statement.
How does the program align with the agency's mission?	For organizational alignment within an agency and for future funding reasons, it is important to connect the program to the overarching agency mission.
Who does the program serve?	Determine if the program is serving an internal agency function or is delivering value to a customer or end user.
Who are the stakeholders for the program?	Stakeholders may be leadership, middle management, frontline personnel, or external stakeholders or end users. Identifying stakeholders upfront will aid in communications and may identify sources for developing detailed requirements.
What does success look like?	"Begin with the end in mind." —Stephen Covey, *Seven Habits of Highly Effective People*
What resources do I have to accomplish the program?	Determine what Government employees must complete based on the types and sensitivities of the efforts. Assess the capability and capacity of staff from the offices managing the program.

Initial Questions	Guidance
Do I need to supplement those resources?	Determine if a contract, grant, cooperative agreement, or other mechanism is needed to leverage non-Government resources.

b. Identifying and Prioritizing Capability Gaps

Capability gaps are the missing knowledge and skills, resources, or leadership stakeholders must obtain to meet their needs and achieve their goals. Capability gaps can occur at any level of an organization. At the senior leadership level, capability gaps can exist as a result of an organization's policy, leadership deficiency, or philosophy and culture. At the middle management level, capability gaps can exist in business processes that govern production, communication, tracking, and documentation functions. At this level, capability gaps can also relate to human performance, such as insufficient training and education or ineffective process implementation when a process is poorly designed.

Capability gaps related to human performance can also exist at the front-line personnel level because of ineffective process implementation when a well-designed process is performed poorly. These gaps can also exist because of individuals who create capability gaps when their attitude or commitment level does not align with the organization's culture. Capability gaps related to underperforming or obsolete equipment or interface features are also most likely to exist at the front-line personnel level. Capability gaps can also exist when an organization fails to meet requirements from external stakeholders, such as an Executive Order mandating the implementation of cloud computing strategies. Other important external stakeholders garnering recent attention as a result of past government and commercial data breaches include cybersecurity, physical security, privacy and identity theft. PMs should constantly survey the obvious as well as the not so obvious environments and enterprises to ensure that the interests of important external stakeholders are not overlooked.

To make informed evaluations of potential concepts (and eventually solutions), you must first understand a capability gap's cause. Knowing the cause refines the need and helps discriminate between concept options, which helps you select the most suitable one. You can approach identifying and evaluating capability gaps from two perspectives: external and internal.

From the external perspective, you identify both the problem and the likely solution by comparing your organization against other agency and industry best practices. The project team can research best practices employed by other agencies or in industry to identify what your organization should be doing (but isn't) to achieve its desired level of performance. This is called benchmarking. Then, you analyze your organization's business rules to identify changes in its goals and policies that need to be made to reorient the organization for improved performance. After that, you deconstruct (i.e., break down) those new or changed goals and policies into actionable and measureable objectives and begin working toward them.

From the internal approach, you assemble a team (i.e., a focus group) of personnel from various levels and functional groups in the organization who offer informed perspectives on the capability gap. This team steps through the typical problem-solving process. First, they brainstorm to identify the problem. Then, they perform root cause analyses to determine the underlying source, or cause, of the problem. Next, using their varied experience and perspectives, they assess the impact on the organization. Finally, the team brainstorms to generate potential solutions. They can refine their impact assessment after they select a specific solution.

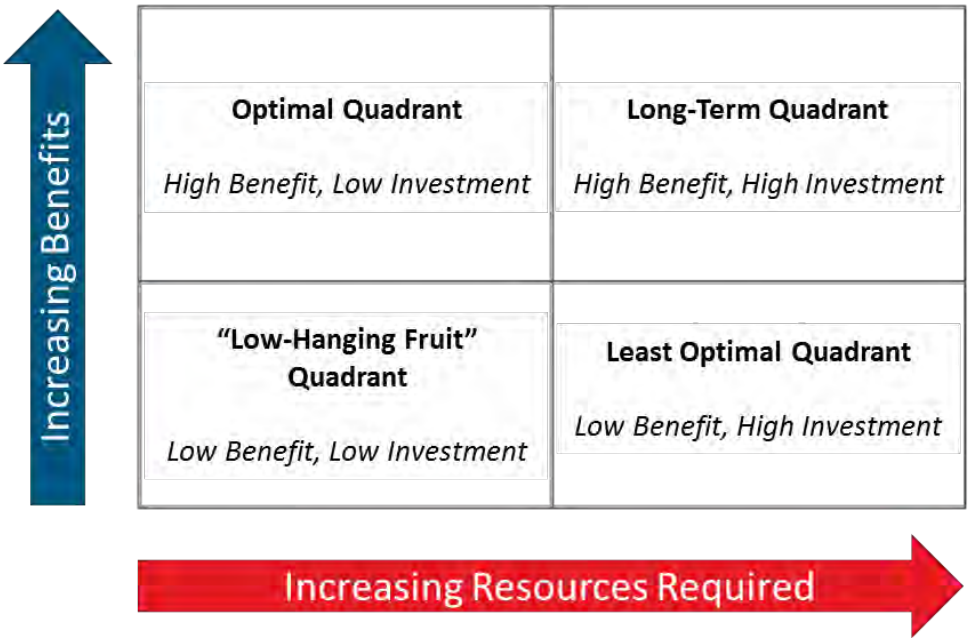
After you identify capability gaps and their causes, you assess and prioritize them. To do this, you evaluate each one to determine the impact on your organization of addressing it or failing to address it. Assessing the problem's impact on the organization identifies who is negatively impacted by the problem; who has the authority to implement a solution; and what failing to solve the problem is currently costing the organization in terms of time, resources, money, and intangible things such as reputation. While the exact solution isn't known yet, you can still estimate general elements about the impact of developing and implementing it. Assessing the solution's impact on the organization identifies where the resources for developing the solution will come from; which personnel are affected by developing the solution and which by implementing the solution; and, finally, the benefit to the organization of implementing a solution in terms of increased efficiency, reduced resource and budget usage, and improved intangibles such as reputation.

c. Prioritize

Using the identified gaps, begin prioritizing what the program and agency need. Evaluating the time, resources, money, and intangible things such as reputation, costs, and risks is one method for prioritization. Using the gain from the investment minus the cost of the investment divided by the cost of the investment produces a Return on Investment (ROI) metric.

In addition to the calculated ROI, the PM can apply the ROI philosophy as part of brainstorming by plotting investments versus benefits on a graph. Actions within the top left quadrant are prioritized as "low-hanging fruit," and longer-term plans are developed to address actions within the top right quadrant.

Figure 5: Prioritizing "Low-Hanging Fruit" Actions

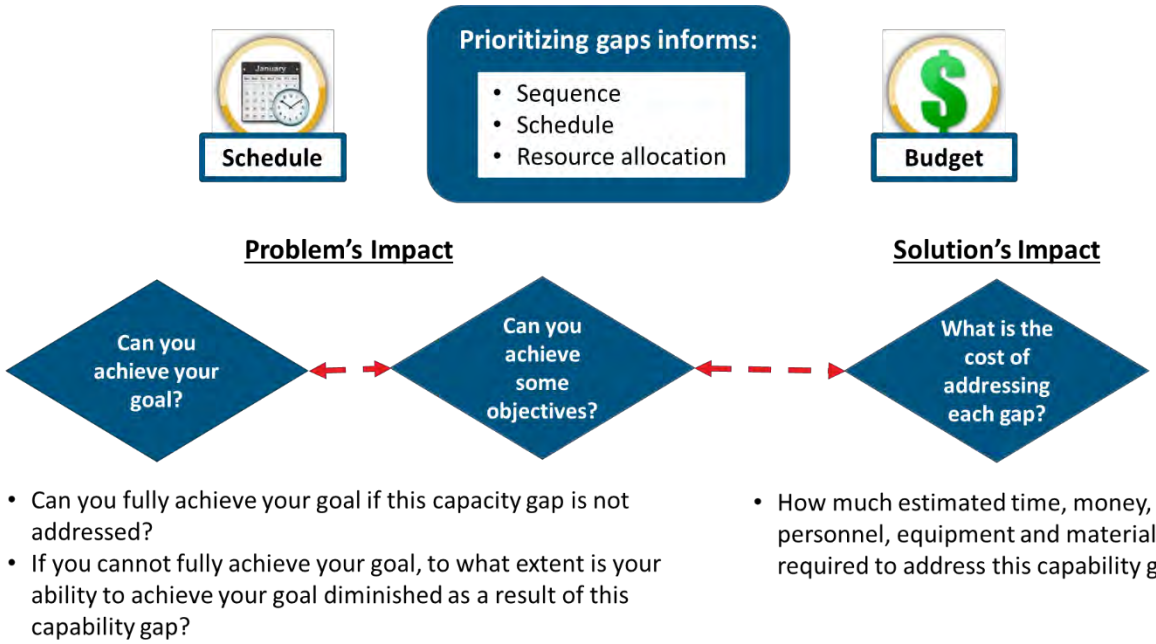


In Agile development, discussed later in Section E.3, this type of continuous prioritization and regular reevaluation occurs to ensure that software or product development continues to address end user needs and adapts to changing conditions.

Prioritizing capability gaps guides the sequence in which your project addresses gaps, the timeframe in which gaps must be addressed, and how your project allocates resources. Assessing the impact of capability gaps gives you the information you need to prioritize them. Prioritizing capability gaps involves answering three questions about each gap. The first two questions rely on information about the problem's impact:

- **First**, can you fully achieve your goal if this capability gap is not addressed? Capability gaps that negatively affect the organization's ability to achieve its goal are higher priority than those that do not affect achieving the goal.
- **Second**, if you cannot fully achieve your goal, to what extent is your ability to achieve your goal diminished as a result of this capability gap? Capability gaps with a more significant negative impact on your ability to achieve your goal are higher priority than gaps with a lesser impact.
- The **third** question relies on information about the solution's impact: How much estimated time, money, personnel, and equipment and materials are required to address this capability gap? Gaps that require less money, time, and resources to address are likely to be addressed sooner than gaps that require more funding and take longer to address. That decision, however, is based on several factors. It is based on the amount of funding and resources required, how and when those funds and resources must be obtained, and the strategic value placed on the capability by the organization's leadership.

Figure 6: Prioritizing Capability Gaps



3. High-Level Requirements

Requirements describe the knowledge, resources, processes, or skills necessary to address a capability gap. Requirements can be developed from either the stakeholder's perspective when they describe what the stakeholder needs or the solution's perspective when they describe a function any potential solution must perform. Once you have identified your goal, determined your capability gaps, and defined your needs, you must establish high-level requirements. High-level requirements differ from more detailed requirements in that they are more general, affecting a broader range of stakeholder interests and possible concepts that lead to a solution to fill the capability gap.

To draft high-level requirements, examine the causes of your capability gap and then write a general statement of how to mitigate each cause. Next, you examine high-level constraints that any concept addressing your gap must comply with, such as those imposed by interface compatibility or security requirements, resource limitations, the operational environment in which the concept resides, or other stakeholder dynamics. Then, write a general statement describing how the concept must comply with the constraint. Finally, you examine the desired outcome of your project if the gap is addressed and then write a general statement describing that outcome.

When writing high-level requirements, it is important to avoid detailing a specific solution. Explain what attributes are needed to address the gap, not the exact method for obtaining those attributes. Processes and technology change, so don't limit options by specifying a particular technology or process in your high-level requirements. While you may be able to quantify your desired outcome, don't assume only one path for achieving that outcome.

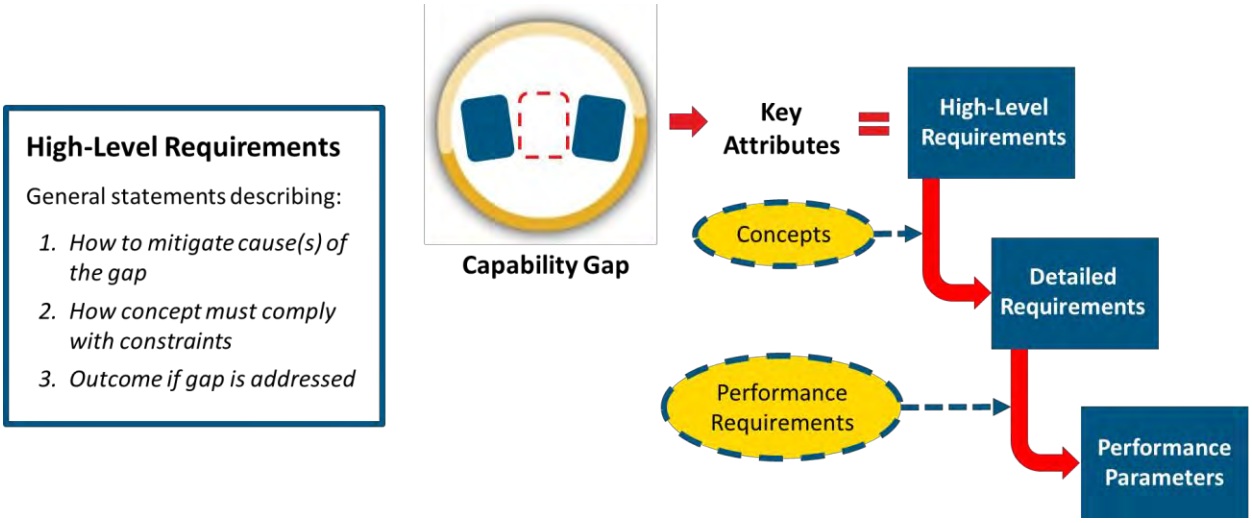
Requirements develop iteratively throughout the life-cycle of a project, as you refine them from general to specific. In the Concept Definition phase, you determine key attributes that describe what is necessary to address the capability gaps you identified. These attributes establish high-level requirements. High-level requirements established in the Concept Definition phase are broken down, or decomposed, into more detailed requirements in the Concept Planning phase. These more detailed requirements include performance parameters that are used to assess the project and the solution during the Development and Implementation phases.

Since requirements develop iteratively from broad, high-level requirements to more detailed requirements and specific performance parameters, it is critical to begin with good, well-defined high-level requirements. As is often the case with iterative development, a small error made in the beginning can grow to a larger, more costly error in the future as iterations occur. There are several reasons why requirements fail to properly guide solution development, resulting in a failed project:

- If requirements do not capture stakeholder input, the project could progress to completion but never address its intended need.
- Requirements that change frequently usually indicate that stakeholders do not know exactly what they need in a capability.
- If requirements are poorly managed, frequently changing requirements may be addressed badly or not be addressed at all.
- If requirements are written vaguely or incompletely, they are likely to be misunderstood and result in an ineffectual solution.

Poorly written requirements, or poor management of frequently changing requirements, are the primary causes of project failure. Projects that use poor requirements may be cancelled before they are begun, exceed budget, fail to deliver on schedule, or fail to deliver a solution that meets with stakeholder satisfaction. Using clear, accurate, and complete requirements, the PM can develop an appropriate solution that results in a successful project.

Figure 7: Requirements



4. Selecting Concepts

Now that you have high-level requirements, you need to select a concept that meets, or has the potential to meet, those requirements. A concept is an explicit assembly of the ideas or operational architecture needed to understand what a system, product, or component is, what it does, how it might address specific mission objectives, and how it is best used. Concept development includes considerations for both material and non-material approaches to filling a capability gap.

A concept may provide an early design idea for stakeholders to assess technical, cost, and schedule needs. Concepts reflect a shared point of view among key stakeholders, conveying a clear description or model of the characteristics or attributes needed to address a specific set of requirements or capabilities. To select a suitable concept, you must identify potential concepts, evaluate them, and choose the most suitable one. That is where market research comes in.

a. Market Research

Market research is collecting relevant information about potential concepts. You conduct market research to identify the different potential concepts, such as purchasing a product or service or implementing a best practice. You also conduct market research to assess the ability of each concept to meet high-level requirements within schedule and budget constraints. Using market research, you evaluate an industry's stability, which is its ability to provide the assets and resources required to develop and maintain the concept.

Conducting market research helps you determine the availability of products, services, or processes that could address a capability gap. Market research also helps you identify manufacturers and providers of available products, services, or processes. Information collected through market research informs your cost estimate for obtaining products or

services or implementing best practices. Additionally, you may identify required characteristics of products, services, or processes that weren't apparent to you from assessing the capability gap. By gathering critical information about your concept options through market research, you can make an informed selection of the most appropriate concept to address a capability gap.

b. Strategic and Tactical Market Research

There are two approaches for conducting market research, each with unique purposes and outcomes: strategic and tactical.

In **strategic market research or market intelligence**, you look at the big picture by performing all the activities necessary to maintain expertise about a product or industry. You continuously evaluate the current marketplace, identify future markets, research technology trends, identify best practices, identify training needs, and research new or changed legal requirements. Strategic market research helps you write better requirements by providing specific data on what is available in the marketplace. It also helps you decide on the best methods for evaluating the performance of a concept against its requirements.

In **tactical market research**, you look at a specific project need and collect information about available resources, supplies, and services that could meet your current requirement. Tactical market research helps determine whether you must design and manufacture custom items to fulfill the requirement or if commercial off-the-shelf (COTS) items exist that could fulfill the requirement. You should also consider, based on your market research, whether you could reasonably modify the requirement to allow for use of COTS items. Alternatively, you should consider whether you can modify the current system, item, or service instead of obtaining a new one. Additionally, tactical market research helps identify small businesses that could fulfill the requirements.

FAR part 10.002(b)(2) outlines procedures for conducting market research. You can gain reliable information by consulting knowledgeable individuals in Government and commercial industries. You may also obtain reliable information by reviewing various approved sources of information. Source lists of similar items, from other Government agencies that use contractors or from trade associations, are approved sources of information. Catalogs and product literature available from manufacturers, distributors, and dealers are also approved sources of information.

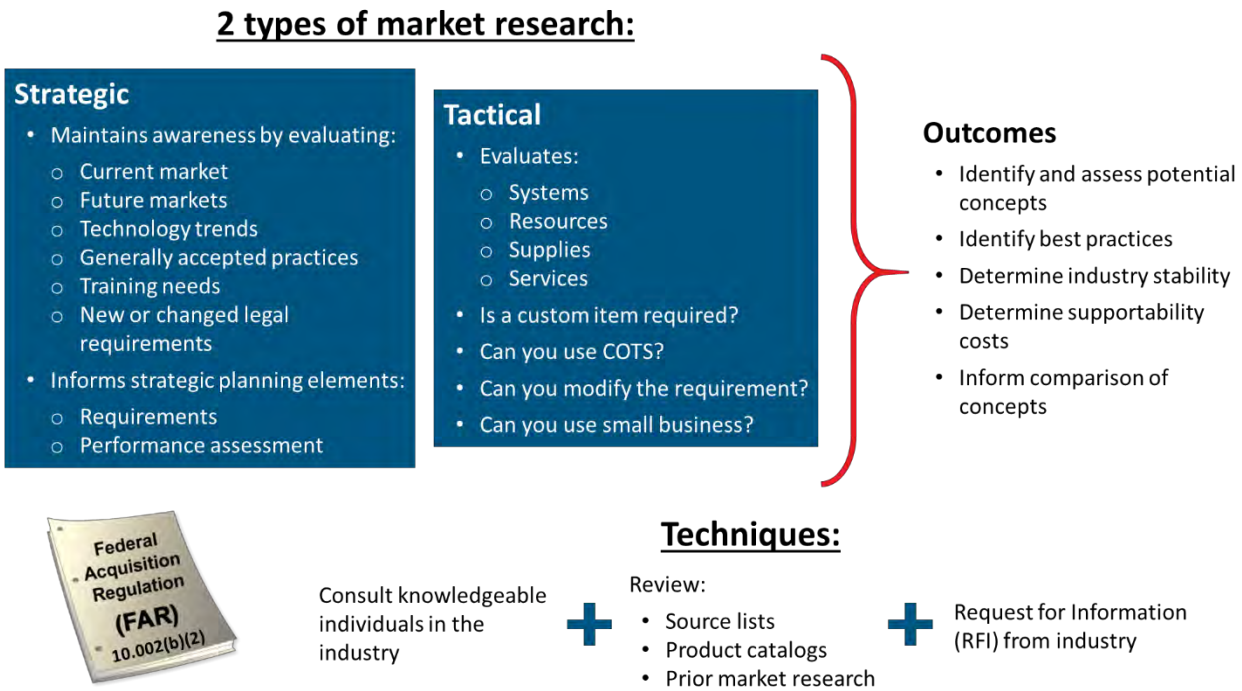
Prior to issuance of the solicitation, government officials – including the PM, end users, or contracting officers – may meet with potential offerors to exchange general information and conduct market research related to an acquisition. There is no requirement that the meetings include all possible offerors, nor is there a prohibition on one-on-one meetings. One-on-one meetings typically are preferred by offerors, so as to not reveal strategies to their competitors. One-on-one meetings should be planned in accordance with agency resources and timelines.

Any information that is shared in a meeting that could directly affect proposal preparation must be shared in a timely manner with all potential offerors to avoid providing any offeror

with an unfair advantage (FAR 15.201(f)). This is because the FAR prohibits preferential treatment of one vendor over another. Where vendor interaction is expected to include contract terms and conditions, any one-on-one meetings should include, or at least be coordinated with, the Contracting Officer. After the solicitation is issued, the Contracting Officer becomes the focal point for these exchanges. At this point, if an organization contacts the PM with a question or seeking information, the request should be sent directly to the Contracting Officer for communication.

Recent market research from another but similar Government acquisition is yet another approved source of information. If you aren't aware of a similar acquisition, you can run a query in the Government-wide database of contracts. Finally, you can post a formal request for information (RFI). An RFI may be posted in Government publications such as the Federal Business Opportunities (FedBizOpps) website, or your agency's website. An RFI may also be posted in commercial or trade publications such as the *Wall Street Journal*, *Business Week*, various technology journals, or project management publications.

Figure 8: Market Research



c. Evaluating Concepts

Once you establish high-level requirements and research the marketplace for concept options of how a given capability gap can be addressed, you need to evaluate those options and select the most appropriate one. Determining the best concept for addressing your capability gap involves considering a few questions: Does this type of concept address the problem? Why or why not? Is this type of concept optimal from a budgetary and scheduling

perspective? Why or why not? Does this type of concept align with organizational philosophy and strategic goals? Why or why not? To help answer these questions, you evaluate a potential concept based on three primary factors.

1. **Performance Measurement**. Performance measurement evaluates whether the concept can address the gap—or perform—and whether its ability to address the gap can be quantified (i.e., measured). A viable concept option should provide a capability that directly supports addressing the problem as it has been defined. For example, if your problem is not being able to print in color because your copiers cannot process colored ink, then hiring new personnel is probably not a viable concept option. A viable concept alternative should provide measurable performance. To be measureable, a concept's performance must be quantifiable as a magnitude of a unit of measure; in other words, you should be able to describe a concept's performance as how much of what is required to fulfill a needed function or attribute. When a concept is measurable, it allows you to assess whether the concept correctly performs the function it is required to perform and how well the concept performs that function.

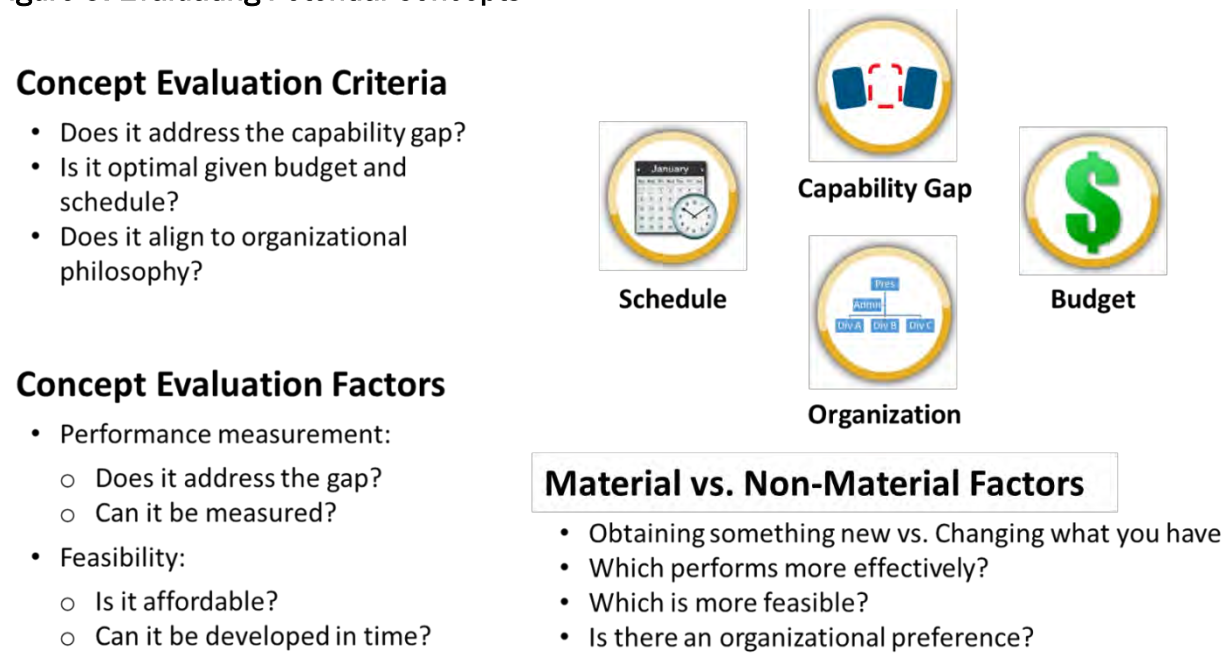
2. **Feasibility**. Can the concept address the gap at an acceptable cost given your organization's ability to secure appropriate funding, and can the concept address the gap on an acceptable schedule given the urgency of your organization's need? Given enough time and resources, it may be possible to keep modifying a concept so it meets some or all of the project objectives. Projects, however, have a definitive schedule and budget. Part of evaluating a concept is assessing feasibility. You assess feasibility by determining whether a given concept, and any solutions that can be developed from it, will satisfactorily achieve requirements within the project's schedule and budget constraints.

3. **Material or Non-Material**. Material concepts involve acquiring a new asset or service, while non-material concepts involve making changes to the organization that do not require obtaining a new asset or service. When comparing material concepts with non-material ones, you should consider how well each kind of concept addresses the capability gap, whether one is more feasible than the other, and how well each kind of concept aligns with your organization's philosophy. When deciding whether a concept has the potential to effectively address your capability gap, is feasible, and aligns with your organization's philosophy, you must consider whether the solutions developed under that concept would be material or non-material.

   Recall that material solutions involve acquiring a new asset or service or improving an existing asset's capabilities. Material solutions may include aspects that are non-material, such as training on how to operate a new or improved asset, but because a new or improved asset or service had to be acquired to implement the solution, the solution is considered material. Material solutions include hardware, software systems, information technology systems, communications systems, supplies and equipment, and facilities.

Conversely, non-material solutions do not involve acquiring physical assets. Instead, they involve making changes to how an organization approaches a given situation to address a capability gap. Possible areas of change when implementing a non-material solution include policy and organizational culture, training, leadership, staffing, and business processes. Your organization may prefer non-material solutions because it is not equipped to implement and support material solutions. Non-material solutions are usually less expensive than material solutions. Conversely, your organizational culture may prefer the measurability of material solutions as opposed to non-material solutions. Or, your organization may have a policy in place that eliminates a potential concept; for example, a hiring freeze would make increasing personnel an unsuitable concept.

Figure 9: Evaluating Potential Concepts



d. Analysis of Alternatives of Concepts

By determining where to find information about potential concepts (market research) and what criteria (performance, feasibility, material/non-material) are used to evaluate potential concept options, the next step is figuring out how to use those criteria. To make an informed decision about which concept is best, you perform an analysis that compares concept options. This comparison is called an Analysis of Alternatives (AoA). The AoA evaluates potential concepts, called alternatives, using a consistent process and a consistent set of criteria. In an AoA, you first refine your potential concept options by eliminating wholly unsuitable alternatives and then discriminate among the remaining alternatives.

The AoA starts off by comparing concepts against elimination criteria. First, determine how well each concept could address the capability gap. Eliminate alternatives that cannot perform as required to achieve the end result. Then, evaluate the cost and benefits of each

concept. Eliminate alternatives that cannot satisfactorily achieve the end result at a reasonable cost. Next, assess the estimated resources and schedule required for each concept. Eliminate alternatives that require too many resources or too much time to achieve the end result. Compare the remaining alternatives with one another using discrimination criteria to determine the most appropriate one. Some discriminators include organizational culture, obtaining the right level of performance to meet your need (neither under-performing nor over-performing at excessive cost and risk), complexity in technology, degree of variability in estimating costs, and uncertainty in creating a preliminary schedule.

When a concept is selected that has high potential for filling the capability gap, the organization begins developing a "concept of operations," sometimes abbreviated CONOPS. Development of the CONOPS is iterative through Concept Development when a material solution is selected to fill the organization's capability gap. The CONOPS is a user-oriented document that describes the characteristics for a proposed material solution or system from a user's perspective. A CONOPS also describes the user organization, mission, and objectives from an integrated systems point of view and is used to communicate overall quantitative and qualitative system characteristics to stakeholders.

Further, the CONOPS describes the proposed system in terms of the user needs it will fulfill, its relationship to existing systems or procedures, and the ways it will be used. CONOPS can be tailored for many purposes, such as obtaining consensus among the project team, developers, sponsors, and user agencies on the operational concept of a proposed system. Additionally, a CONOPS may focus on communicating the user's needs to the developer.

Figure 10: Analysis of Alternatives (AoA)

Analysis of Alternatives

- Evaluates alternatives consistently

Best Practices

- Use structured process
- Focus on current need
- Give objective and equal consideration
- Document decisions and rationale

Elimination Criteria

- Compare against **requirements**:
  - Effectively address capability gap?
  - Benefit worth the cost?
  - Reasonable development resources and schedule?

Discrimination Criteria

- Compare against other **concepts**:
  - Most appropriate?
    - Organizational culture
    - Appropriate level of performance
    - Risk

e. The Business Case

In order to gain stakeholder approval and initiate a project, the PM or end-user representative provides decision makers with a description of the need and related capability gaps, benefits of addressing those capability gaps and meeting the need,

estimated cost of the project, selected concept (or selected solution), and feasibility in terms of schedule and personnel requirements. All this information, including the AoA process and resulting rationale for undertaking the project, is documented in a business case.

The business case is a logical intersecting point between all three of the decision loops within the Federal Triad: Requirements Development, Budgeting, and Governance. Depending on the strategic goal, need, and capability gap, if the concept alternatives and perceived solution reveal that a material solution is required to meet the need, this decision drives the type of life-cycle approach required (either developmental or commercial buy). If a developmental life-cycle is used, the PM may need to prepare two business cases, one for selecting the concept and another business case (or an update to the concept business case) for selecting the solution. If a commercial buy life-cycle approach is required, it's likely that a single business case is required for selecting a material solution.

When the business case is prepared and presented to senior stakeholders and the decision is made to proceed with the project, this denotes formal project initiation in the overall acquisition process. When a project is formally initiated, stakeholders or sponsors provide funding (budget authority), personnel authorization, and other resources required on the project along with entrance and exit criteria for the next life-cycle phase. Additionally, if a PM has not been formally selected to lead the project, the selection is made at this project initiation milestone.

Since approval of the business case initiates a project, development of the business case is presented in more detail in the section on Governance.

5. Performance Requirements

After identifying the organization's capability gaps and developing the high-level requirements and concepts that address those gaps, the last step in requirements development is to deconstruct the high-level requirements of the viable alternatives as revealed in the AoA of those concepts. Deconstructing high-level requirements into performance requirements is a key step when concept development points toward selecting a material solution to meet the need.

a. Types of Requirements

All requirements describe the desired outcome needed to achieve a goal, but different types of requirements describe outcomes in different ways. A requirement can be functional, non-functional, or product- or project-wide.

Functional requirements, sometimes referred to as performance parameters, describe the functions the solution must perform. If a requirement describes an activity, such as detect, transmit, or decode, it is functional.

Non-functional requirements, also referred to as attributes or simply physical requirements, describe properties or qualities the solution must possess, such as maximum weight or size. If a requirement describes appearance, dimensions, or usability, it is non-functional.

Typically, non-functional requirements describe aspects related to functionality that are just as important as functional requirements.

Product or project requirements are global constraints that apply to the entire solution or project life-cycle, such as "solution will have no environmental impact." If a requirement describes a function needed to satisfy a formal mandate or outlines a constraint that applies to the whole project or entire solution, it is a product or project requirement. Typically, product or project requirements assess how well functional or non-functional requirements comply with product or project constraints.

b. Performance-Based Requirements

No matter which of the three types your requirement may be, it will be most effective if it is a performance-based requirement. A performance-based requirement describes the desired outcome that will result from meeting the requirement. Performance-based requirements allow developers to generate innovative, cost-effective solutions that produce the desired outcome.

Unfortunately, people often write requirements that are not performance-based because it takes more effort to write a good performance-based requirement. A non-performance-based requirement describes a specific method for obtaining the desired outcome. When requirements state that an outcome must be obtained using a specific approach, they prevent the developer from exploring alternative ways to achieve the outcome.

Figure 11: Performance-Based Requirements

c. Progressive Elaboration

Requirements are refined through progressive elaboration. Progressive elaboration is refining requirements based on new information and as more information becomes available. Requirements development is an iterative process in which the general, high-level requirements you established in the Concept Definition phase are refined or elaborated upon in the Concept Planning phase to establish detailed requirements when more specific information becomes available. Requirements are refined when they are deconstructed, resulting in tiers or subordinate levels of requirements.

d. Deconstructing Requirements

Deconstruction begins with breaking a high-level requirement down into supporting detailed requirements. The relationships between higher-level requirements and their supporting requirements are often referred to as "parent-child" relationships, so called because when the higher-level requirement is deconstructed, it acts as the "parent" from which supporting requirements are established, which are its "children." Deconstruction continues by breaking down detailed requirements into simple, discrete requirements that cannot be deconstructed any further. These derived requirements provide a basis for comparing solution alternatives.

To deconstruct a higher-level "parent" requirement, you first analyze the constraints and risks associated with that requirement. Next, modify the requirement to comply with constraints, mitigate any identified risks, and identify the conditions necessary to achieve the requirement's outcome. Then, derive a detailed "child" requirement by describing what is necessary to achieve a condition in support of the higher-level "parent" requirement.

Finally, you prioritize all requirements according to the value each one delivers if it is met. Value can be measured as either how essential meeting the requirement is to addressing the need or the importance stakeholders place on meeting the requirement, regardless of its impact on addressing the need.

e. Requirements Management

A successful project results in a solution that meets the need. Requirements describe what is necessary to meet the need. If your requirements fail to accurately describe the need, the solution developed to meet those inaccurate requirements will be ineffective or inappropriate and will not meet your stakeholders' expectations. Because requirements have such a direct impact on the success of your project, it is essential that you manage them well throughout the life of your project.

Deconstruction creates the need to manage requirements because it involves refining existing requirements or deriving new, detailed requirements. For example, the PM might change an unrealistic requirement to reflect an outcome that involves less risk to achieve or deconstruct a requirement into two new, simpler requirements. Changed and newly-derived requirements require close management to ensure they capture stakeholder input and user needs; are accurate, complete, and clearly understood; and can be traced back to the goal they support, the source that established them, and the rationale for any changes made to them.

The process for managing requirements is essentially version control and is performed every time you deconstruct a requirement. Requirements management is an iterative process and conducted in all phases of the project life-cycle. The steps taken in requirements management are tailored to the project phase in which they apply. Requirements management involves four steps:

- **First**, discover what attributes the solution must have to address a capability gap and meet the need.
- **Then**, document descriptions of these attributes in clear, concise language as detailed requirements.
- **Next**, verify and validate the requirements support achieving the project's goal and describe an outcome stakeholders approve of.
- **Last**, trace every requirement back to its source.

These four steps are discussed in more detail below.

f. Requirements Discovery

The first step in requirements management is discovery, also called requirements gathering. Several techniques can be used to discover new requirements or identify needed changes to existing requirements. The PM can observe work or capabilities being performed in the current system, interview stakeholders, participate in business event workshops, or brainstorm with subject matter experts (SMEs).

- Examine the role of the current system and the environment in which it operates to understand its functionality, features, and areas for improvement. When assessing potential solutions, this information provides insight into the functions and features to evaluate. From observing how end-users perform their work, identify new approaches to grouping tasks, new sequences in which to perform processes, and areas where new techniques and equipment can improve task or process performance. Systems engineers often perform this process.
- Interview stakeholders by conducting structured interviews that use a set of questions prepared before the interview. Structured interviews ensure that you cover all the necessary topics and that you cover those topics consistently.
- Business events are recurring situations, activities, or outcomes that happen during the course of performing typical business processes. In business event workshops, an end-user representative may describe or re-enact the work currently performed in response to business events. Re-enactments may also demonstrate the work that should be performed to correctly respond to business events.
- Brainstorming with SMEs brings together participants from a variety of positions with different perspectives and expertise to generate as many uncensored ideas as possible for what would make the best solution.

g. Documenting Requirements

Like requirements gathering, documenting requirements involves collaborating with stakeholders who describe their performance needs and cultural or policy constraints; end-users who describe their work processes, work environments, and usability needs; systems engineers who describe functional and non-functional attributes the solution must possess; and other project team members, such as finance representatives who describe project and product-wide constraints including budget and schedule.

The team should designate a specific individual, or group of individuals, who draft requirements with input from others to promote consistency and accountability. In some organizations, while the project manager and project team may contribute to requirements development, the responsibility for actually drafting system requirements rests entirely with the end-user's representative. This prevents the project manager from drafting requirements that do not accurately describe the end-user's need and then building to those requirements, resulting in a solution that technically meets requirements but fails to actually address the end-user's need.

Regardless of who actually drafts requirements, requirements can be from two perspectives: that of the end user or that of the solution. When written from the end-user's perspective, requirements describe how the end-user plans to implement the solution in their work environment. End-users and stakeholders often contribute to these types of requirements. When written from the solution's perspective, requirements describe how the solution is expected to operate by depicting a typical day in the life of the system or providing a forecast of expected operation. Systems engineers and other project team members often contribute to these types of requirements. The end-user's work environment and anticipated operation of the solution are sometimes described in a document called the Concept of Operations.

While you can write requirements from either of these two perspectives, one perspective you should not write requirements from is that of the developer. This is because requirements written from the developer's perspective tend to describe a specific method the developer should use to achieve the desired outcome. Describing a specific method the developer should use does not contribute to establishing performance-based requirements.

Requirements should meet several criteria. First and foremost, well-written requirements are implementation-free. They are also discrete, compatible, consistent, accurate, and unambiguous. Additionally, well-written requirements are modifiable, traceable, and verifiable. To elaborate, well-written requirements are:

- Implementation-free, meaning they are performance-based. If your requirement describes a specific approach, or implementation, for achieving the desired outcome, it is not performance-based. Performance-based requirements are implementation-free because they describe the desired outcome without describing how to achieve that outcome.

- Discrete, meaning they describe a single result that must be achieved by the solution. If your requirement contains the word "and," it is likely not a discrete requirement and should be deconstructed into discrete requirements.

- Compatible with other requirements, meaning they do not contradict or conflict with another requirement. If requirements are not compatible with one another, examine how the need and its capability gaps are defined and de-conflict the requirements.

- Consistent, meaning they all capture the same kinds of information. While requirement formats vary, some key information should be included in every requirement, such as the type of requirement; whether it is functional, non-

functional, or global to the project; the reason for establishing the requirement in the first place; the individual or group who established the requirement; the actual requirement itself; and a record of all changes to the requirement.

- **Accurate**, meaning they provide a complete, correct description of an attribute or process that is possible, do-able, and legal. Inaccurate requirements may be incomplete, contain erroneous information, or describe an outcome that is unattainable.

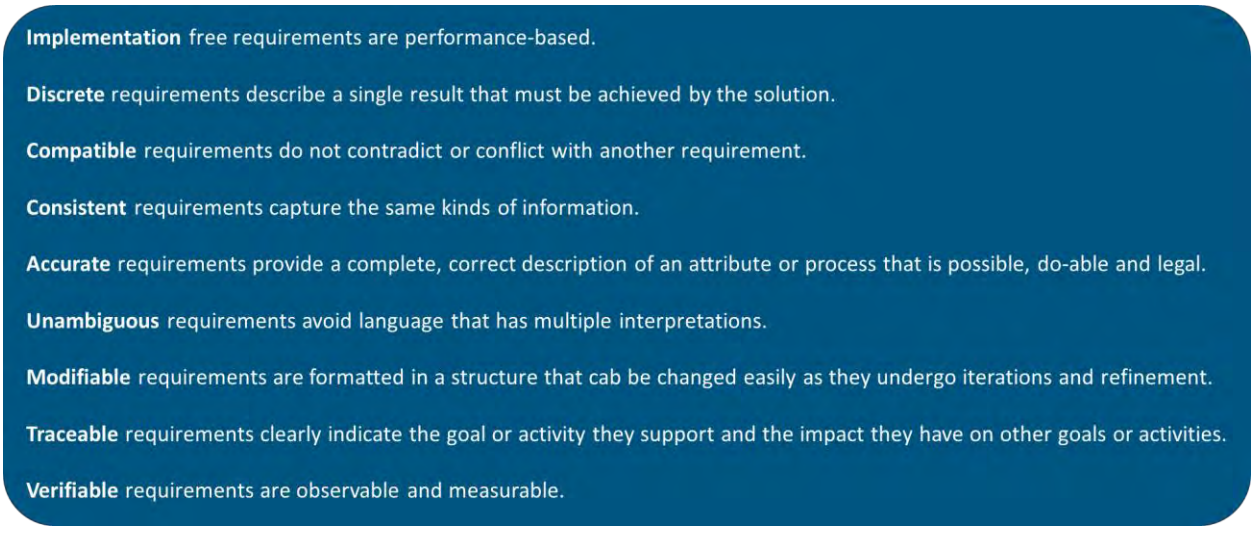
- **Unambiguous**, meaning they avoid language that has multiple interpretations. Requirements should have only one interpretation. Avoid using technical language or jargon since not everyone understands such terminology. Instead, use "plain" English.

- **Well-written** requirements are modifiable, meaning they are formatted in a structure that can be changed easily as they undergo iterations and refinement. The project team should define the format for your requirements before you begin requirements gathering.

- **Traceable**, meaning they clearly indicate the goal or activity they support and the impact they have on other goals or activities. To define the project's scope, requirements must trace back to the project goal they support achieving.

- **Verifiable**, meaning they are observable and measurable. Requirements that are not verifiable are useless for ensuring effective solution development and result in a failed project. Your requirements should describe concrete, necessary outcomes by using the words "must" or "shall" and describe intended outcomes by using the word "will."

Figure 12: Well-Written Requirements



How to document requirements. Documenting requirements involves more than simply writing down your well-written requirement. It involves gathering several pieces of important information about the requirement. Before you document your requirement, assign it a unique identifier for easy reference later.

To begin, identify the type of requirement you are recording. This allows for categorizing or grouping requirements. Is it a functional, non-functional, or a global product- or project-wide requirement? Next, describe the intent of the requirement. For example, a functional requirement is likely intended to detail a function the solution must perform.

Then, explain why the requirement was established. For example, a functional requirement is likely established to provide a measure for evaluating the solution's performance.

After that, identify who established the requirement.

Now, actually write down the well-written requirement. This is the "meat" of a requirement and what most people think of when they hear the word "requirement." Ensure your requirement details how the requirement supports the project's goal. Identify other requirements that impact this requirement or that this requirement impacts. Additionally, identify whether the requirement conflicts with any other requirement, activity, or goal. A well-written requirement should not conflict with another requirement.

Finally, keep an accurate record of the requirement's history. This includes recording when the requirement was first identified, when the requirement is verified, and when the requirement is deleted if it is deemed unnecessary. Another critical part of the requirement's history is capturing every change to the requirement by recording the date of the change and the source of the change. While you document requirements individually at first, you will need to compile them into a requirements document once you have finalized them.

h. Verify and Validate

With your documented requirements, the next step in requirements management is to verify and validate those requirements.

Verifying requirements is different from validating requirements, but they both involve proving that your requirements meet expectations. During the Concept Planning phase, verification is proving that a requirement aligns with the objective or goal the solution must support. When you verify a requirement in this phase, you are answering the question, "Does meeting the requirement contribute to achieving the project's goal?" A well-documented requirement should clearly indicate the rationale for why it was written, which should describe how the requirement supports achieving the project goal, and a listing of dependencies. Dependencies detail other requirements that the requirement supports or is supported by.

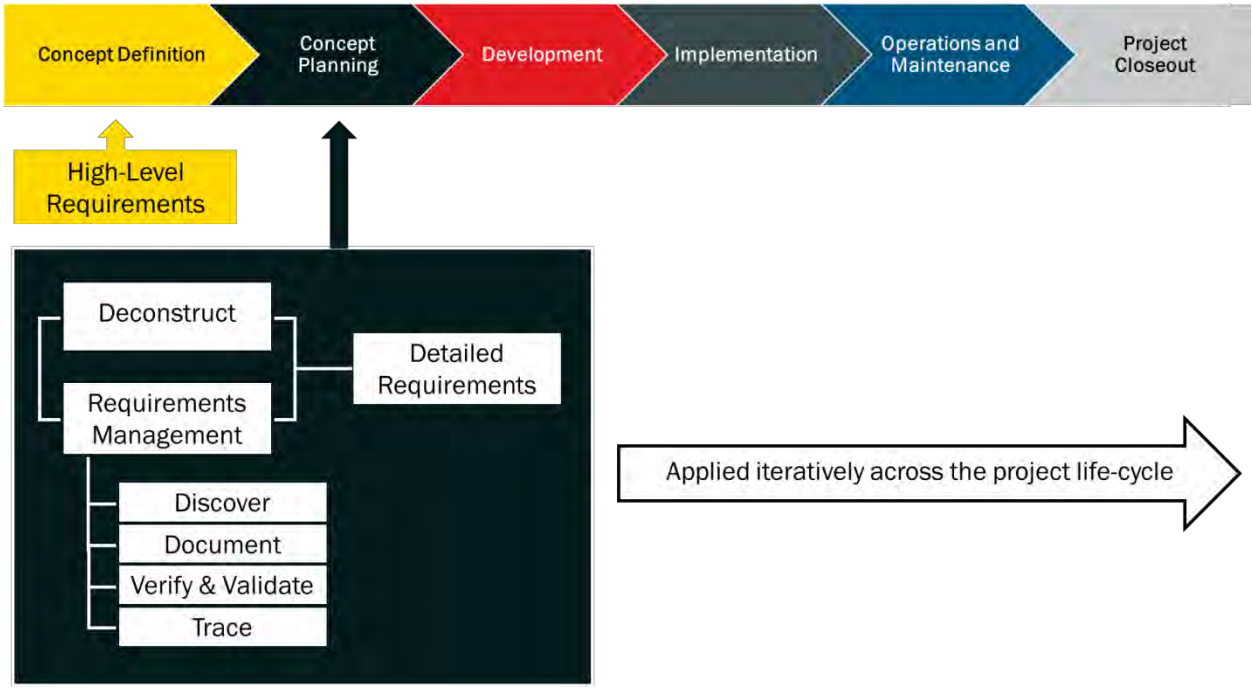
Validation is proving that a requirement meets your customer's satisfaction. When you validate a requirement in the Concept Planning phase, you are answering the question, "Does the requirement describe an outcome the customer needs and wants?" When

compared against the customer's needed and desired outcome, valid requirements should describe what is needed to meet project objectives, describe outcomes that are within the project's scope, be compatible with any assumptions to which the project is subject, and comply with all constraints placed on the project.

i. Tracking Requirements

Once you've verified your requirements, the last step in requirements management is to trace each requirement. When you trace a requirement, you track the requirement back to the objective or goal it supports, its parent requirement (if it has one) and any child requirements, and the person or party who created the initial requirement or instigated the change to the requirement. Tracing requirements involves mapping and managing all of these relationships.

Figure 13: Requirements Management



j. Performance Parameters

Performance requirements that describe a function the system must perform or an attribute the system must possess are sometimes expressed as performance parameters. How fast must it work? How accurate must the data be? How reliable must the system perform? The need for high or robust performance parameters correlates to levels of quality, timeliness of delivery of the capability, and cost of the asset. Perfection is expensive. Setting performance parameters too high tends to drive a specific solution, removes alternatives, adds costs, and often adds little to no business value. Stakeholders should be challenged to identify the

minimum acceptable values as that point at which the investment ceases to be valuable. The difference between the optimal and the minimum value is the trade space.

PMs must be able to determine if a deviation from what values are wanted over what is really needed is cost effective and can be delivered on schedule. Certain critical functions may have near 100% compliance requirements, such as explosive detection systems, but others may offer flexibilities. Sometimes a certain level of performance can be traded off while still maintaining a reasonable level of capability that represents increased utility for the end-user while remaining within cost and schedule constraints.

Certain categories of performance parameters are sometimes referred to as "key performance parameters" or "key system attributes." These requirements represent a critical function or attribute the system must possess. If these key functions or attributes cannot be achieved and delivered to the end user, the consequences usually warrant a complete restructuring of the overall project approach or possible project termination.

Next, let's return to the Concept Planning phase and examine the role of detailed requirements in the solution Analysis of Alternatives.

6. Selecting a Solution

a. Analysis of Alternatives – Solutions

You know how to deconstruct high-level requirements into detailed requirements and how to manage requirements through iterative deconstruction. Next, using your detailed requirements, you perform another AoA to select the preferred solution approach. You record and communicate your conceptual design, solution approach, and the rationales for your choices through the performance-based requirements document, statement of work, and request for proposal (should your solution require an acquisition). The solution AoA is performed in the Concept Planning phase.

Conducting a solution AoA helps you prioritize requirements and decide how completely each requirement should be met. At this point there could be many detailed requirements that fully describe what is needed to meet your project's goal. Developing a solution that completely meets all requirements would likely be very expensive and take an excessive amount of time. Because organizations have a limited amount of resources and time, identify which requirements are most critical to allocate resources to and determine how completely those requirements should be met. Typically, more comprehensive solutions meet requirements more completely and cost more to develop.

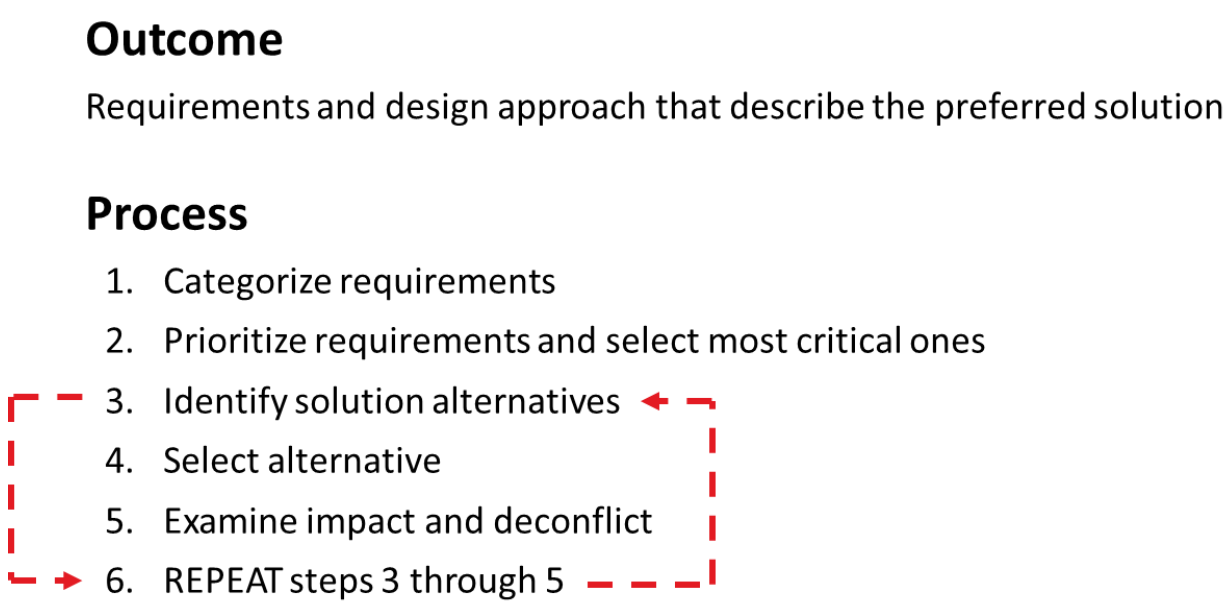
The solution AoA performed in the Concept Planning phase differs from the concept AoA performed in the Concept Definition phase. In the Concept Definition phase, the AoA looks at alternatives among training, personnel, equipment, processes, and organizational restructuring, the outcome of which is selecting a high-level approach, or concept, for addressing a capability gap and meeting the need. It is sometimes mistakenly assumed that the solution AoA conducted in the Concept Planning phase builds on the selected concept to determine a specific equipment model or training approach. This is not correct. In the

Concept Planning phase, you conduct an AoA between requirements and design approaches for meeting each requirement, the outcome of which is to select the most appropriate set of requirements that the solution must fulfill and the optimal design approach for meeting each requirement. Together, these outcomes describe the preferred solution approach.

Figure 14: Concept AoA vs. Solution AoA

To select the optimal set of requirements to describe the preferred solution approach, you must first group your requirements into categories. Next, you prioritize the requirements within each category and select the one or two highest-priority requirements from each category to use in your solution AoA. Then, you examine each high-priority requirement and identify different ways the solution could meet each requirement. After that, you conduct trade-offs between solution alternatives to determine the optimal way to meet each requirement given cost and schedule constraints. Once you select a solution alternative for one requirement, you must examine the impact of the selected alternative on other high-priority requirements. You must de-conflict any negative impact that a solution alternative has on high-priority requirements.

Figure 15: Evaluating Solutions



Requirements categories. You begin your solution AoA by grouping all your requirements into categories. Recall that when you documented your requirements, you provided the requirement type and a description of the requirement. These pieces of information help you to categorize your requirements. While requirement categories can vary by agency and project, there are some basic categories that apply to most projects.

- Performance thresholds describe the functions a solution must perform.
- Security describes the features and functions the solution must possess to meet security mandates.
- Interoperability describes the features and functions the solution must possess to be compatible with, communicate with, and operate effectively with existing systems and applications.
- Total life-cycle cost details the budgetary constraints the solution must comply with, including maintenance costs that may affect the frequency and complexity of maintenance, repair, and update activities.
- Operational environment describes the conditions in which the solution will be implemented by the end-user.
- Physical describes the dimensions, appearance, and location of the solution.
- Solution source describes how the solution will be obtained (e.g., whether the solution will be a COTS item or be developed from scratch).

Prioritize requirements. After categorizing your requirements, you must prioritize the requirements within each category. Deciding which requirements are highest priority should be a collaborative process that receives input from your customer and end-users, project team members, and senior leadership. When documenting each requirement, detail other requirements that are supported by or support each requirement. Then evaluate the

requirement and assign it a priority level based on the impact the requirement has on achieving the goal. The more vital a requirement is to meeting a capability gap, the higher the priority. Use the one or two highest-priority requirements from each category to conduct your solution analysis of alternatives.

Evaluate requirements. Once you've identified the most critical requirements in each category, select one high-priority requirement to evaluate. For the selected requirement, identify different ways the solution could achieve meeting that requirement. These fall into three groups: (1) a non-developmental approach by acquiring a COTS solution, (2) a developmental approach by designing a new system, and (3) a combination of the previous two where a commercially available item is modified to meet specific Government requirements not available in the commercial marketplace. These three possible design approaches are your solution alternatives.

Trade-offs. Now that you have identified the solution alternatives for meeting your first requirement, conduct trade-offs between the solution alternatives to determine the optimal way to meet that requirement given cost and schedule constraints. Much like the concept AoA during the Concept Definition phase, you conduct trade-offs between solution alternatives by comparing the level of performance each alternative will provide and the financial cost, manpower resources, and time required to implement each alternative and obtain its level of performance. This is sometimes called a performance efficiency trade-off.

Negative impact. Each solution alternative, if implemented, will uniquely impact your other high-priority requirements. You must examine the impact of your selected alternative to see if it negatively impacts or conflicts with other requirements. Two common methods for resolving negative impact are eliminating the unsuitable alternative or modifying requirements. Each method presents different challenges. When you eliminate an unsuitable solution and choose one of the remaining alternatives instead, you must still de-conflict any negative impact the newly selected alternative may have. Because every alternative will have a unique impact on other requirements, you should consider which alternative will have the lesser negative effect. If you eliminate an unsuitable alternative, you must repeat step 4 (select an alternative) and step 5 (examine the impact of your selected alternative) and then conduct a trade-off analysis comparing each alternative's impact.

If none of your alternatives creates an acceptably low negative impact on other requirements, you may have to modify requirements to accommodate the solution alternatives available to you. Modifying requirements significantly affects solution selection because requirements are dependent on each other and on the operational environment. Changing one requirement may mean you have to change the operational environment on which the requirement was based or that you have to change other requirements that it supports or that support it. If you modify requirements or the operational environment reflected in your requirements, you have to begin the solution AoA over again because alternatives selected prior to modifying requirements may not meet the new, modified requirements.

b. Requirements and the Life-Cycle

Now that you understand the basic steps involved in requirements management, you can tailor your application of those steps. Depending on the concept selected and the need to use a developmental or commercial buy life-cycle approach, the PM tailors the requirements development steps to match the complexity and level of risk involved with the type of life-cycle model selected.

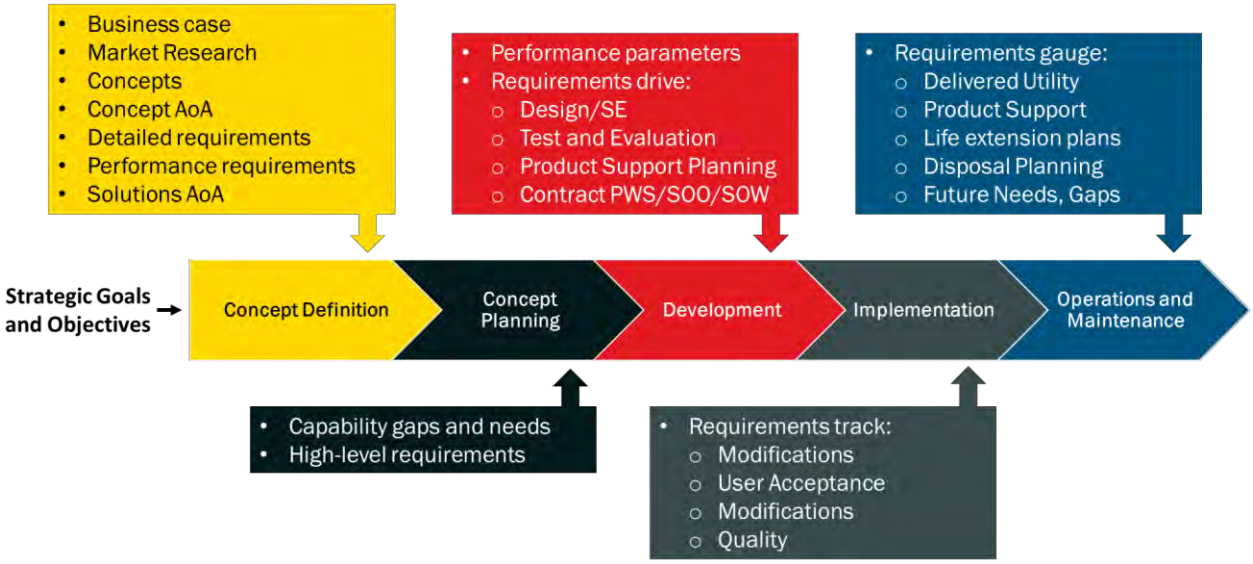
In the **Development phase**, the team compares the emerging design and prototypes with requirements and makes decisions about changing the prototype, requirements, or both. This is the discovery activity. These design decisions are documented and then verified and validated.

In later project phases, answer the question, "Are you building the solution correctly by verifying that prototypes and developed solutions meet requirements established in earlier phases?" You answer this question by validating that prototypes and developed solutions still reflect what the customer needs and desires. As before, you must trace your design decisions back to their source and map out their impact on requirements and design components. The design decisions you make in the Development phase become the requirements for the following phase.

In the **Implementation phase**, compare the emerging product or service with requirements and the design and make decisions about changing the developed product or service, the design, its requirements, or all three. Document these decisions in operations and maintenance documents that become requirements for the following phase. Once the developer creates the final iteration of the solution, either at the end of the Development phase or at the beginning of Implementation phase, finalize the requirements to reflect the solution that the developer actually produced and that the end-user will field test. These finalized requirements are what the customer uses to verify the quality of the solution and grant acceptance of the solution.

In the **Operations and Maintenance phase**, compare the performance of the operating product or service with requirements, the design, and operations and maintenance documents. Make decisions about changing the operations and maintenance documents or modifying the product or service, design, or requirements. Document those decisions—that information is used to inform future projects.

Figure 16: Requirements in the Life-Cycle



D. Budget Planning and Execution

As requirements are being developed, the PM must consider the budget life-cycle, the agency budget, and the funding priorities of the project. As requirements are developed, project costs are estimated and become input for agency budget planning and programming. The PM must continually monitor the budget, the project's adherence to the allowable budget, and forecast future budgets. Each agency differs in their budget planning process and procedure, but all agencies must submit their portion of the President's Budget Submission to Congress no later than the first working Monday each February. The following section explains the Federal Government's budget planning and execution process.

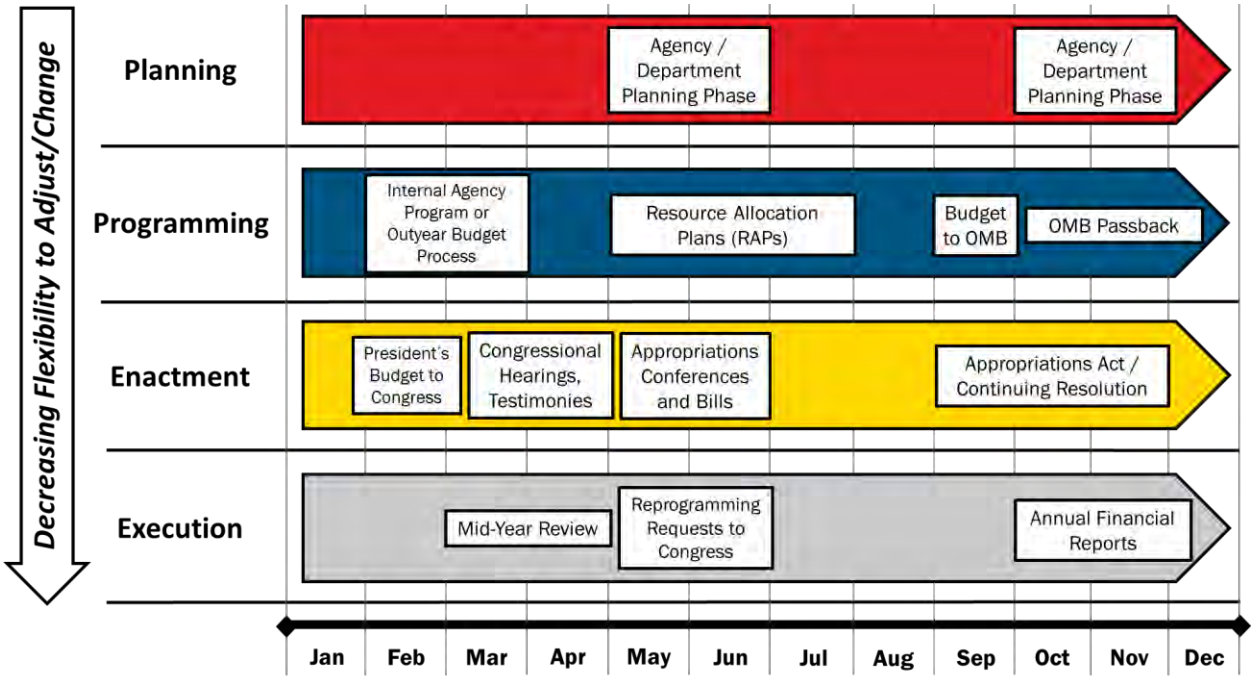
1. Resource Allocation Process

Planning, Programming, Budgeting, and Execution (PPBE) is a cyclical process consisting of four distinct but interrelated phases. Agencies differ widely in how they label these four basic processes, but all agencies perform them regardless of how they are labeled agency to agency.

- **Planning**. Establish strategic priorities and capabilities required to achieve the strategy. Consider Planning as all the capabilities the agency wants.
- **Programming**. Apply the resources to programs and projects that provide the capabilities required to achieve strategic priorities. Consider Programming as all the capabilities the agency thinks it can afford.
- **Budgeting**. Properly price the programs, and develop justifications and an execution plan. Consider Budgeting as all the capabilities the agency realistically will receive.
- **Execution**. Perform and monitor the spending of approved plans. Consider Execution all the capabilities the agency receives funds to spend.

As represented by the budget PPBE process diagram, all agencies are managing multiple budgets simultaneously. As the first budget is being executed, the second budget is being proposed to Congress. As the second budget is being proposed to Congress, the third budget is in planning stages within the Executive Branch. Finally, multi-year budgets are being planned beyond the third budget to begin shaping key agency investments and priorities.

Figure 17: The Resource Allocation Process



2. Budgeting and Projects

Agency plans, programs, and budget actions are ultimately a calendar-driven enterprise, regardless of when capability gaps are identified, solutions are required, or when stakeholders approve the progressive steps in an asset's life-cycle process. The challenge for the PM is to manage the variations in the resource demands of the project within the time constraint of the suspense for the President's Budget Submission going to Congress no later than the first working Monday each February.

Rarely will full funding be available for project initiation and all phased efforts thereafter. This constraint often requires agencies to forecast years in advance of their resource requirements. Agencies will program and budget for potential projects in general program categories and use the budget authority received for these forecasted requirements as "seed" funds to get a specific project started. For example, an agency whose general mission profile involves transporting hazardous materials will program and budget for funds required for future acquisitions in this category of assets.

This general budget line item may enter the President's budget labeled as "Hazardous Material Transport." Any future capability gap and need that results in the decision to initiate a relevant project could be initially funded from this general category of funds until budget authority is approved for a specific solution to the need. Examples of specific solutions may be new ground transport trucks outfitted with GPS tracking technology or a new section of railroad track dedicated to hazardous material transport. This initial funding gets the project initiated and funded until accurate cost estimates can be gathered and funding requested in the agency's next budget submission for inclusion in the President's Budget Submission.

3. The Business Case

As stated earlier, the business case is an intersecting point between Requirements Development, Budgeting, and Acquisition Governance. Approval of the business case formally initiates and funds the project. If an item must be developed using a developmental life-cycle approach, it's likely the initial funding for the project will come from a general budget category, as discussed above, and will only be the minimum amount required to keep the project solvent until objective funding amounts come from future budgets submissions. In this situation, a second business case (or revised case) may be required to justify the objective funding amounts.

If the solution warrants a shorter, less risky commercial-buy life-cycle approach, a combination of general category funds, reprogrammed ("stolen") funds from lower priority programs, and future budgeted funds could fund the entire project. A situation could arise where a project is generated but no funding avenues are available to get the project started. A project could wait as long as a complete budget and enactment cycle (12–24 months) before budget authority exists to formally initiate the project. Of course, agency priorities and needs could also evolve during this lapsed period. A project today may not be a project tomorrow.

4. Budget Planning and Timeline

The following table reflects some of the major budget planning timelines. It's important to provide timely budget information to secure funding for programs and projects and be vigilant for communications on budget requests.

Table 6: Major Budget Planning Timelines

The Outyears – Planning	
Agency Planning Process	May – June and October – November
The Budget Year + 1 – Programming	
Internal Agency Program or Outyear Budget Process	February – March
Resource Allocation Plans (RAPs)	May – July
Budget to OMB	September
OMB Passback	October – December
The Budget Year – Budget Enactment	
President's Budget to Congress	February

Congressional Hearings, Testimonies	March – April
Appropriations Conferences and Bills	May – June
Current Year – Budget Execution	
Mid-Year Review	March – April
Reprogramming Requests to Congress	May – June
Annual Financial Reports	October – December
Appropriations Act/Continuing Resolution	September – November

5. Budget Assembly and Submission

In the summer, the Office of Management and Budget (OMB) sends budget guidance to agencies that includes overall budget numbers prepared based on estimates from previous budget years. Agencies then develop their priorities and budget requests based on that guidance. The Office of the President and OMB work together to determine what should be prioritized and provide recommendations and Presidential decisions back to the agencies (known as the passback). Agencies can then request adjustments from OMB prior to the President's budget being finalized.

On or before the first Monday in February, the Office of the President submits a detailed budget request for the next fiscal year. Based on the President's submission, the House and Senate budget committees propose their own budgets, which sets targets for spending, tax revenue, and policies. During Congressional committee reviews, agency senior leadership may be called before the various budget committees to explain and justify their budget submissions. PMs will often be tasked to prepare information to assist agency leads during these review sessions. The House and Senate then vote on the budgets and reconcile one overall budget approved by Congress. Based on the approved budget, discretionary spending is divided among the 12 committees that manage appropriations. The budget does not go to the President for signature.

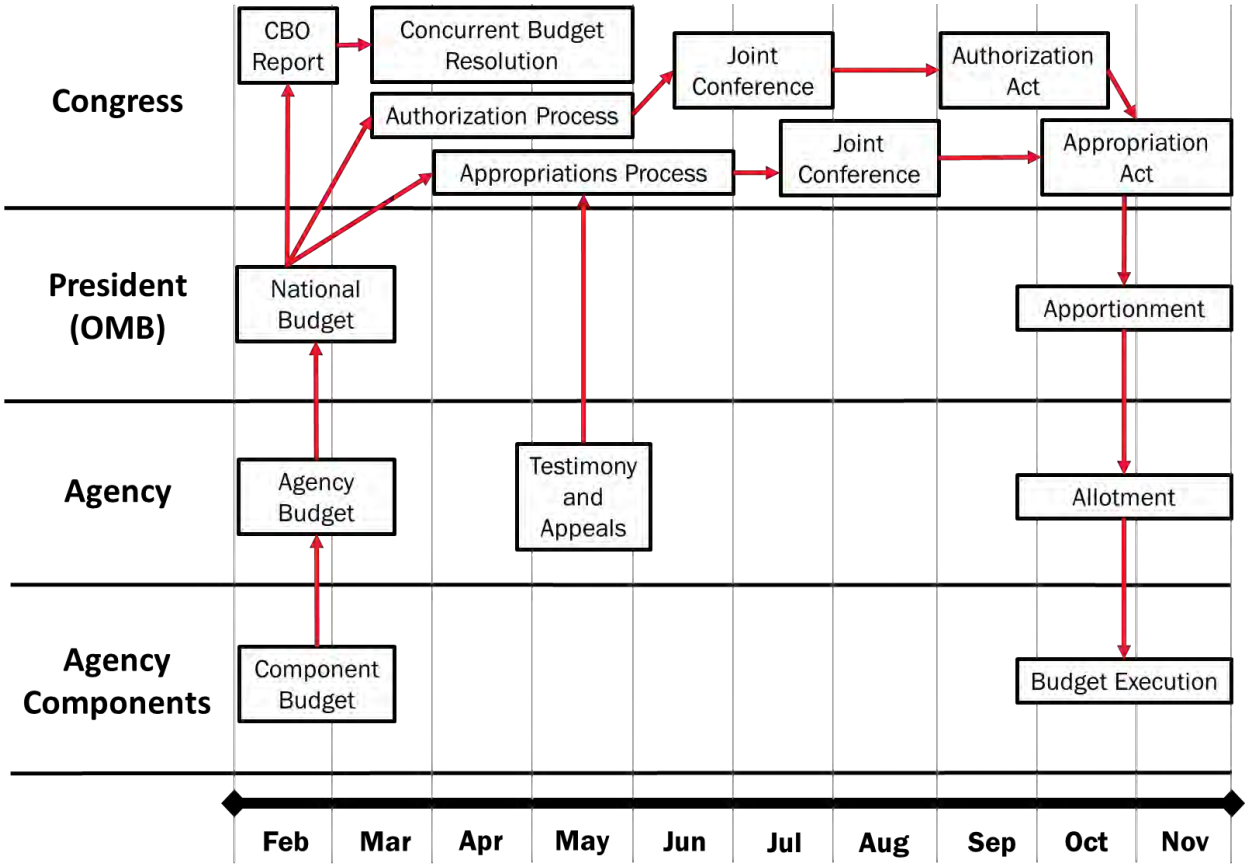
6. Congressional Enactment and Timeline

The Congressional appropriations process and timeline are, for the most part, fixed. With the exception of Continuing Resolutions, Congress has a process in place to pass appropriations on or before September 30th each year. The Senate and House of Representatives both have budget committees, which are responsible for authorizing and appropriating the overall budget to all Federal agencies. Congressional Appropriations committees provide funding, and the Authorization committees provide direction for the authorized funding. These Authorizations and Appropriations are enacted into law, and OMB then allocates the overall budget between the various agencies.

In Figure 18, Congressional Enactment activities take place from the first part of February through September 30th of the previous fiscal year of the budgeted year. For example, for the FY17 budget, Congressional enactment activities begin with submission of the President's budget to Congress in early February, calendar year 2016. Congress' goal is to pass the Authorizations and Appropriations Acts for the budget year by September 30th each year. If Congress fails to meet the September 30 deadline, Congress enacts a Continuing

Resolution Authority (CRA) with special guidelines to the Federal agencies on how they can obligate and commit operating funds until Congress passes the Authorization and Appropriations Acts. When CRA is evoked, Congress usually gets the budget finally enacted within the first quarter of the budgeted fiscal year.

Figure 18: The Congressional Enactment Cycle



7. Budget Execution

Budget Authority. Actual currency, cash funds, or bank accounts are not distributed to the agencies. Funding for all agency needs is actually budget authority, or authorization to commit Government funds to approved agency tasks such as acquisitions, payroll, supplies, and other operating expenses for a specific period of time, specific purpose, and specific amount.

OMB allocates budget authority down through successive comptroller levels until funding arrives at the level in the organization that's authorized to allocate those funds to perform project work. Agencies record commitments, incur obligations, and make expenditures during the overall funding execution of projects and related activities. These terms reflect how budget authority eventually gets dispersed in the form of payments coming out of U.S. Treasury accounts:

- **Commitment**. Commitments are budgetary and accounting actions taken to authorize and reserve funds for future obligations in the current fiscal year. Essentially, a commitment is the setting aside or earmarking of funds that will be used in the future for the purchase of goods or services. As pre-obligations, they are not legally binding and are not encumbrances of a fund. This administrative reservation of allotment and budget authority is based on a documented, anticipated future expenditure for known liabilities such as payroll, approved acquisitions, or other documentation.

- **Obligations**. An obligation is any financial action that legally binds the Government, such as orders placed, contracts awarded, services received, and similar transactions for bona fide needs existing during a given period that will require payments during the same or a future period. All obligations are for the purpose authorized by law, within amounts authorized, executed before the end of the period of availability of the appropriation, and supported by documentary evidence that is in writing and approved by a duly authorized official. An obligation may not be authorized before enactment of the applicable appropriation unless otherwise provided by law. Each obligation action must meet requirements prescribed by the FAR, the Antideficiency Act, and agency policy.

- **Expenditure**. An expenditure is an actual disbursement of funds in return for goods or services. It is frequently used interchangeably with the term "outlay." When obligations come due and payable based on a documented invoice, bill, or note, outlays result in the actual disbursement of cash payment from U.S. Treasury accounts. Administrative lead times that occur between receipt of a legal invoicing action and disbursement of cash payment must be managed and accounted for in financial transactions and lead times.

8. Appropriations Law

Federal funds are made available for obligation and expenditure by means of appropriation acts (or occasionally by other legislation) and the subsequent administrative actions that release appropriations to the spending agencies. The use or "availability" of appropriations once enacted and released is controlled by various authorities:

- The terms of the appropriation act itself;
- Authorizing legislation;
- Legislation that prescribes a function or creates a program that the appropriation funds;
- General statutory provisions that allow or prohibit certain uses of appropriated funds; and
- General rules that have been developed largely through decisions of the Comptroller General and the courts.

These sources, together with certain provisions of the Constitution, form the basis of "appropriations law".

The legal availability and use of Federal appropriations is based on three core elements: purpose, time, and amount.

- **Purpose**. The "purpose statute" (31 U.S.C. 1301(a)) prohibits Federal officials from using appropriated funds for purposes other those for which the funds were appropriated. This constraint is often referred to as the "color of money."
- **Time.** Appropriations are made for certain periods of time or may be without time restrictions. Different agencies and different programs may have different time periods during which money must be used. Expired funds are returned to the Treasury.
- **Amount**. All obligations and expenditures must be within the amount established by Congress. Agency-specific budget processes place additional limits on appropriated amounts through use of internal allotments and allocations of funds as part of the agency's control process to ensure compliance with the Antideficiency Act.

The Antideficiency Act prohibits Federal agencies from obligating the Government, by contract or otherwise, in excess of or in advance of appropriations unless authorized by a specific statute. The Act requires the heads of Executive agencies to report violations to the President and the Congress with a copy to the Government Accountability Office (GAO).

The Bona Fide Needs Rule and Severability of Services. The Bona Fide Needs Rule is one of the fundamental principles of federal appropriations law. Simply stated, a "fiscal year appropriation may be obligated only to meet a legitimate, or bona fide need arising in, or in some cases arising prior to and continuing to exist in, the fiscal year for which the appropriation was made." The general rule is that services acquired by contract generally are chargeable to the appropriation current at the time the services are rendered. However, the Comptroller General has held that the question of whether to charge the appropriation current on the date the contract is executed, or to charge funds current at the time the services are performed, depends upon whether the services are severable or non-severable. While services may be classified as either severable or non-severable, it is possible for a single contract to contain a significant portion of both types. In such cases, they must be structured as separate contract line items and funded in accordance with appropriations policy.

PMs need to be cognizant of these appropriations rules and how they apply during contracting actions for specific types of contracts, and whether the funds used are governed by incremental or full funding policy. This is important when addressing the question of severable vs. non-severable services. Volume 1, Chapter 5 of the Federal Appropriations Law (Red) Book, discusses this topic. A task is severable when an agency realizes a benefit at the time the services are provided, even if the contract has not been performed to completion. A service is non-severable if the service produces a single or unified outcome, product, or report that cannot be subdivided for separate performance in different fiscal years.

Goods and services on contract are generally viewed as chargeable to the appropriation current at the time the services are rendered according to the contract in effect. However, a need may arise in one fiscal year for services which, by their nature, cannot be separated for

performance in separate fiscal years. The general rule is that the fiscal year appropriation current at the time the contract is made is chargeable with payments under the contract, although performance may extend into the next fiscal year. A contract which is viewed as non-severable is chargeable to the fiscal year in which it was made, notwithstanding that performance may have extended into the following fiscal year. Chapter 5 of the Red Book contains some examples and further discussion of "severable" and "non-severable" contracts.

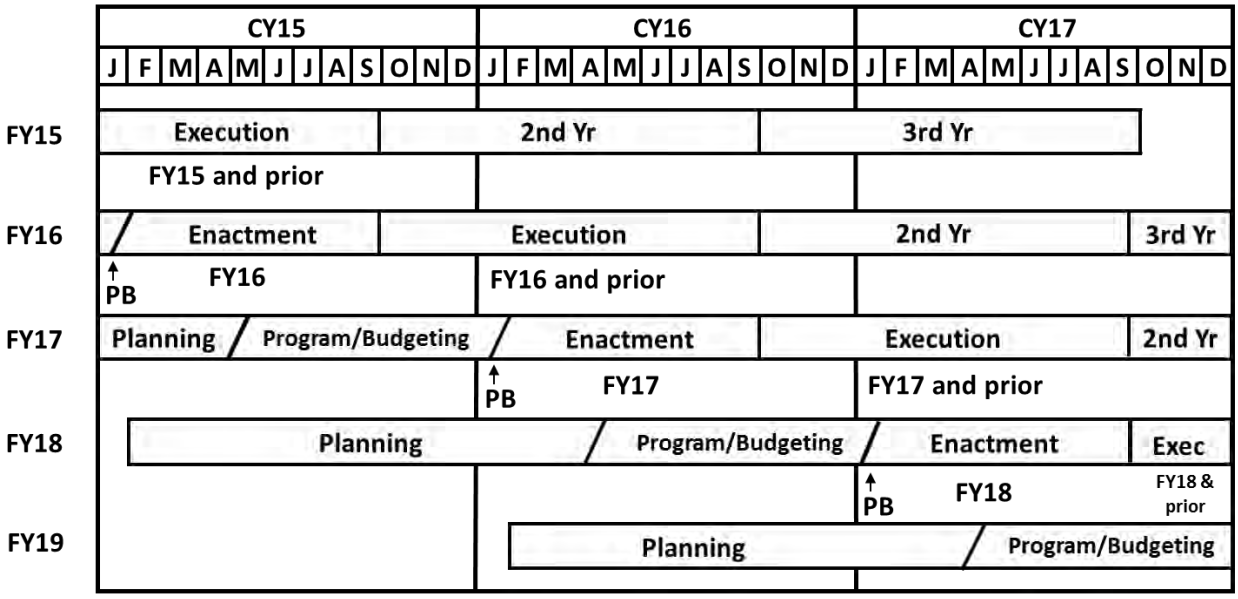
GAO's *Principles of Federal Appropriations Law*, commonly referred to as the "Red Book," is the authoritative source for appropriations law.

9. Executing the Project Budget

The PM and the project team are responsible for ensuring the proper execution of the project budget according to agency policy and Federal statute. Agencies are funded with multiple variations in the types and amounts of appropriations enacted by Congress. As previously discussed, appropriations are structured for a specific purpose, amount, and year. Some types of appropriations are for use only in the single year they are appropriated. Other appropriations are multi-year in that they can be obligated in the fiscal year they are first appropriated and additional years thereafter.

At any given point in time, the project team could be providing information for future agency budget requirements, executing and accounting the current budget authority to run the project, and tracking multi-year funds over several years to insure they are used appropriately and within their period-of-use limitations. The following figure represents this accounting and planning challenge for the PM and the project team:

Figure 19: The Budget Cycle



Correct appropriation spent in the years it's appropriated for, and for the correct assets

The chart depicts that in mid-May of calendar year 2015, the project team is performing these budget actions simultaneously:

- **FY15:** Executing (spending) their FY15 budget authority and any other past multi-year funds that have not expired
- **FY16:** Responding to information requests regarding the FY16 budget submission currently in the Congressional enactment process
- **FY17:** Preparing the project funding requirements for agency FY17 programming and budgeting actions so the agency can build its portion of the FY17 President's Budget (PB) submission, due in February 2016
- **FY18:** Providing the projects FY18 resource requirements as part of the agency's FY18 planning process, which could include the generation of new capability gaps and needs

These congruent activities also must take into account the progress (or lack thereof) of the project in its journey down the life-cycle path and any new or changed requirements coming from the PM's stakeholder community. The risks involved with the Federal budgeting process make Federal project management nothing like its counterpart in private industry. In the end, this is taxpayer money. It warrants the PM and the project team's best efforts to insure it's spent wisely.

a. Industry Finance

Insight into how private industry finances projects can assist the PM and project team during market research as well as help the team gain an understanding of the general financial health of an organization. Also, during source selections, understanding contractor finances assists in understanding cost, pricing, and other contract related financial information. The following job aids were taken from the Defense Acquisition University's PM eToolkit.

b. Contractor Profitability Ratios

The basic concept of profitability ratios is to measure net income against revenue or against the investment required to produce it. There are three principal profitability ratios with which you should be familiar. They are:

1. **Return on Sales**, which shows what percentage of dollars are left after the company has paid for all costs, interest, and taxes. It is expressed as:

   Return on Sales = Net Income ÷ Sales

2. **Return on Total Assets**, which looks at the efficiency with which management has used its resources—the company's assets—to generate income. It is computed as:

   ROA = Net Income ÷ Total Assets

As noted, **Return on Assets** (ROA) addresses how well management utilizes the assets of the firm in generating income. The ROA formula reflects the combined result of Return on Sales and the total asset turnover ratio (total sales/total assets), broken down as follows:

ROA = Net Income ÷ Total Sales *X* (Total Sales ÷ Total Assets)

3. **Return on Stockholders' Equity** measures the rate of return on the owners' investment—their equity in the company. This is also known as **Return on Equity** (ROE)**:**

   ROE = Net Income ÷ Stockholders' Equity

   ROE can also be broken into two components: return on assets and financial leverage (a ratio reflecting the relationship of creditor to owner financing—expressed as total assets/stockholders equity). This is shown by:

   ROE = Net Income ÷ Total Assets *X* (Total Assets ÷ Stockholders' Equity)

   These profitability ratios give three different viewpoints concerning the "bottom line" on the income statement—how much net profit is being made on each sale, how much is being made for the assets that are employed, and how much is being made for the company owners.

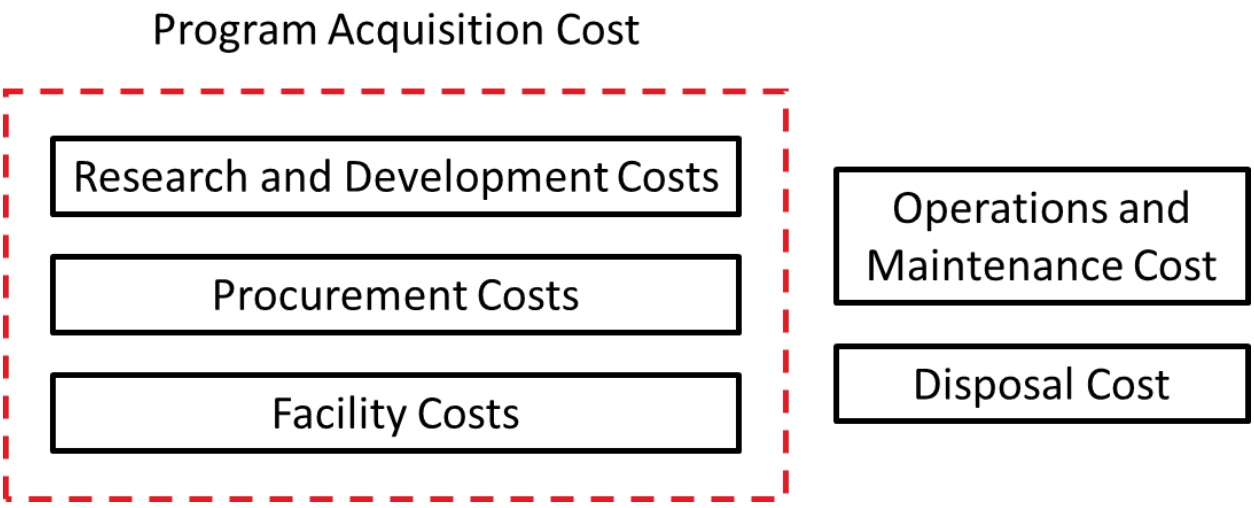
From an owner's perspective, another profitability ratio you may be aware of is **Earnings per Share** (EPS):

EPS = Net Income ÷ Number of Shares of Common Stock Outstanding

10. Life-Cycle Cost Components

Program costs fall into very specific categories with very specific funding sources, and the PMs must be careful to ensure costs precisely map to budgets and funding sources. While immediate costs are the primary focus of the PM's budget, a number of additional costs must be considered in the life-cycle costs of the project.

Figure 20: Life-Cycle Cost



11. Cost Estimating

As part of the agency budgeting process, PMs are responsible for developing cost estimates for individual projects that then roll up into program, office, and bureau budgets. Cost estimating can become a difficult undertaking. PMs are encouraged to use all available agency assets at their disposal to create accurate cost estimates. A good reference to start with is the General Accountability Office (GAO) Estimating and Assessment Guide, March 2009.

Creating cost estimates is an iterative process, beginning with the highest levels of project information until it becomes more and more granular. Estimates may not be exact and are usually given in ranges showing the lowest and highest predictions. Ranges represent the PM's level of confidence in the cost estimating process and product. The smaller the range, the more confident the PM is with the estimate.

In addition to providing inputs to the agency's budget, estimates set the baseline expectations for the project. Estimates are used to determine how long the project is likely to take, how much it should cost, and the amount of resources needed. While multiples types of estimates exist at various phases in the project life-cycle, all estimates include narratives that detail:

1. The techniques used to develop the estimate;
2. Assumptions and constraints used;
3. The range of accuracy; and
4. The outcome in dollars.

Preliminary Estimate. The preliminary estimate is made during AoA of the concept and subsequent selection period, so little cost detail exists. The preliminary estimate is used to set the initial funding level of the project. Accuracy of the preliminary estimate can be as

much as plus or minus fifty percent. A preliminary estimate may also be called a feasibility estimate or a rough order of magnitude (ROM).

Budget Estimate. The budget estimate is developed in the Concept Planning phase and may also be called a design, control, or appropriation estimate. More information is available about the concept, allowing for a basic budget. Accuracy of the budget estimate is roughly minus twenty to plus twenty-five percent.

Definitive Estimate. The definitive estimate is developed near the end of the Concept Planning phase. At this point, well-defined requirements and product specifications exist and are detailed in the work breakdown structure (WBS). Accuracy of the definitive estimate is plus or minus ten percent. The definitive estimate is used to create the project's cost baseline.

Potential costs included in estimates to consider are:

- Labor
- Equipment
- Materials
- Services
- Overhead
- Inflation
- Contingencies
- Risk

Multiple techniques exist for estimating costs. Some of the most frequently used are:

- **Top-Down Estimates**. Estimates derived from looking at the entire project and basing the estimate on previous costs. Top-down estimates are less accurate than other forms of estimating. Top-down estimating is often used early in the project life-cycle when little information exists.

- **Bottom-Up Estimates**. Estimates derived from examining costs for each item in the WBS. This approach is very detailed—it requires a detailed WBS and additional time to examine each WBS element.

- **Analogy**. Comparison to one similar existing system; based on judgments. Little or no data exists, and the estimate is relatively quick, easy, and flexible. Analogy is frequently used in early project life-cycle phases. When generating an analogous cost estimate, examine a similar project and use actual information, not estimated or predicted information, from that project to predict the cost of like elements in another project. Another way of generating an analogous cost estimate is by using a large quantity of historical data and then basing the upcoming project's costs on those averages.

- **Parametric**. Comparison to many similar existing systems, and based on statistical analysis. The PM determines primary cost drivers and establishes Cost Estimating

Relationships (CERs). Parametric is used in early to mid-project life-cycle phases. When generating a parametric cost estimate, the estimator uses some of the parameters identified for an upcoming project as well as findings from market research to define known data points for the project. Relationships exist between these known data points. Costs are estimated by applying a mathematical equation to these relationships to scale them larger or smaller until they match the project's parameters. The exact equation varies depending on the relationship scaled to fit the project.

- When generating a cost estimate based on expert judgment, provide the parameters identified for the upcoming project to a credible expert who knows about the project's concept or market. This expert applies experience and expertise to the project parameters to provide an informed estimate of the cost for a specific aspect of the project.
- Sometimes there may be sufficient data points to generate an exact cost. To generate an exact cost, the estimator needs to know the exact quantity of a required product or service and the exact cost of that product or service. If your project will span multiple years, the estimator needs to know the purchasing power of a dollar during those future years, called the time-value of money. The time-value of money can describe a future point in time or a past point in time. Inflation and interest rates are the most commonly understood aspect of the time-value of money. By applying an equation to these exact data points, the estimator generates an exact cost.

12. Gate Reviews and the Project Budget

Projects vary greatly in their progression down the life-cycle. No two projects progress at the same rate. When the project team agrees that the specific activities of a life-cycle phase are complete, the team plans for the decision process that takes place in a gate review. The goal is to show evidence to project stakeholders that the project is ready to move on to the next phase and gain their approval to do so.

During the gate review, project stakeholders will focus special attention on how well current project funds were executed as well as what funds and other resources will be required in follow-up project phases. Often, budget management becomes the centerpiece of the review for both the exit criteria for completing a project phase and the entrance criteria for moving into the next phase. The gate review becomes an event where funds can be approved, disapproved, or taken away and given to other priority agency needs. It's important that PMs pay close attention and prepare well for a gate review to ensure the project is adequately funded.

It's common that a procurement action will occur in close proximity to starting a new project phase. It's a best practice to have the contracting process completed just short of award but unsigned until the required funding is approved. Once a favorable gate review decision is gained and funding authorized, the contract can be signed and the project's next phase can proceed without the normal time lag associated with contract administrative lead time.

E. Acquisition Governance, Part 1

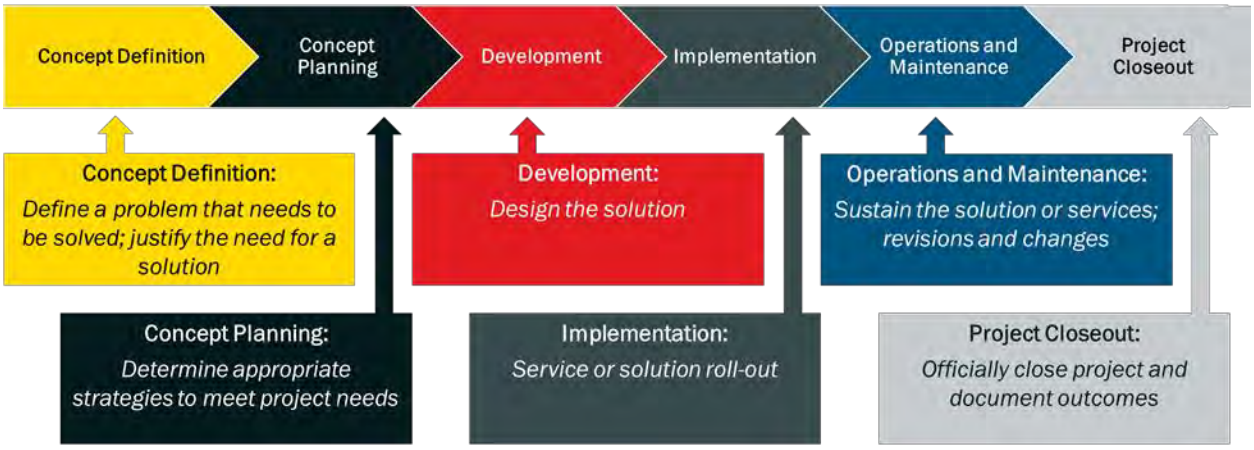
Acquisition governance begins at the inception of the project. Governance includes those activities in the Federal Triad that comprise the regulating and controlling functions of the project according to agency-specific directives and guidance on managing the project life-cycle, procurement functions as governed by the FAR, and agency supplements to the FAR. Expertise needed to develop a product or solution may not be resident within the Federal agency and will require outsourcing or contracted support. It is critical that PMs, who may also serve as Contracting Officer's Representatives (CORs), understand acquisition governance from projection inception through project closeout.

The drivers in acquisition governance are successful completion of project scope events in the project life-cycle and the procurement cycle. Examples include favorable decisions at gate reviews to proceed into the next life-cycle phase, approval of budget plans and allocation of funds, awarding contracts on time so that deliverables are available when needed, and achieving operational capability when the product is being actively used in its intended operational environment. Successful events during governance are dependent on how well project and product risks are managed and mitigated. Managing risk is critical in order to achieve an acceptable balance with the other two prime drivers in the overall acquisition process: the calendar for the budgeting process and identifying capability gaps and concepts in the requirements development process.

1. The Project Life-Cycle Model

The process through which a project develops from start to finish is called the project life-cycle. Although project life-cycles vary among Federal agencies, most project life-cycles encompass the facets of the sample six-phase life-cycle model used in this guidebook. Life-cycles are composed of a series of phases or iterations where specific work is performed to transform concepts and requirements related to a material solution that fills an agency capability gap or need into a cost-efficient product or system. They work on a definitive schedule and produce products that provide the needed utility the end-user ultimately requires. Phases are separated by points in time known as gate reviews or milestone reviews, which is when the principle stakeholders on the project assemble to review project progress in past phases and decide if the project is ready to proceed into future phases.

Figure 21: The Six-Phase Project Life-Cycle Model



1. **Concept Definition.** Analyze organizational objectives and identify where gaps in capability exist to meet those objectives.

2. **Concept Planning.** Determine the specific solution and its requirements to meet the objectives of the project, and develop the project plan for the execution of the project work, including schedule, resources, and quality control.

3. **Development.** Follow the project plan to design the product or solution and evaluate if the outcome meets project objectives and solution requirements.

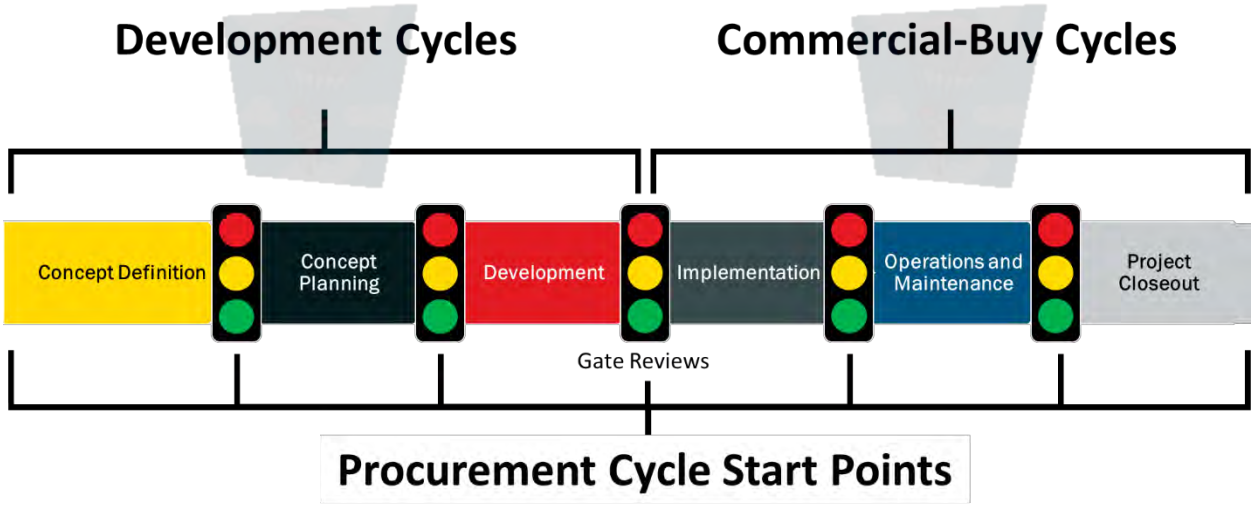
4. **Implementation.** Produce and deploy the fully functional product or service in what's called the rollout or fielding. The rollout pushes the product or service to the end-user.

5. **Operations and Maintenance.** Sustain the product or service through a support system. This is the longest and most costly phase of a project in the long term, making it important that the product or service be cost-effective and meet performance requirements.

6. **Project Closeout.** Project closeout includes two sets of activities. First, the project team documents against the required deliverables how the project has or has not met the project goals and objectives as well as documents lessons learned for future programs and projects. Second, the system or item acquired has reached the end of its useful life and must to be disposed of with the least amount of cost and potential impact on the environment.

Note that not all projects will move through each phase of this life-cycle or move through the life-cycle at the same pace. Therefore, the life-cycle process for each project will be tailored based on project needs, requirements, complexity, stakeholder interest, and level of risk.

Figure 22: Tailoring the Project Life-Cycle



Life-cycle management frameworks fall into two basic categories according to the type of asset being acquired: 1) Development Cycles and 2) Commercial–Buy or Non-Developmental Cycles. Most acquisitions can buy something "as is" off the commercial market or modify a commercial item to accommodate a few unique Government requirements. However, when a very specific need cannot be found in the commercial marketplace, the item must be designed, prototyped, tested, and then manufactured before it's implemented for operational use.

The point here is that your life-cycle phases and milestones adjust according to how you will fill the need. You "parachute" or enter into the life-cycle at different points according to the maturity level of the asset's requirements, the market availability of the asset or its components, and the technology that best meets the asset's performance requirements.

The following provides a brief overview of each phase of the life-cycle.

a. Concept Definition

Concept Definition is the first phase in the project life-cycle and serves as a foundation for future project phases. The purpose of Concept Definition is to determine whether there is a need for a project, if meeting the need is worthwhile, and, if it is worthwhile, to gain approval from senior leadership to begin planning the project. This phase includes five steps.

First, define the organization's need and examine the organization's capabilities to meet that need. Addressing any gaps in those capabilities becomes the project's purpose. Next, describe what is required to achieve that purpose. Then, select an approach, or concept, that will meet the requirements for addressing the capability gaps identified. After that, define the scope and estimate cost/benefits, the preliminary cost, and required resources. Finally, justify the initiation of the project and document that justification in a project business case. Different agencies will vary in their approach, format, and terminology for the

business case; this guidebook uses the business case. The business case is discussed in the section on Project Life-Cycle Processes.

The Concept Definition phase of a project ends with a gate review where these questions can be answered:

- Is the business need justified?
- Are the high-level requirements established?
- Is the team ready for Project Planning?

When these questions can be answered, Concept Planning can commence.

b. Concept Planning

The Concept Planning phase determines the specific solution and its requirements to meet the objectives of the project and plan for the execution of the project work. The Concept Planning phase has several steps, beginning with a kick-off meeting. Following the kick-off meeting, define and refine the project's requirements, select a solution that meets those requirements, and plan the project work.

Planning is not something done once. Planning is iterative. Plans will be updated throughout the project life-cycle, and the same is partially true of requirements. Requirements are defined and then continually added to, subtracted from, or refined as needed. However, the further the project progresses through the life-cycle, the more solid and relatively constant the performance requirements for the item being acquired must remain. This helps lower the project's risk and turbulence to cost, schedule, and performance adjustments.

Changes made to the requirements will necessitate changes to cost and schedule, and vice versa. After detailing the project's requirements and creating the needed project plan documents, the project baseline can be established. Similar to requirements and planning, as changes occur throughout the project, the baselines are also updated. More about Concept Planning is thoroughly discussed in Section C, Project Requirements Documentation.

c. Development Phase

In the Development phase, project tasks focus on finalizing the design and creating, or developing, the project solution. The Development phase concludes with the Development phase gate review, during which it is determined whether or not the solution meets requirements. If the solution meets the requirements, the project is ready for the Implementation phase.

The Development phase offers many opportunities to evoke the project risk management plan. A large number and array of resources are committed, rapidly consumed, or spent in the Development phase, which makes the Development phase the riskiest and most dynamic life-cycle phase, and it is also high cost. The length and complexity of the Development phase depends on the scope of the project solution. However, the Operations

and Maintenance phase is actually the phase where the majority of the total life-cycle cost of the project is consumed, upwards of 70% or more. That said, this cost is accumulated over a much longer period of time than in the Development phase, where high costs accumulate and resources are consumed rapidly in a short time span.

Solution approaches may be developmental, such as a custom development where design begins with blank engineering drawings, or non-developmental, such as the purchase or modification of a COTS system, where solutions leverage existing designs and performance parameters. Not all Federal projects require a new developmental solution, which entails a full, large-scope Development phase. On the other hand, purchasing COTS solutions as-is or modifying existing systems very often requires a reduced Development phase.

The Development phase has three steps:

- Design
- Develop
- Delivery

During design, determine how to develop and design the preferred solution. This entails a series of design reviews, proceeding from the conceptual or preliminary reviews initially conducted during Concept Definition and Concept Planning, toward a final design review in the Development phase of the life-cycle. Systems engineering processes occupy much of this development activity. During the final design review, the preferred solution's detailed requirements and tasks are finalized, and a formal sign-off of the solution design is taken before project work begins.

In the develop step, project work and planning documents are executed to support the creation of a fully functional project solution. Even if the project is of limited scope and complexity, the project manager may work with systems engineers, product support specialists, and testers to conduct preliminary evaluations of the project solution to ensure requirements are being met. The analyses and conclusions of these evaluations are documented in systems engineering plan updates and in a testing and evaluation, or T&E report, for further review and action. The develop step leads to a fully functional solution that is then delivered or presented to the customer for final testing and review.

Recall that these final reviews culminate in a gate review, which determines whether or not the project can move forward, go into production, and eventually deployed to end users in the Implementation phase.

The progression of tasks throughout the design, develop, and deliver steps involve both the development of the project solution, or product development, and execution of many project management functions. Solution development and project management happen simultaneously across all three steps. The PM is responsible for interfacing with industry contractors, systems engineers, and product support specialists that may be developing the solution. The PM is also responsible for managing the overall project scope to reduce risk.

The Development phase concludes with the Development phase gate review, where it is determined whether or not the solution meets requirements and is ready to enter the Implementation phase. During Implementation, the product goes into various levels of production.

d. Implementation Phase

In the Implementation phase, project tasks focus on evaluating the product, planning for implementation, and determining whether or not the product is capable of operating and maintaining operations on a long-term basis.

The implementation of the product is undertaken in three steps:

1. Test and evaluate
2. Implement
3. Prepare to transition

Test and Evaluate. In the Implementation phase, test and evaluation occurs in the operational environment. An operational environment is a setting with conditions and a product as close to realistic as possible with typical users performing typical operations. Operational testing results are documented and submitted in a T&E report. This report is discussed in a Readiness Review, or a review of the product's operational capabilities.

The Readiness Review is a review of the product's T&E results, gathered in the operational environment, to determine whether the product satisfies documented requirements. The Readiness Review examines the product against four key elements:

- Capability gaps
- Performance
- Cost
- Operational outcome

The PM works with the systems engineer to evaluate the product and answer the following questions:

- Does the product sufficiently close the capability gap as identified in the Concept Definition phase?
- Does the product perform at or above performance standards?
- Was the product developed and implemented within budget?
- Does the product achieve the operational outcomes as documented in the statement of need?

Implement. Based on test and evaluation results, the Implementation Plan (sometimes called the Fielding Plan or New Equipment Plan) documents how, when, where, and to whom the product will be deployed, installed, and transitioned into operation. This plan is put together by the PM and operations manager and answers the following questions:

- Who is involved in the deployment? Are multiple teams needed to field the product across multiple locations?
- Who is responsible for doing what? Who accounts for the product once it leaves the developer?
- Who is in charge of deployment? Who delivers and signs for the new equipment?
- Also, when will deliveries and deployments occur? Is the product delivered as one or multiple units?
- What due dates are crucial?
- Will deployment occur at a physical location, or is deployment happening virtually to devices, such as a desktop or mainframe system?
- What hardware or software is necessary to complete installation?
- What will happen to existing equipment?
- When will the product be ready to transition from Implementation to Operations and Maintenance, and how will users be trained on the new solution?
- Does the solution come with any initial support, such as spare parts, training manuals, diagnostic equipment, or supplies?

Next, in the implement step, the PM follows the Implementation Plan to manage and document the implementation of the product in an operational environment.

Prepare to Transition. In the Implementation phase, product support managers or logistics specialists work closely with the PM and other systems engineers to develop and ensure the readiness of an effective and efficient maintenance support system. Ensuring the effectiveness and efficiency of a support system begins in the Concept Planning and Development phases, where product support reliability and maintainability are planned and infused into the product's design.

In preparing for the transition to Operations and Maintenance, the Product Support Plan or Integrated Logistics Management Plan is updated and outlines what tasks are necessary for maintaining and sustaining the product, the proposed schedule for product support services, and what costs are associated with product support tasks. To update and implement the Product Support Plan, the PM must ask:

- What products or services are needed to sustain the product throughout its life?
- Who will be responsible for executing product support tasks?
- How long will the solution be operational and need product support services?
- When will support tasks occur?
- How much will product support services cost?
- Can the project budget afford the product support tasks and schedule as outlined in the Product Support Plan?

As the product transitions from Implementation into Operations and Maintenance, the PM needs product support systems and services that help meet availability goals for the product and business processes for management of the project through to Closeout. When product and project goals have been finalized and documented, the project is ready for review.

In the Implementation phase gate review, the project sponsor and members of senior leadership review the completed deliverables, such as the T&E results, the Implementation Plan, and Product Support Plan. Once the project sponsor and members of senior leadership determine that all tasks and deliverables meet entrance criteria, the team proceeds to evaluate the project based on the sustainability of the product solution, a primary exit criteria. Whatever the outcome is, it should be captured in an approval document, which documents the operational capabilities of the product and outlines whether or not the Product Support Plan is approved.

Senior leadership and the project sponsor use exit criteria to evaluate whether the project is ready to proceed to the Operations and Maintenance phase. This evaluation depends on four questions:

- Does the product meet requirements to close one or more capability gaps?
- Does product performance meet or fall below technical performance standards?
- Did operational implementation of the product meet or exceed project budget?
- Is funding available and stable to support operations and maintenance of the product?

If the answer to these questions is "yes," the project continues to the Operations and Maintenance phase. If the answer to any of these questions is "no," the project sponsor and senior leadership may conditionally approve the project and proceed to Operations and Maintenance, defer the gate review decision until desirable conditions are met, or modify the project management plan significantly to include terminating the project altogether.

e. Operation and Maintenance Phase

The Operations and Maintenance phase serves to transition the product into a long-term or sustaining environment. A successful sustaining environment is defined as one that is cost-effective while meeting operational tasks within budget and that continues to meet the Statement of Need. The Statement of Need is the description of how each capability gap is addressed and the specific benefits of addressing each gap.

To ensure the effective and efficient operation of the solution, the Product Support Plan is executed. The Product Support Plan is first created during the Concept Planning phase and is then refined during the Development and Implementation phases. It describes what products, systems, training, and maintenance services are needed in the sustaining environment of the Operations and Maintenance phase. All operational tasks in the sustaining environment are managed by the operations manager. The operations manager, or function, is the entity that takes over managing the asset or solution after it transitions from being managed by the PM and project team.

At regular intervals in the Operations and Maintenance phase, the project sponsor and members of senior leadership conduct gate reviews to evaluate how well the solution is performing in the sustaining environment and whether or not the solution still meets requirements and needs.

The solution continues to operate in the Operations and Maintenance phase, assuming any changes and improvements to the project and solution were successful and the solution continues to meet needs and requirements as well as if funding is available to continue operations. Operation and maintenance of the project and solution is undertaken in three steps:

- Transition
- Manage
- Prepare to close

During transition of project responsibilities from the PM to the operations manager in the Implementation phase, the PM's primary responsibilities are to manage ongoing change and quality issues as well as ensure the successful transition of project resources, successful fielding of the product itself to end-users, and successful transfer of management responsibilities to the operations manager in a logical manner. Fielding a new product to end-users can be a complex task, involving training for operators and maintainers, physical transport of the system to the geographic location of use, property accountability actions, and providing the required product-support package of equipment and parts to maintain the fielded system. The operations manager is responsible for performing all management tasks related to the sustainment of the project solution once received, including tracking how the new system and its support package is received by the end-users and conducting several evaluations or tests of the solution in the operational environment.

The Project Transition Plan facilitates successful project transition from Implementation into Operations and Maintenance, and supports the Project Development Brief. The Project Transition Plan, which the project manager and operations manager create in the Implementation phase, provides processes for coordinating successful project handoff, determining how members of the project team transition into operations, and deciding what project documentation is transferred to the operations manager and how that transfer is to happen.

During transition, product support specialists and systems engineers work with the project and operations managers to implement a previously developed Concept of Operations (CONOP) that is iteratively assembled prior to the Implementation phase. A CONOP includes objectives for the Operations and Maintenance phase, such as product performance in its operational setting, product modification, product support, and maintenance and training goals. While developing the CONOP, systems engineers plan or develop any required physical or virtual interface systems the product must interoperate with, such as storage devices, enterprise operating systems, and prime power sources.

The PM and the operations manager ask several questions to ensure successful project transition:

- Is there an agency-approved process for project transition?
- What is the established timeline for project transition, and when will handoff officially begin?
- What responsibilities do the PM and the operations manager have?

- Will members of the project team change? Will some members transfer to the operations team?
- What are the roles and responsibilities among team members?
- How will members of the project and operations team communicate?
- What project documentation does the operations team need for successful transition and operation?
- Is the applicable project documentation finalized and ready for handoff?
- If there are outstanding action items, how are they addressed?

By documenting the answers to these questions, the PM and the operations manager will have a complete and thorough plan to review. The plan will be reviewed during the Project Development or Transition Brief, which officially marks the beginning of project transition, including the change in management responsibilities.

The operations manager now becomes responsible for operations and maintenance activities and works closely with product support specialists to manage the ongoing operations and maintenance of, and improvements to, the fielded product. Multiple project elements must be managed, including:

- Project communication
- Resources
- Schedule
- Operational costs
- Project risks
- Quality
- Changes or modifications to the product and project processes
- Service and maintenance contracts
- Technology

The operations manager and PM coordinate and collaborate to ensure proper execution of documentation developed in previous project life-cycle phases, such as:

- Project technical plans (systems engineering, test and evaluation, logistics)
- Communications Management Plan
- Risk Management Plan
- Quality Management Plan
- Quality Assurance Surveillance Plan
- Change Management Plan

It is the operations manager's responsibility to evaluate performance of the product in the sustaining environment and submit an Operations Analysis Report. The Operations Analysis Report, which is developed by the operations manager and reviewed by the PM, documents the results of several analyses, including end-user and customer feedback, product and project performance, financial analysis, risk analysis, and compliance with policies and standards.

The operations manager does not draft the Operations Analysis Report until well into the Operations and Maintenance phase in order to have sufficient data regarding the solution to conduct a comprehensive analysis. The PM reviews the analyses and assessments in the Operations Analysis Report to answer two important questions:

1. Does the solution continue to provide desired results as defined in the Concept Definition and Planning phases?

2. And is improvement or replacement of the solution, in whole or in part, needed?

The Operation Analysis Report helps the PM determine if improvements or project and product modifications should be implemented. In the Operations and Maintenance phase, some improvements to the project and product are inevitable because once the product or system is operational, limitations and opportunities for improvement become apparent. Regardless of how robust the past testing and evaluation of the product have been, operational use of the product with likely surface the need for modifications or improvements of the fielded product.

Changes to the product come from several sources, including requirements evolution, quality deficiencies, upgrades to existing equipment and software, changes in systems that interface or interoperate with the solution, and a loss or lack of funding to continue operations. Change can also arise out of updates to policy or Federal regulation, variability in the availability of suppliers and vendors, and fluctuation in market trends, such as inflation. When changes are significant and affect the project baseline, the change must be approved by the Change Control Board, which is the entity responsible for reviewing and approving any changes to the project and product baselines during the final phases of the project life-cycle.

As the Operations and Maintenance phase progresses, the final stage is preparing for project and system closeout. Senior leadership and the project sponsor use exit criteria to evaluate whether the project is ready to proceed to the Closeout phase. This evaluation depends on three questions:

1. Does operation and maintenance of the solution continue to satisfy project and operational requirements?

2. Does operation and maintenance of the solution still satisfy agency and end-user needs?

3. Is sufficient funding available to continue operating and maintaining the solution?

If the answer to these questions is “yes,” the project and product continue to operate in the Operations and Maintenance phase with intervals of review and continuous evaluation based on the questions above.

f. Closeout Phase

The solution moves into the Closeout phase if the product reaches the end of its useful life, the product solution is no longer relevant to the customer, or if funding is unavailable to continue operations. Closeout includes two primary activities: (1) disposition or disposal of the product and (2) conclusion of project management activities, which may occur well before the product itself is finally disposed.

The first goal of the Closeout phase is to properly complete necessary disposal or disposition of materials, parts, or supplies. Another goal is to capture any general project management information from the project and share it with future projects. This information can become a valuable training resource for new project managers. Closing out a project also frees up resources that are no longer being used and allows them to be applied to other projects and activities. The last key goal of this phase is to archive project records. These records include various project plans and estimates as well as all contracts that were awarded and executed.

The document guiding this final phase of the project life-cycle is the Closeout Plan. Closeout Plans vary by agency but typically contain documentation of the project's performance, a list of project resources, post-implementation plans for activities that will occur after closeout, and a list of closure activities in the form of a Closeout Checklist. Closeout activities are the same whether you are closing out an entire project or just a portion of a project. The Closeout phase has three parts:

- Contract closeout
- Administrative closeout and lessons learned
- Product disposal

If your project includes acquisitions, contract closeout will require verification that all work on contracts is complete. If the project has multiple contracts, each contract is assessed individually. The Contracting Officer takes the lead in contract closeout with inputs from the Contracting Officer Representative (COR) and technical team. When closing out Government contracts, FAR 42.1502(b) states that an evaluation of contractor performance must be made for each contract that exceeds the threshold for simplified acquisitions. The project's COR is responsible for working with the Contracting Officer to provide ratings and comments to the contractors. The Contracting Officer is then responsible for verifying the contractor received all payments and closes out the contract in accordance with FAR Part 4.804. The final step in contract closeout is to archive contract information.

This administrative closeout involves obtaining confirmation that the solution delivered meets all stated requirements of the sponsor, customer, and all stakeholders. This includes verifying that all deliverables have been submitted and accepted. The Closeout Checklist is also a deliverable of the project documentation and ensures that every task has been achieved. If there are any materials or equipment to be disposed of at the end of the project, that will be taken care of during administrative closeout as well.

The final step in the administrative closeout process is to document the lessons learned throughout the project. The PM should hold a "lessons learned" meeting with the project team members to record what worked well on the project and what should be repeated. The PM should also document the challenges or problems encountered and make recommendations for improvement. The PM should celebrate the project's successes and recognize team members for their individual contributions to the project. The Lessons Learned Report is another deliverable for the project documentation.

Product disposal is often unplanned and unfunded on projects, but disposal should be planned and budgeted up front and early in the Concept Planning phase. It should then be modified throughout the rest of the project life-cycle to accommodate project and product changes as they evolve. This planning is especially critical if the product's design involved use of hazardous materials or would have any other related impact on the physical environment. Environmental, Safety and Occupational Health (ESOH) plans assembled during integrated logistics and product support planning must include arrangements for disposing of the product along with the provisions of the myriad of laws and Executive Orders for protecting the environment.

Other closeout planning actions should include:

- Physical recovery and transport of the system;
- Storing products or systems for possible future use;
- Recovery, reproduction, refit, or remanufacturing actions;
- Disposition of repair or spare parts inventories;
- Provisions to reclaim value from the product through sales to the public or other entities;
- Provisions for salvaging any components of the product that could be used on other current or future projects; and
- Deciding if any of the technical data and other documentation can be used or applied to other projects.

Disposal can be costly if not budgeted for appropriately. The cost and associated risks of disposal are often overlooked, assumed, or knowingly ignored as "somebody else's problem."

2. The Business Case

The business case and its approval by senior stakeholders formally initiates the project. Selection of the PM may not occur until the business case is approved. Also, approval of the business case is usually when the project becomes fully funded. In order to gain approval and initiate a project, the PM needs to provide decision makers with a description of the need and related capability gaps, benefits of addressing those capability gaps and meeting the need, estimated cost of the project, selected concept, and feasibility in terms of schedule and personnel requirements. All this information, including the analysis process and resulting rationale for undertaking the project, is documented in a business case.

For a small percentage of projects classified as "Major Acquisitions," organizations must submit OMB Exhibit 300 to the Office of Management and Budget. OMB Exhibit 300 is a type of business case form submitted by an organization to OMB to justify the organization's request for funds in support of its major acquisition. The majority of Federal projects, however, are not classified as major acquisitions and will not require OMB Exhibit 300 reporting but may require a business case process. Business case formats and content vary by agency. You should draft a business case that meets your agency's requirements. Regardless of format, every business case provides stakeholders and decision authorities with a compelling argument that the project's benefit to the organization is worth its cost.

a. Why a Business Case?

Organizations have a limited amount of funding and resources, and every project in an organization requires a portion of those limited funds and resources. Federal organizations often have more project needs than funding and resources to accommodate those needs. Management must evaluate the worth of each project against other projects competing for resources and against the organization's priorities.

The business case provides the information needed to evaluate a project's worth by clearly detailing the positive effect that the project will have on the organization and the cost required to complete the project and achieve its positive effect. The business case aids an organization's leadership in determining project feasibility, justifying and acquiring resources, prioritizing which projects are initiated sooner and which later, and establishing criteria, such as scope and high-level requirements, for assessing the success of a project. The business case should:

- Detail the AoA, including a description of concept options evaluated, the process used to evaluate them, the concept selected as most appropriate, and the rationale for choosing that concept.
- Outline the strategic goals the project will support and corresponding performance parameters that measure how well the project addresses capability gaps and supports those goals.
- Provide an estimate of the project's total life-cycle cost, which includes the cost of developing, implementing, and maintaining the project's concepts. This cost estimate should list current funding sources and describe the types and dollar amounts that funding the project will need as it progresses through the life-cycle, which may include projections for multiple years.
- Describe any predicted project risks and provide a preliminary plan for mitigating those risks.
- For projects with reporting requirements in accordance with OMB Circular A-11 and FAR Part 34.2 requiring an EVM system, the business case should include EVM data, such as the EVM method selected and the type of EVM data that will be collected.
- Identify all project stakeholders.

A project's budget and schedule includes the money and time needed to administer the total project, often called "cradle to grave." Because of this total life-cycle approach to project management, the business case should also describe how your project will collect

operational analysis data. Operational analysis data details post-project activities, such as how to address system performance issues and modifications as well as the cost of maintaining the system through its expected life.

b. Analysis

To make a good justification for the project, senior leadership needs objective, quantifiable information. To do this, the PM and project team perform several analyses and document the process and results for each in the business case.

- First, conduct a cost-benefit analysis. This analysis compares the financial cost of developing, implementing, and maintaining the concept against the predicted benefits provided to the organization.
- Next, perform an affordability assessment. This assessment examines the financial costs and benefits of a project derived from cost-benefit analysis by analyzing them in the context of the organization's current and future funding. In other words, can you afford it?
- Finally, because manpower is a primary cost driver and greatly impacts an organization's ability to achieve its strategic goals, the analysis contains a draft manpower estimate report. This report describes the effect of implementing the concept and addressing the gap in terms of which personnel are affected, the labor-hours and additional skills required to develop and support the concept, and when in the project life-cycle these personnel resources are required. Note that your organization may require these analyses to be documented in separate deliverables instead of included in the business case.

Cost-benefit analysis involves three steps. First, identify all the elements that contribute to the cost of a concept over its lifetime. This includes the financial, time, and personnel costs to develop the concept through acquisition or manufacturing, implement the concept through training or process re-engineering, operate the concept, maintain the concept through repairs or updates, and dispose of the concept when it no longer meets the need. Next, identify the benefits the organization will gain once the concept is developed and implemented. Whenever possible, describe these benefits in quantifiable terms, such as dollars saved, fewer hours spent, or less personnel required to perform a task. Finally, compare the financial, time, and personnel costs of implementing a concept to address a gap against the quantified benefits of using the concept to address the gap. For a project to be worth the investment, the benefit should ideally exceed the cost, but this is not always the case. Some projects, such as the U.S. space program, provide societal benefits that justify the project despite its cost exceeding any financial benefits.

c. Cost Estimating

Accurately predicting the cost of a project is challenging. To help make accurate cost predictions, a number of cost estimating techniques exist that approximate the financial resources required to implement a project. These techniques include analogous cost estimating, parametric cost estimating, relying on an expert's judgment, and calculating

exact cost. Cost estimating is explained in more detail in the Budget section of this guidebook.

To employ any of these techniques, the PM and team must identify a few basic project parameters such as estimated project duration; project elements with associated costs, such as equipment, materials, facilities, services, and training; and estimated number of project personnel and their wages. When documenting a cost estimate, include the rationale for why and how a cost estimating technique was applied, the calculations used and the values input into those calculations, any assumptions or constraints applied, and the outcome in dollars.

d. Cost

Whether it is the price of purchasing equipment, facilities, or personnel, cost should always be measured in dollars. Benefits can include elements that are automatically measured in dollars, such as a lower purchase price, and elements that are not automatically measured in dollars, such as shorter processes, improved reputation, employee satisfaction, or public welfare. The PM and team perform benefits forecasting to measure benefits in terms of dollars, thereby providing a basis for comparing the dollar cost of obtaining benefits against the dollar value of their positive effect. In benefits forecasting, identify the benefits, quantify them, and estimate the effect of the benefits across future years.

When identifying the project's benefits, determine what type of effect each benefit will have, and then group benefits with similar effects together. Next, to the extent possible, quantify the benefits in terms of hours saved, dollars saved, or less personnel required to perform a task. Then, forecast the positive effect of benefits across future years. Finally, compare benefits against the cost of developing the concepts that provide those benefits and trace each benefit back to one or more of the organization's strategic goals or mission.

Benefits can be described as either tangible or intangible. When a benefit can be measured, or quantified, it is considered tangible. Lower investment cost and decreased labor hours are two examples of tangible benefits. Tangible benefits typically involve acquiring, or reducing, assets and personnel. Tangible benefits result in a concrete effect that can be attributed directly to a cause. For example, a lower purchase price results from lower initial investment costs. Intangible benefits are difficult to quantify. Instead of reducing personnel, intangible benefits enable personnel to perform more efficiently (e.g., increased morale or better communication). While intangible benefits can contribute to a concrete effect, it is difficult to clearly demonstrate that intangible benefits are the cause of a concrete effect.

Once the PM and team have identified and quantified the project's benefits, they now have the information necessary to forecast the effect of those benefits across future years. To forecast a benefit, extend the benefit's positive effect for the period of your analysis, typically one, two, or four years. When calculating a benefit's extended effect, adjust the prediction to account for several factors: (1) the decreased purchasing power of a dollar each successive year, referred to as the time-value of money (the time value of money increases costs and decreases value of financial benefits); (2) operations and maintenance or update costs that offset financial benefits; (3) the decreased number of times a benefit

occurs each successive year, referred to as transaction or usage volume variance; and (4) the lessening of a benefit's positive effect over time, referred to as diminishing returns. The following examples help clarify these factors further:

- **Time-Value of Money.** If inflation increases, then the purchasing power of a dollar decreases—it takes more money to buy the same items. Increasing costs offset financial benefits and decrease the value of financial benefits.

- **Operations and Maintenance/Updates Costs.** If a purchased item requires periodic maintenance by the manufacturer that is not included in the purchase price, you would increase the cost of the item to include maintenance costs. Increased costs offset financial benefits.

- **Transaction or Usage Volume Variance.** If a benefit occurs five times the first year but only occurs four times the second year and three times the third year, you would decrease the estimated benefit each year accordingly.

- **Diminishing Returns.** Systems perform better when they are new than after they have some wear and tear after years of use, requiring you to decrease the estimated benefit each year accordingly.

Once you have estimated total life-cycle cost and forecast the positive effect of the benefits the project will provide in terms of dollars saved, compare the project's cost against its benefits to determine if the project is worthwhile. If the project is determined to be worthwhile and you can trace each benefit (or group of benefits with similar outcomes) back to one or more of the organization's strategic goals or mission, this will solidify the justification for the project.

A cost-benefit analysis results in a simple determination of the organization's ROI. "Return" means the quantified benefits a concept will provide. "Investment" means the cost of developing the concept that provides those benefits. ROI expresses the comparison between benefits and cost, or what the organization receives in return for investing in the development of a concept.

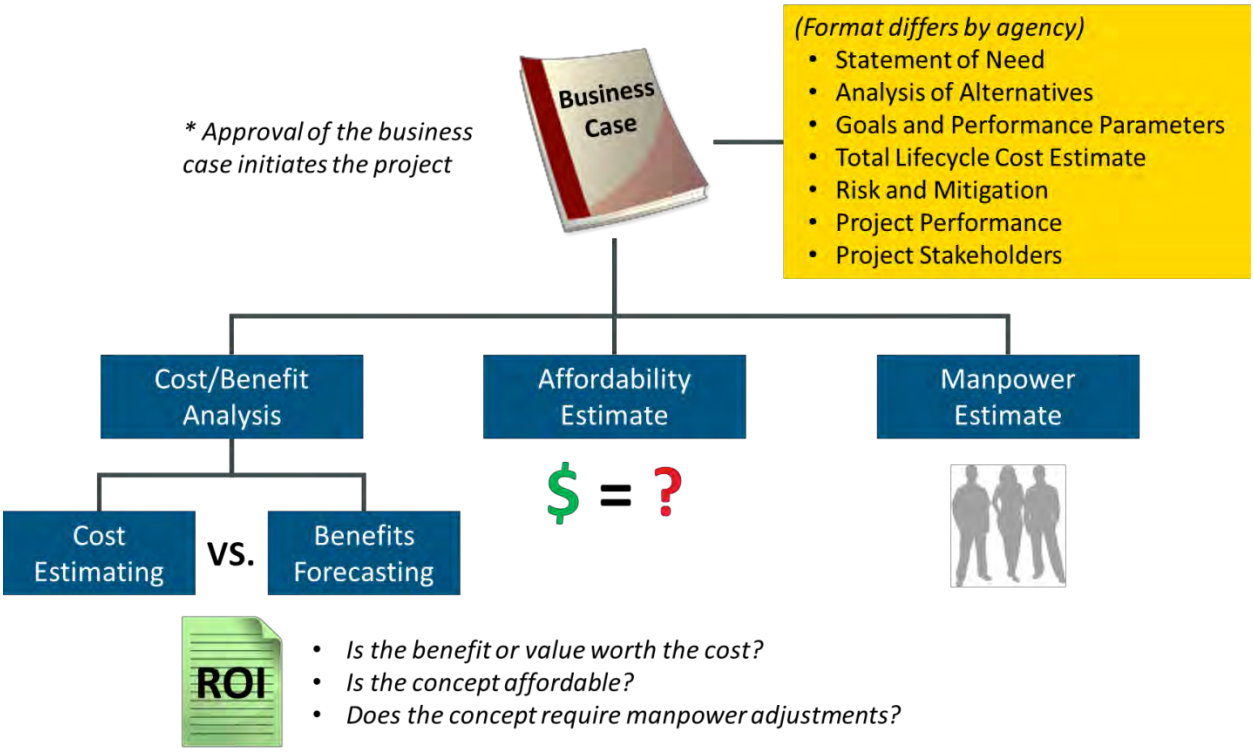
e. Affordability Assessment

An affordability assessment expands on the cost-benefit analysis by examining the comparison of costs to benefits over a specific period of time. By using data from the cost-benefit analysis, the total cost is calculated at the end of the period of time the affordability assessment covers. As part of the affordability assessment, also determine when during the period of analysis the positive effect of a concept's benefits will offset the cost of developing the concept that provides those benefits. This is sometimes referred to as the "break-even point" or the "payback period."

Personnel resources. Manpower estimates are included in the business case and details personnel requirements for the concept for every fiscal year the end-user will implement the concept. It estimates the number of both Federal and commercial personnel required to

provide training for, operate, and maintain the concept after it has transitioned from the project team that developed it to the end-user who implements it. The manpower estimate should detail the skill types and number of full-time equivalent positions for each skill type required each year. Additionally, detail the assumptions and cost-estimating relationships used to calculate these estimates.

Figure 23: The Business Case



3. Project Life-Cycle Processes

The following section includes the generic processes and functions that are applied at different times throughout the entire project life-cycle and characterizes the tasks, deliverables, milestones, procedure, and process of project management.

a. Project Kick-Off

Before the PM and project team can make progress in planning the project, they hold a kick-off meeting to outline the goals of the project and the expectations of the project sponsor as well as to assign roles and resources to the project. They will also create a high-level schedule for the tasks and deliverables of the project. Important outcomes of a project kick-off include three key documents that, once approved, set the parameters for your project and guide detailed planning. These key documents are the Project Charter, the Scope Statement, and the Team Charter.

The Project Charter states the project's objectives, identifies success measures, and gives you the authority to begin the actual project work. It should reference the decisions and outcomes of the Concept Definition gate review. The Scope Statement contains a narrative description of what project work needs to get done. The Team Charter provides information regarding rules and standards for members of the project team.

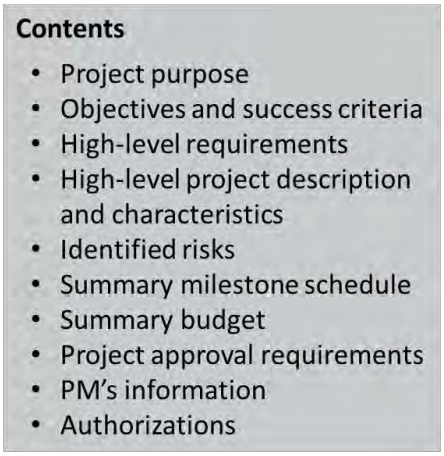
The Project Charter, built on information in the business case, is a very important planning document because it initiates the project in the context of assembling the PM and the project team. The PM will likely write the charter or at least contribute to it. Begin the Project Charter with a brief statement of the project's purpose, linking the project to the agency's mission and strategic plan. In other words, why are you undertaking this project? Then, provide greater detail about the purpose of the project in the project objectives. What do you want to accomplish? With each objective, state its criteria for success. How will you know you have met your objectives? State the requirements, as known at that point. Restate the high-level requirements from the business case, revising them if necessary in view of any changes since its approval.

For the next section, write a description of the project. Describe the products or services that the project will provide. Since it is early in the project, this description will also be at a high level. However, include as much detail as possible because future project activities will be based on this information. Include a list of risks identified to date along with any project assumptions, dependencies, and constraints. These risks should be addressed in the context of project costs and schedule and performance parameters. List project milestones and specify their due dates to help outline the project schedule. Also include a summary of the project's budget, which you can obtain from the project's sponsor or the finance office. Be sure to include the project's approval requirements. You can determine this information by asking questions like, "What does project success look like?" and "Who determines if the project was successful?"

Insert a section about the project manager, addressing the PMs authority and responsibility on the project. Finally, end the charter with a section for authorizations. The signatures of the authorizers empower you to start the work of the project.

Figure 24: The Project Charter

The Project Charter becomes the "contract" between the PM, project team, and senior stakeholders



** Team members sign during kick-off meeting*

b. Scope Statement

The Scope Statement is a narrative description of the project's scope, or what needs to be accomplished on the project. It is important to create this document early in the life-cycle because it contributes to other planning processes. Once developed, the Scope Statement provides a baseline for decisions made later. Also, by defining the project's scope, it helps to develop and confirm understanding among stakeholders of the project's boundaries.

The Scope Statement begins with a detailed description of the project's work. This description should include the requirements of any products that will be acquired, modified, or developed to meet the customer's needs. Next, clearly state the user's acceptance criteria for all products. How will the user determine if the delivered product is satisfactory? Using the Specific, Measurable, Attainable, Relevant, and Time-Related (SMART) method to write the acceptance criteria will ensure success is measureable. Additional information on using SMART is included in Section G of guidebook.

Include a list of project deliverables. A deliverable can be a piece of equipment, a report, or even training. Continue defining the boundaries of the project. If any exclusions, or work not to be included, have been identified, ensure they are clearly stated as out of scope.

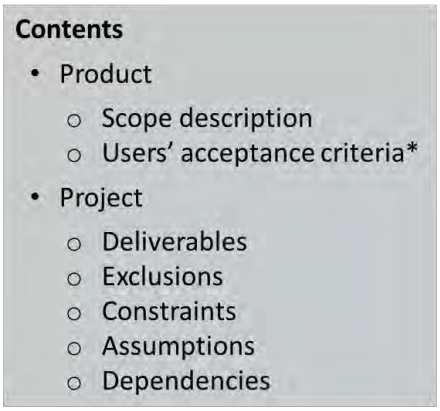
Be sure to include any known technical, cost, and schedule constraints in the Scope Statement. Determining these constraints can help recognize competing demands for resolution. Constraints on the project might be related to funding, time, human resources, quality, technology available, or other areas. Include any assumptions made while planning for the project in the Scope Statement. Project assumptions are statements that are accepted as true that may impact the project. Lastly, list any dependencies that exist on the

project. For example, on-time completion of the first phase of construction depends on the architect providing blueprints by the specified date.

It takes practice to write a comprehensive Scope Statement, and it is important that the PM and team get the Scope Statement right as it defines the boundaries of the project.

Figure 25: The Scope Statement

The Scope Statement describes the work to be accomplished on the project



** How will the user determine if the delivered product is satisfactory?*

c. Kick-Off Meeting

The project kick-off meeting is one of the first meetings in the Concept Planning phase of the project. There is a lot to cover in the meeting, so allow sufficient time. Many important decisions must be made during this meeting, so it is vital that those with the authority to make decisions attend the kick-off. Do not hold the meeting until the PM, project team, the project sponsor, the customer, and representatives from all departments participating in and impacted by the project are able to attend.

Clearly state the objectives of the kick-off meeting on the agenda so that all attendees know what needs to be accomplished. The objective of the kick-off meeting is to establish project goals and expectations, assign roles and responsibilities, and create a high-level schedule for the tasks and deliverables. It is also the perfect opportunity for the PM to begin building a team that is motivated for success. To help accomplish all of this during the kick-off meeting, the attendees will review, update, and approve the Project Charter and Scope Statement. Also, the kick-off meeting is where the team creates a Team Charter. Finally, during this meeting, the project obtains all necessary document approvals from senior leadership to move forward with the work of the project. The following discusses how to review and approve these three key documents during the project kick-off meeting.

In preparation for an effective kick-off meeting, send the draft Project Charter to all participants along with their meeting invitations. When reviewing the Project Charter in the meeting, briefly outline the purpose of the project and discuss the project's objectives and success criteria. Encourage all attendees, especially the customer and project sponsor, to participate in this discussion as the group validates the success measures outlined in the Project Charter. Follow these guidelines during the kick-off meeting:

- As needed, review and validate the high-level requirements, project description, and product characteristics. Knowing that changes will occur as the project progresses, the goal is to clarify what is known at this point. Later in the project, trace the project's requirements back to this high-level list.
- Discuss any identified risks and the risk tolerance threshold for the project. Identifying possible risks is the first step in risk-management planning for the project.
- Review the summary list of milestones and deliverables. This list will be used later in the planning process to create a breakdown of the work to be performed.
- Review the budget information with the sponsor, and verify that the funds are available.
- Validate the approval requirements for the project with the sponsor and the customers in attendance.
- Finally, ensure that team members have a clear understanding of the PM's responsibilities and the level of authority.

When the group finishes reviewing, validating, and approving the Project Charter, all team members sign it to show their agreement. With the signature of the sponsor, the approved Project Charter becomes an agreement between the sponsor and the project team to complete the work of the project.

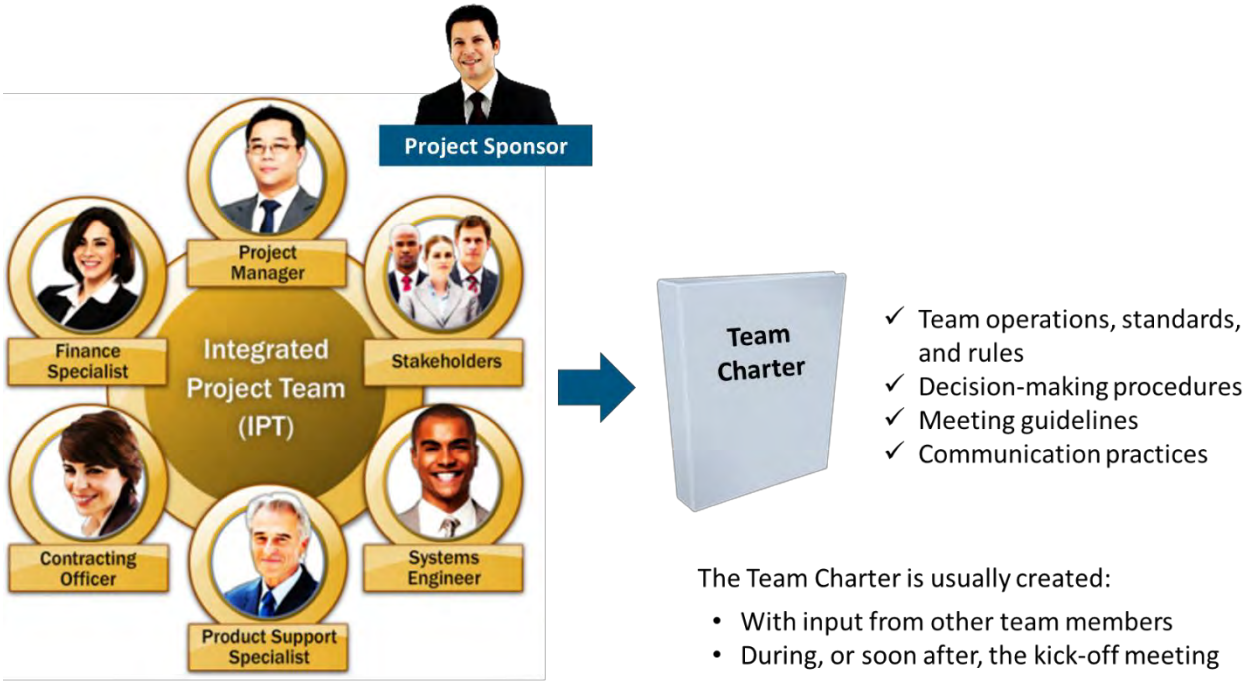
Scope Statement. Following the same process used to review the charter, review the Scope Statement with the team. With the key stakeholders in the room, this is the perfect time to validate that the Scope Statement correctly identifies all stakeholders. Confirm that all agree to the description of the project's work. Review key milestone dates, the resources that will be employed, and the methods those resources will use to complete the work. Then, confirm the overall impacts and goals of the project. Revise the Scope Statement if needed so that the answers to these questions reflect the agreement of the members of the team. From this point forward, the scope of the project will be managed. But it is this version of the statement, agreed upon at the beginning of the project, that is used as a basis for scope-related decisions as the project continues.

d. Team Charter

The Team Charter, or operating agreement, documents how the team will work together. There is no required format or content for the Team Charter, but it should include the procedures for making team decisions. This should include identifying a tie-breaker for times the team is unable to reach consensus. Include information related to how and when team meetings will be conducted and a communication plan for ensuring all team members are aware of ongoing discussions and decisions as they are made. Though the Team Charter can be created at any time during the project, it is not usually created before the project

kick-off. The earlier it is created, the earlier members of the team can begin working effectively toward meeting their goals. The PM can create the Team Charter with the project sponsor and present the finished document to the other team members. Alternately, all identified members of the team can create it together. Getting input from team members generally increases their buy-in and support of the Team Charter. When the Team Charter is complete, all members of the team sign it, signifying agreement to abide by its provisions.

Figure 26: The Team Charter



e. Tasks, Deliverables, and Milestones

All project life-cycle phases contain associated tasks and deliverables. The phases of the life-cycle are divided by milestones or gates which serve as the logical breakpoints in the life-cycle.

- **Tasks** are activities that support the project.
- **Deliverables** are tangible work products that result from the tasks.
- **Milestones** are significant events in the project, such as the completion of a deliverable, or a decision (gate) review of phase events that are noted as such in the overall project plan.

f. Gate Reviews

Projects move through each phase in the project life-cycle by passing through gates at the conclusion of each phase as shown below in Figure 27. Gate reviews allow stakeholders to

review what has been done in the past phase, make decisions based on that review, and plan and direct the work scheduled to happen in the next phase.

Gate reviews determine the following:

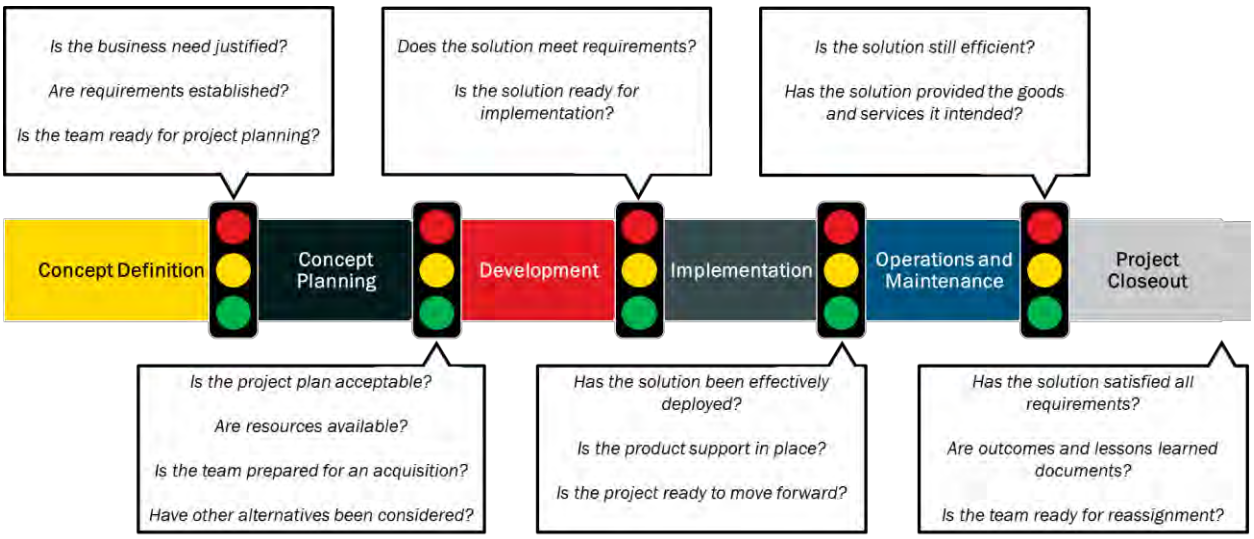
1. Will the project move ahead as planned?
2. Will discrepancies be fixed and then the project can move ahead?
3. Will discrepancies be fixed and then another gate review must occur?
4. Will the scope change as a result of the gate review?

A designated governance body leads the gate reviews and may include agency leadership from various offices, including the acquisition and financial offices, the program manager, the business owner, and other critical stakeholders. Membership should vary by the criticality of the project to the agency mission.

In the gate review, the governance body is provided with the documents and deliverables that will be used to evaluate whether the project has met the agreed upon criteria to proceed. These criteria set the conditions to be met for exiting the past phase and entering the next phase, thus often referred to as exit and entrance criteria. The gate review will also surface issues and questions that relate to managing project cost and schedule and scope risk as well as ensure that the project continues to both meet its purpose and address identified needs. Gate reviews should be concluded with a decision memorandum documenting all decisions made, including the criteria and tasks and deliverables expected in the next phase.

Represented by traffic lights, gate reviews determine whether the project should stop, proceed with conditions, or move into the next project life-cycle phase. Figure 27 contains key questions that should be asked in each gate review.

Figure 27: Gate Reviews



Best Practice. Although formal personnel performance reviews usually happen annually in the Federal Government, gate reviews provide an ideal opportunity to review individual team members' performance in that phase and provide feedback on what they did well and what they could improve upon moving into the next phase. Organizations that continuously seek to improve will conduct such sessions multiple times during the course of a long project.

g. Software Development

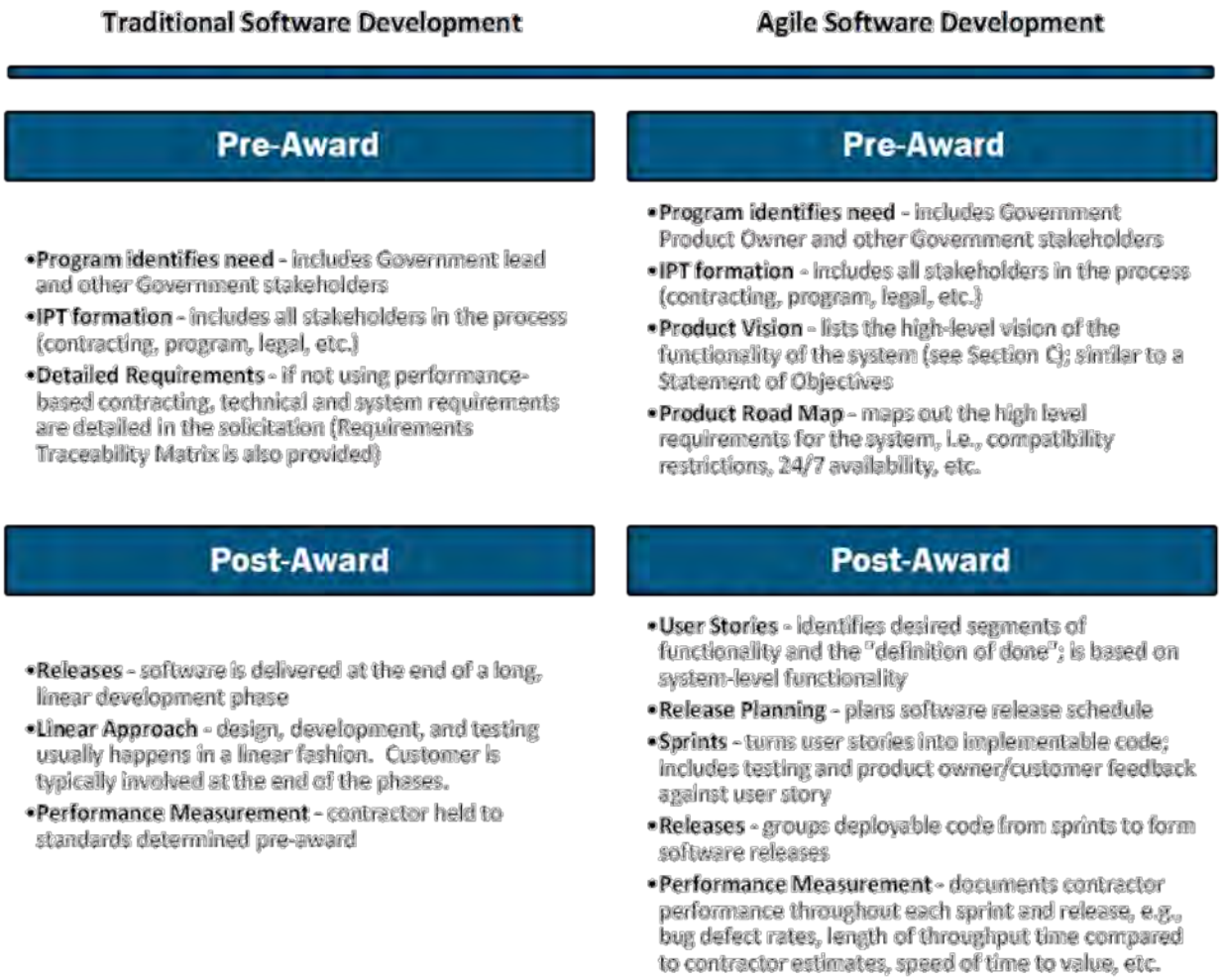
Two basic software/IT development strategies exist: Waterfall and Agile (modular). With waterfall or single-step, the solution moves through the development cycle once. In other words, the acquisition, development, and deployment of the entire system occur in a series of progressive singular efforts. This strategy works best for software acquisition projects where the requirements are understood, defined, supported by precedent, stable, and low risk.

Agile is a development methodology in which requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes transparency, adaptive planning, evolutionary development, early delivery, continuous improvement, and encourages rapid and flexible response to change. According to the Manifesto for Agile Software Development, the Agile methodology values:

- Individuals and interactions over processes and tools;
- Working software over comprehensive documentation;
- Customer collaboration over contract negotiation; and
- Responding to change over following a plan.

Multiple Agile approaches exist including Adaptive software development, Agile unified process, Kanban, Scrum, and many others. Both the U.S. Digital Services Playbook and the TechFAR point to Agile as a best practice in software development projects. As part of the acquisition process, Agile is different than traditional development approaches, as depicted in the figure below.

Figure 28: Traditional vs. Agile Software Development (TechFAR)

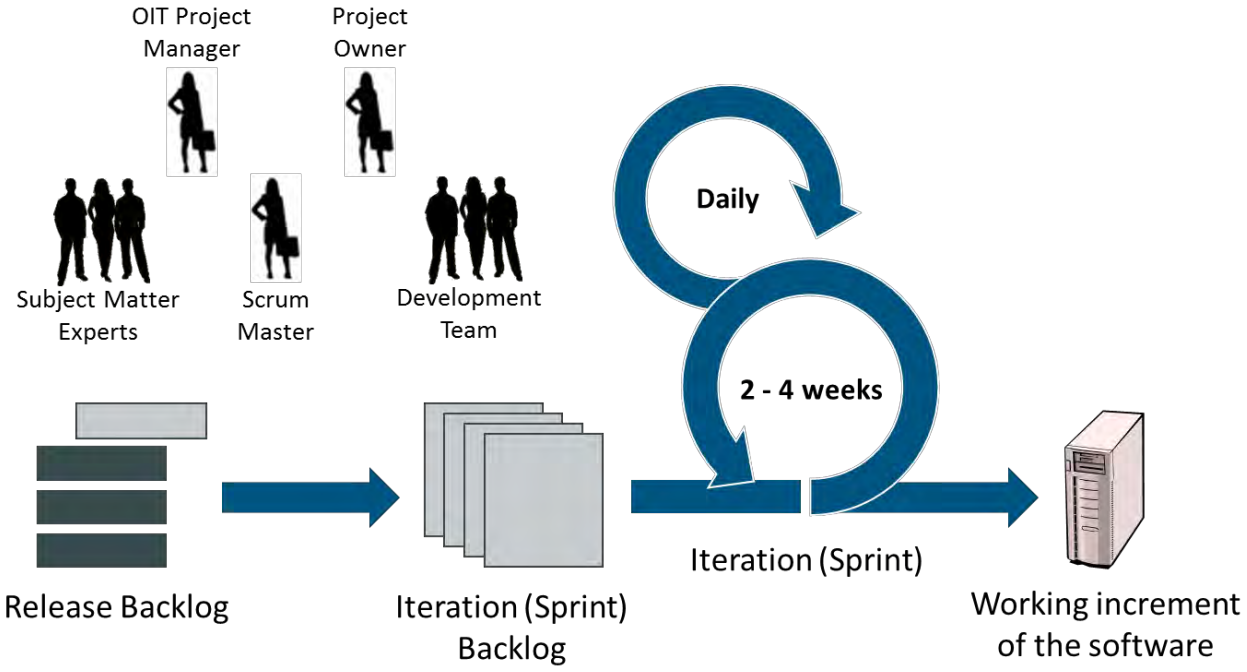


Most Agile development methods break the tasks into small increments with minimal planning and do not directly involve long-term planning. Iterations or sprints are short time frames that typically last from one to four weeks. Each iteration/sprint involves a cross-functional team working in all functions: planning, requirements analysis, design, coding, unit testing, and acceptance testing. At the end of the iteration/sprint, a working product is demonstrated to stakeholders. This minimizes overall risk and allows the project to adapt to changes quickly. An iteration might not add enough functionality to warrant a market release, but the goal is to have an available release (with minimal bugs) at the end of each iteration. Multiple iterations/sprints might be required to release a product or new features.

The Agile approach satisfies the customer through early and continuous delivery of valuable software. The approach offers a high success rate because work is completed early and is ongoing in the process. As noted in the U.S. Digital Services Playbook, "Ship a functioning 'minimum viable product' (MVP) that solves a core user need as soon as possible, no longer than three months from the beginning of the project, using a 'beta' or 'test' period if needed."

The figure below depicts a typical Agile process. With an Agile software development process, the Product Vision feeds into the product backlog, which contains a prioritized list of user stories (technical functionality for the system). The sprint backlog contains user stories that have been reviewed, scrubbed, and selected by the team to be worked on during a sprint. The 1–4 week sprint cycle turns user stories into implementable and shippable code. This code is ready for production, but is usually held or bundled into a larger software release.

Figure 29: Typical Agile Process



h. Frequently Used Project Management Documents

Effectively managing the project life-cycle requires planning and documentation. The following documents or topic areas should be developed early in the project, and they should be reviewed frequently during project execution. Project documentation should be tailored to the size and complexity of the project. Large, complex projects will have more if not all of the following documents, while smaller projects will have a lesser set, commensurate with the level of project risk and stakeholder engagement. Formats for these various documents are not included in this guidebook to avoid conflict with agency-specific documentation requirements. Confer with your agency acquisition and project management offices to obtain formats for your project and product documentation.

Table 7: Common Project Documentation

Document	What it Includes
Project Management Plan	Sometimes called the Acquisition Strategy. Comprises the overall technical and business management approach for the project and may contain the content of all the proceeding plans and documents.
Project Charter	● Project Purpose (Linked to the Agency's Mission/Strategic Plan) ● Objectives and Success Criteria ● High-Level Requirements ● High-Level Project Description/Product Characteristics ● Identified Risks ● Milestone Schedule Summary ● Budget Summary ● Project Approval Requirements ● Project Manager Contact Information ● Authorization/Signatures
Acquisition Plan	A document required by FAR Part 7.1 for certain types of procurement actions.
Work Breakdown Structure (WBS) and WBS Dictionary	● Breaks the project into discreet tasks that have time and resources associated for being able to measure work. ● The WBS Dictionary defines the scope and deliverables, contains associated activities, and lists milestones to assess progress.
Integrated Master Plan	Hierarchy of event-based tasks and significant accomplishments required to move through gate reviews/milestones.
Integrated Master Schedule	Time-based schedule containing the networked, scheduled tasks necessary to ensure successful project execution.
Stakeholder Plan	Identifies key project stakeholders.
Communications Management Plan	● Which stakeholder receives the communication (e.g., the customer) ● What information is communicated (e.g., a status report) ● How often communication will occur (e.g., monthly) ● How information will be sent (e.g., via meeting, e-mail) ● Who on the project team is responsible for communication (e.g., project manager)
Risk Management Plan	● Risk Register – Prioritized list of all identified project risks ● Risk Tolerance – The established level of risk stakeholders are willing to accept ● Risk Response Plan – Matches a response strategy (accept, transfer, avoid, mitigate) to each risk documented in the risk register

Document	What it Includes
Quality Management Plan	Identifies the criteria used to: ● Evaluate quality, including product and project requirements, quality standards that apply to the project, and the metrics used to measure quality ● Compare performance against requirements and standards ● On performance-based acquisitions, the contractor is responsible for developing a Quality Assurance Plan (QAP)
Test and Evaluation Plan	Includes details for tests and performance measures that the project must achieve to move to the next phase.
Quality Assurance Surveillance Plan (QASP)	Created by: ● Government when included in performance-based acquisitions ● Offerors when submitted with proposal or by the Government in response to the vendor's QAP Details: ● What Government will manage ● Who will conduct monitoring ● How performance will be assessed ● Acceptance criteria ● Remedies for unacceptable performance
Change Management Plan	Describes how the project team will identify, track, and respond to changes.
Product Support Plan	Defines the life-cycle support that will be needed for product developed.

4. Systems Engineering

Systems engineering is the aspect of project management through which the project manager and project team iteratively determine what the solution, or system, will be, evaluate the system iteratively as it is designed and developed to ensure it meets requirements, and document the iterative development of the system (configuration management). Systems engineering is an interdisciplinary process encompassing the entire technical effort to evolve and verify an integrated, balanced set of system, people, and process solutions that satisfy customer needs.

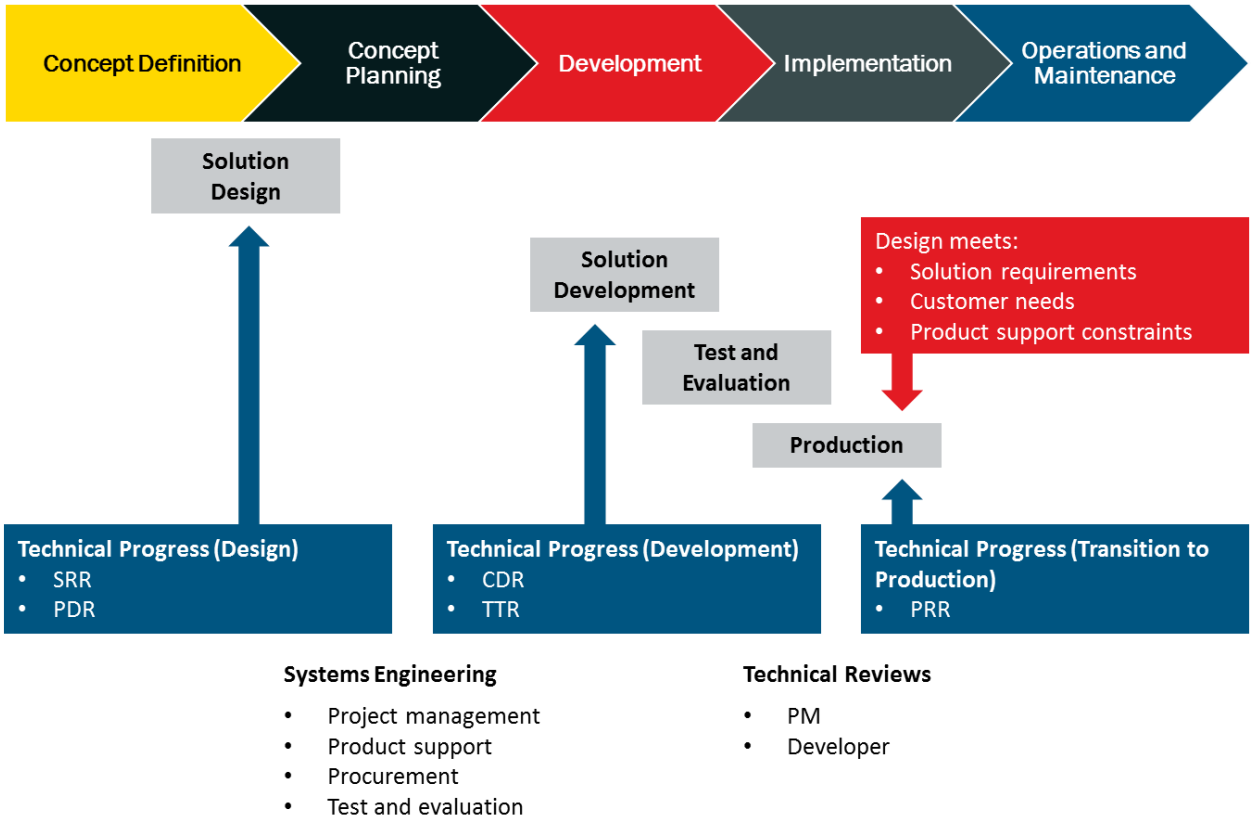
Systems engineering activities and outcomes interact with most project management decisions and actions throughout the project life-cycle. SE is integral to other functional areas such as test and evaluation, life-cycle logistics, cost estimation, manufacturing, and information technology. The end goal of SE is a balanced systems design, delivered within cost and schedule constraints. Getting to a balanced system design requires making trade-off decisions among technical performance, cost, and schedule constraints.

a. Developmental or Commercial

If a project strategy is tailored toward using a COTS solution, the majority of the SE activity has already been done by the product developer or manufacturer. In this case, the project team's SE role will be to review the system provider's SE process for proper application and ensure its design meets solution requirements. However, if the project strategy is tailored toward a solution that requires developmental activities, the project team's role in applying SE and technical management processes will increase proportionally with the level of technical risk of the project. In this case, the product developer will continue to do the majority of the actual SE activities, but the project team will need to understand the developer's process fully and assess the technical processes used by the product developer while managing that technical effort to ensure it meets system requirements. The primary methods the project team employs to assess the developer's SE activities include:

- Convening technical reviews throughout the life-cycle;
- Conducting Government-sponsored tests of developmental systems, or conducting audits of the developer's testing when acquiring commercial-off-the-shelf systems; and
- Employing quality control and assurance activities.

Figure 30: Systems Engineering and the Product Life-Cycle



b. Systems Engineering Plan

The purpose of the Systems Engineering Plan (SEP) is to guide development, communication, and management of the overall SE approach that guides all technical activities of the program. The SEP documents key technical risks, processes, resources, metrics, SE products, and completed and scheduled SE activities. The SEP also details the timing and criteria for the conduct of technical reviews. The SEP is a living document that should be updated as needed to reflect the program's evolving SE approach and/or plans and current status. Topics the SEP may address include:

- Development planning
- Technical reviews
- Design trade-off decisions and history
- Technical risk and opportunity management
- Technical performance measures and metrics
- Configuration management
- Modeling and simulation use
- Manufacturing and producibility
- Software management
- Reliability, maintainability, supportability
- Value engineering
- System security
- Open-system architecture
- Environmental, safety, and occupational health
- Item-unique identification
- Electronic spectrum impact
- Test and evaluation

SE Activities in the Life-Cycle. Systems engineering occurs throughout the project. The solution design aspect of systems engineering occurs during the Concept Definition and Concept Planning phases of the project life-cycle. The solution development aspect of SE occurs during the Development phase of the project life-cycle. Most of the test and evaluation aspect of SE occurs during the Development and Implementation phases of the project life-cycle. The SE decisions made in earlier project phases continue to affect the system and the end-user through the Operations and Maintenance phase.

c. Technical Reviews

Periodically, the project manager and the developer conduct technical design reviews to evaluate SE decisions and outcomes and assess the technical progress of the project in terms of solution design and development. Technical reviews also verify that design decisions and outcomes continue to meet solution requirements, customer needs, and product support constraints that describe the resources available to the customer for operating and maintaining the system. The following outline common technical reviews used in SE:

- **System Requirements Review (SRR).** The SRR is a multi-disciplined technical review to ensure that the developer is ready to proceed with the initial system design. This review assesses whether the system requirements reflect the selected solution. All system requirements as derived from the documented set of detailed requirements or performance parameters should be defined and consistent with cost, schedule, risk, and other system constraints as well as with end-user expectations. SRR is usually performed in the later portion of the Concept Planning phase.

- **Preliminary Design Review (PDR).** The PDR ensures the preliminary design and basic system architecture are complete and that there is technical confidence the selected solution can be satisfied within cost and schedule goals. The PDR provides the acquisition community, end user, and other stakeholders with an opportunity to understand the trade studies conducted during the preliminary design and thus confirm that design decisions are consistent with the user's performance and schedule needs. The PDR is conducted early in the Development phase.

- **Critical Design Review (CDR).** The CDR provides the acquisition community with evidence that the system, down to the lowest system element level, has a reasonable expectation of satisfying the full-up system performance requirements within current cost and schedule constraints. The CDR establishes the initial product baseline for the system and its constituent system elements. It also establishes requirements and system interfaces for enabling system elements such as support equipment, training systems, maintenance, and data systems. The CDR occurs in the later stages of Development when initial full-up prototypes of the system can be assessed.

- **Test Readiness Review**. The TRR is a multi-disciplined technical review designed to ensure that the subsystem or system under review is ready to proceed into formal testing. The TRR assesses test objectives, test methods and procedures, scope of tests, and safety, and it confirms that required test resources have been properly identified and coordinated to support planned tests.

- **System Verification Review (SVR).** The SVR is the technical assessment point at which the actual system that will closely reflect the product to be fielded to end-users is verified to meet operational requirements. The SVR occurs near the end of the Development phase and in the early Implementation phase before and during any operational testing is conducted on the product. It serves as the technical review function if design changes are required as a result of operational testing but before full-rate production of the product.

- **Production Readiness Review (PRR).** The PRR determines whether the system design is ready for production and whether the developer has accomplished adequate production planning for entering production. This includes ensuring a robust design of manufacturing processes that will produce relatively defective-free systems off the production line. The PRR occurs just before full-rate production in the Implementation phase.

- **In-Service Review (ISR).** The ISR is a multi-disciplined assessment to characterize the in-service health of the fielded product and its enabling system elements (training, user manuals, documentation, product support, etc.). The ISR provides feedback to the program manager on how well the system is delivering the capability to the end-user, with acceptable operational performance. Multiple ISRs would occur during the Operations and Support phase of the project.

d. The Systems Engineering Process

The steps in the systems engineering process include:

- **Step 1**. Define system-level requirements (the same activity as establishing high-level requirements in the Concept Definition phase).

- **Step 2**. Define item-level requirements, and **Step 3**, determine system design, occur during the Concept Planning phase. The two steps are performed iteratively to determine the system's design.

  Step 2 is the same activity as deconstructing high-level requirements into discreet, detailed requirements. As part of the systems engineering process, you assign each discreet, detailed requirement to a system function or component.

  In Step 3, you use these discreet requirements to determine your system design through a series of trade-offs similar to how you conducted an AoA to identify the preferred solution approach. You explore, analyze, and test different system designs until you achieve an overall design that meets system-level requirements and is a balanced systems design.

- **Bottom-up Review**. Once you think you have a system design that meets all your discreet, detailed requirements, you assess your design from the bottom up by answering the question, "Does the way my system design meets lower-level requirements support meeting higher-level requirements?" In other words, while an airplane's individual parts may meet their allocated requirements individually, will the plane actually fly when all the parts are put together? If the current design does not achieve system-level requirements, you repeat the process beginning in Step 2 by double-checking your requirements and how you deconstructed them.

- **Step 4.** System production starts in the Development phase and continues early in the Implementation phase of the project life-cycle. In system production, the developer builds and produces multiple quantities of the system and/or system components to meet requirements. Early production items are produced in the Development phase to test out the manufacturer's production processes and assembly line as well as to produce a small number of production-representative items for operational testing.

- **Step 5**. System verification occurs when the developer or the Government conducts test and evaluation to verify that the system meets requirements. Like Steps 2 and 3, Steps 4 and 5 occur near simultaneously in an iterative cycle.

- **Step 6.** System Validation occurs at the end of Development and, for more complex systems, the beginning of the Implementation phase. In system validation, the end-user conducts test and evaluation to validate that the system meets end-user needs. For some types of products, verification and validation occur simultaneously.

- **Step 7**. System integration occurs in the Implementation phase. In system integration, the developed, verified, and validated system is installed or fielded into the end-user's operational environment. This would also include fielding the typical product support package of spare parts, maintenance equipment, training for operators and maintainers, facilities, and any other services required to support the product and the end-user.

- **Finally, Step 8**. Transition occurs when full ownership of the system changes from the developer who built the system to the customer who will operate and maintain the system. Transition can also refer to the transition from one step in the systems engineering process to the next (e.g., from system design to system development).

Figure 31: Steps in the System Engineering Process

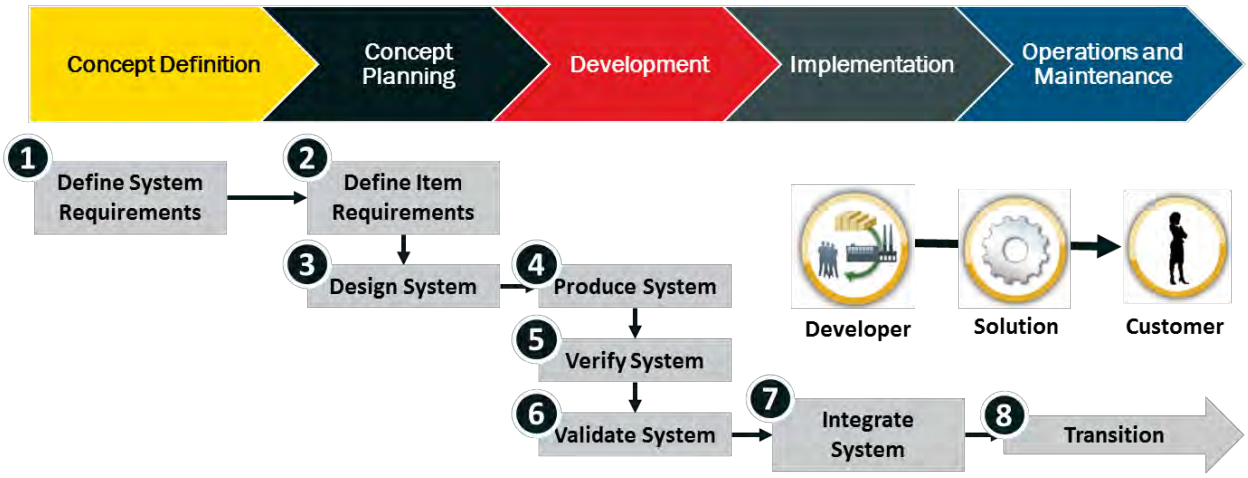
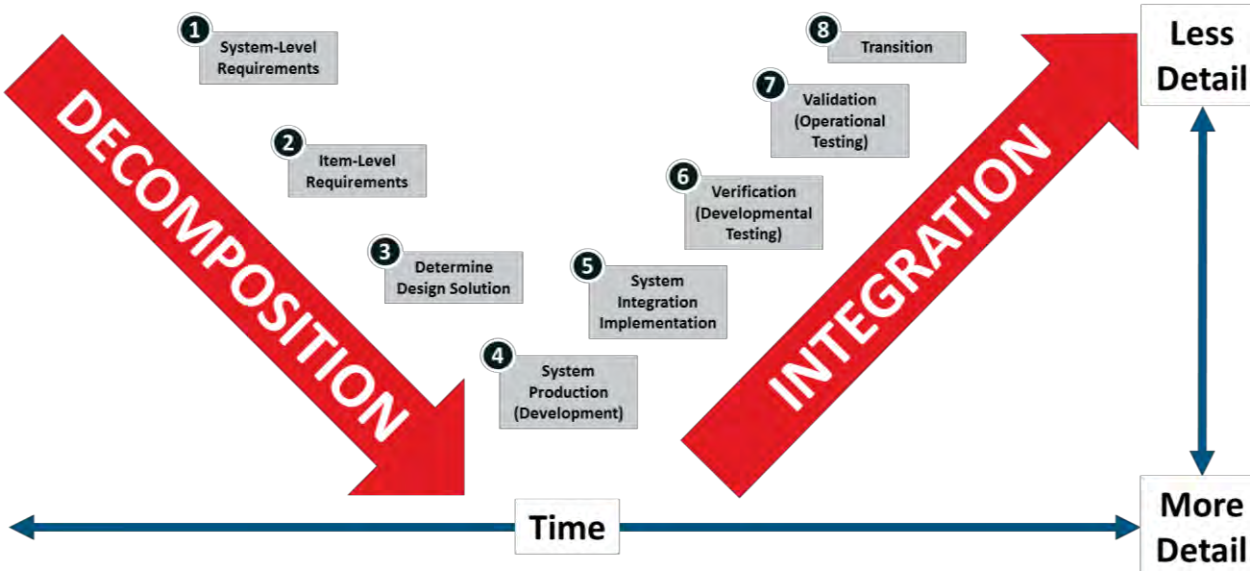


Figure 32: The Systems Engineering "V"



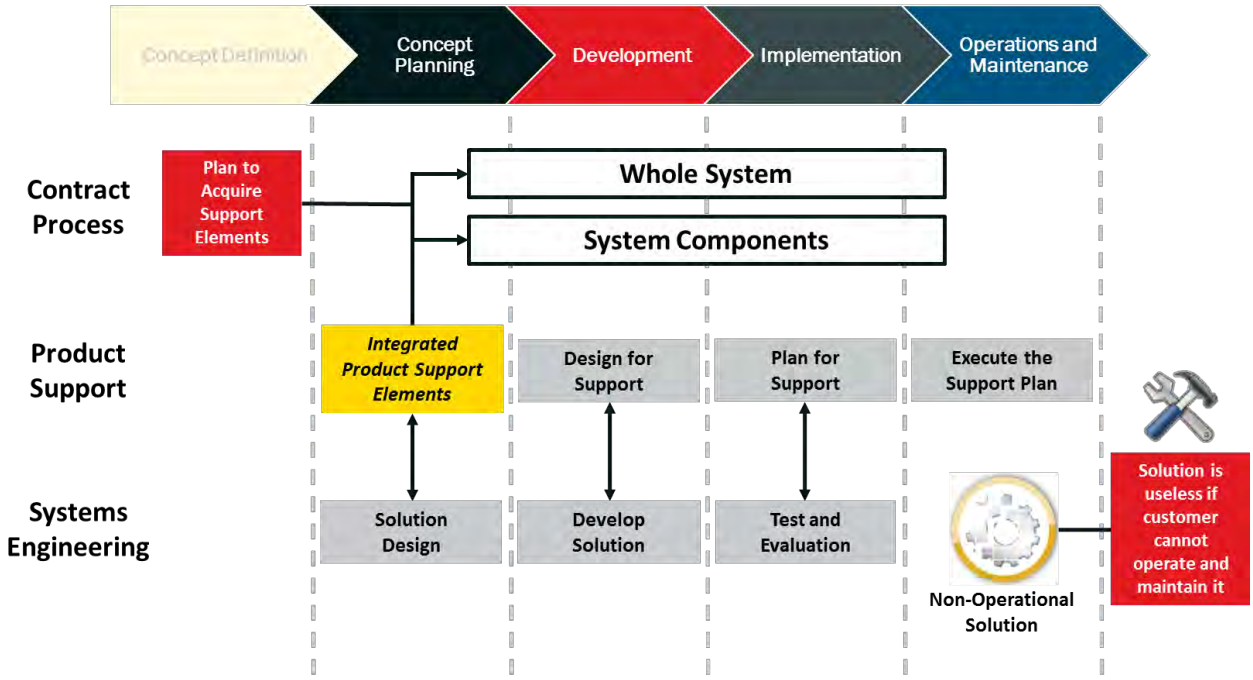
e. Systems Engineering and Product Support

One of the most valuable aspects of performing systems engineering is product support: the personnel, equipment, procedures, and supply chain the customer requires to maintain the system after Implementation and throughout its useful life. Product support includes (1) designing the product with its supportability in mind; (2) planning the support process for when the product is transitioned to the end-user; and (3) executing that support plan in the Operations and Maintenance phase. Product support impacts acquisition because supportability elements, such as maintenance plans, supply chain management, training, and replacement parts must be designed, planned for, and acquired just like the components obtained to design and develop the system.

Throughout the Development phase and during the early part of the Implementation phase, product support considerations are regarded as a design performance parameter and are designed into the system. Product support planning also occurs at this time to determine how the customer will execute the product support plan during the Operations and Maintenance phase. Once the system enters this last phase, the customer executes the product support plan, and the plan may be adjusted later based on customer feedback.

Product support requirements significantly constrain systems engineering. A system, no matter how well-designed, is useless if the customer does not have the resources to operate and maintain it. Because supportability so significantly constrains solution design, systems engineering activities and product support planning often are performed at the same time. More resources invested early in a supportable design and a viable support plan result in lower overall life-cycle cost. When considering total life-cycle costs, the majority of those costs occur in the Operations and Maintenance phase. The end goal of SE activities in product support are to field a product to the end user that is available and ready to perform when called upon and is affordable.

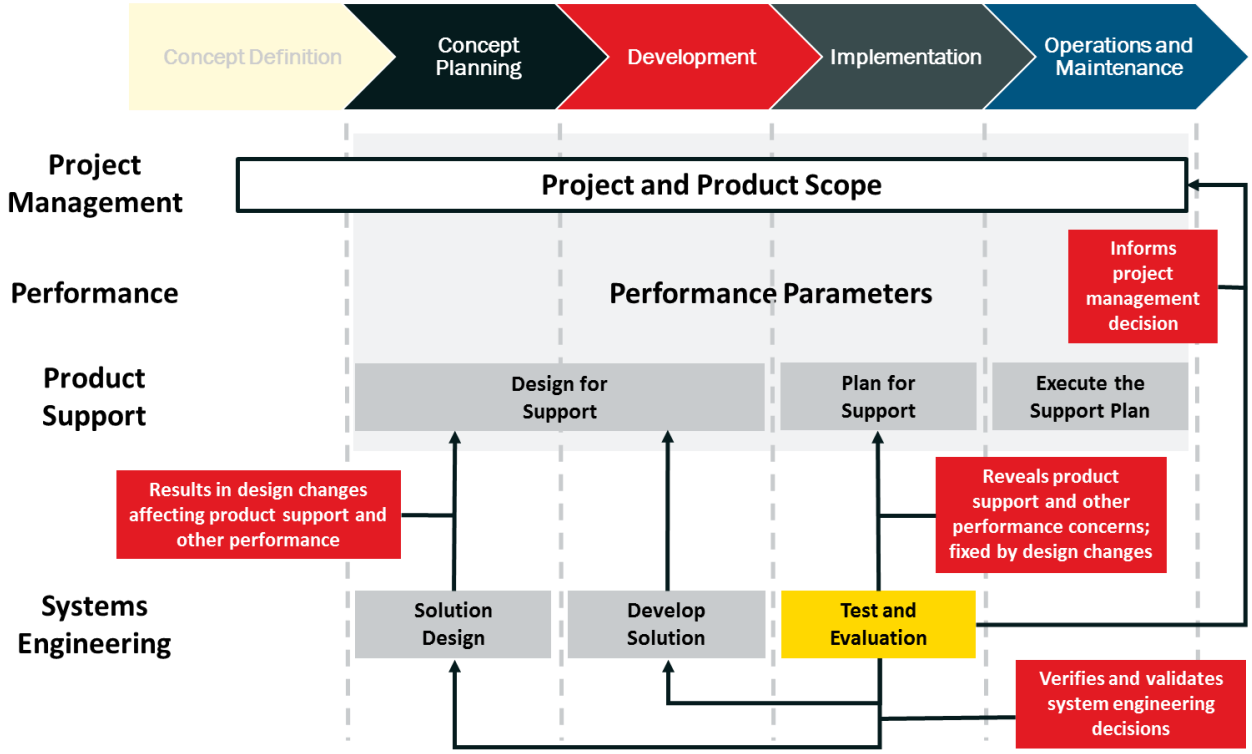
Figure 33: Systems Engineering and Product Support



f. Systems Engineering and Test and Evaluation

A critical element of systems engineering is conducting test and evaluation activities. T&E verifies systems engineering decisions by comparing solution design and prototypes against requirements and end-user needs. If T&E reveals a concern that results in a change to solution design, that change must carry through to product support. Additionally, T&E provides data required to make informed project management decisions, such as impacts on schedule and budget that result from design changes. Finally, T&E can also reveal product support concerns that you resolve through systems engineering by changing the solution design accordingly.

Figure 34: Systems Engineering and Test and Evaluation



g. Commercial Off-the-Shelf (COTS) Items

The PM and Systems Engineer should consider the following during SE activities when evaluating use of COTS products:

- The intended product-use environment and the extent to which this environment differs from (or is similar to) the commercial use environment;
- Human systems integration, documentation, security, hardware/software integrity, reliability risk, operational environment, and corrosion susceptibility/risk;
- Planning for life-cycle activities, including sustainment, supply chain risks, obsolescence, and disposal;
- Developing relationships with vendors for long-term availability of the product;
- Supportability, if vendor or marketplace changes occur;
- Test and evaluation of COTS items, including early identification of screening, functionality testing, and usability assessments;
- Protecting intellectual property rights by being aware of pertinent intellectual property right issues associated with commercial items acquisitions, especially with the acquisition of commercial software products;
- Preference for open source items;
- Ability to modify or interface COTS software with other software, even if Government-generated or owned; and

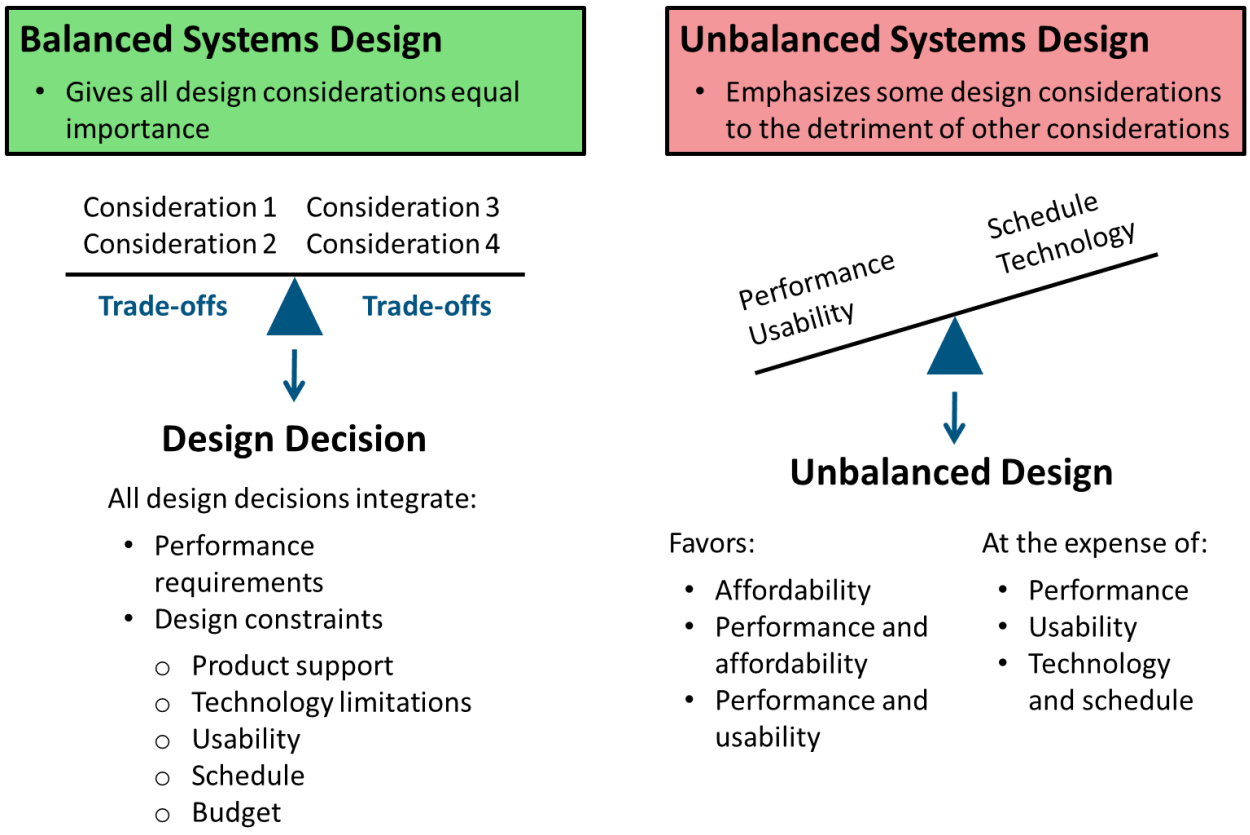
- Ability to have insight into the SE process used to design the item, its configuration management, and the features and functions of upgrades and changes.

h. A Balanced Design

The most significant benefit of performing systems engineering is a balanced system design. A balanced system design is one that gives each design-consideration equal importance and results in a design decision that reflects all design considerations optimally.

Systems engineering achieves a balanced system design by integrating solution performance requirements and design considerations and constraints, such as product support, technology limitations, usability, and project schedule and budget, into all design decisions. This is often accomplished through a series of trade-off decisions, which add or remove system attributes in support of one consideration or constraint over another. An unbalanced system design emphasizes one design consideration to the detriment of another, increasing cost and schedule or reducing overall utility to the end-user.

Figure 35: Balanced System Design



i. Value Engineering

Value Engineering (VE) has been used by the Federal Government and industry since the early 1960s. The OMB Circular No. A-131 implements VE in all Federal agencies and is part of the Office of Federal Procurement Policy (OFPP) Act as updated in Public Law PL-111-350 in 2011. The law and the circular make VE mandatory across the Government.

VE is not engineering in the technical design context. Also referred to as Value Methodology (VM), it is a systematic and structured approach for improving projects, products, and processes. VM is used to analyze and improve manufacturing products and processes, design and construction projects, and business and administrative processes. VM is a practice that is distinguished from other management techniques by three elements: (1) the analysis of functions; (2) uses a multi-disciplinary team approach; and (3) the VE Job Plan, a step-by-step approach that achieves results.

Value is the reliable performance of functions to meet customer needs at the lowest overall cost, and it can be calculated as such: **Value = Function/Cost.** Function is what the product or service is supposed to do; and Cost is the expenditure needed to create it.
VM helps achieve an optimum balance between function, performance, quality, safety, and cost. The proper balance results in the maximum value for the project. The VM follows SAVE International's® standard job plan (illustrated below), which consists of eight steps:

1. **Orientation**. Identify and prioritize the issues, draft the scope and objectives, establish evaluation factors, and assemble the study team.

2. **Information**. Gather information to better understand the project.

3. **Function Analysis**. Analyze the project to understand and clarify the required functions.

4. **Creative**. Generate ideas on all the possible ways to accomplish the required functions.

5. **Evaluation**. Synthesize ideas and concepts, and select those that are feasible for development into specific value improvements.

6. **Development**. Select and prepare the "best" alternative(s) for improving value.

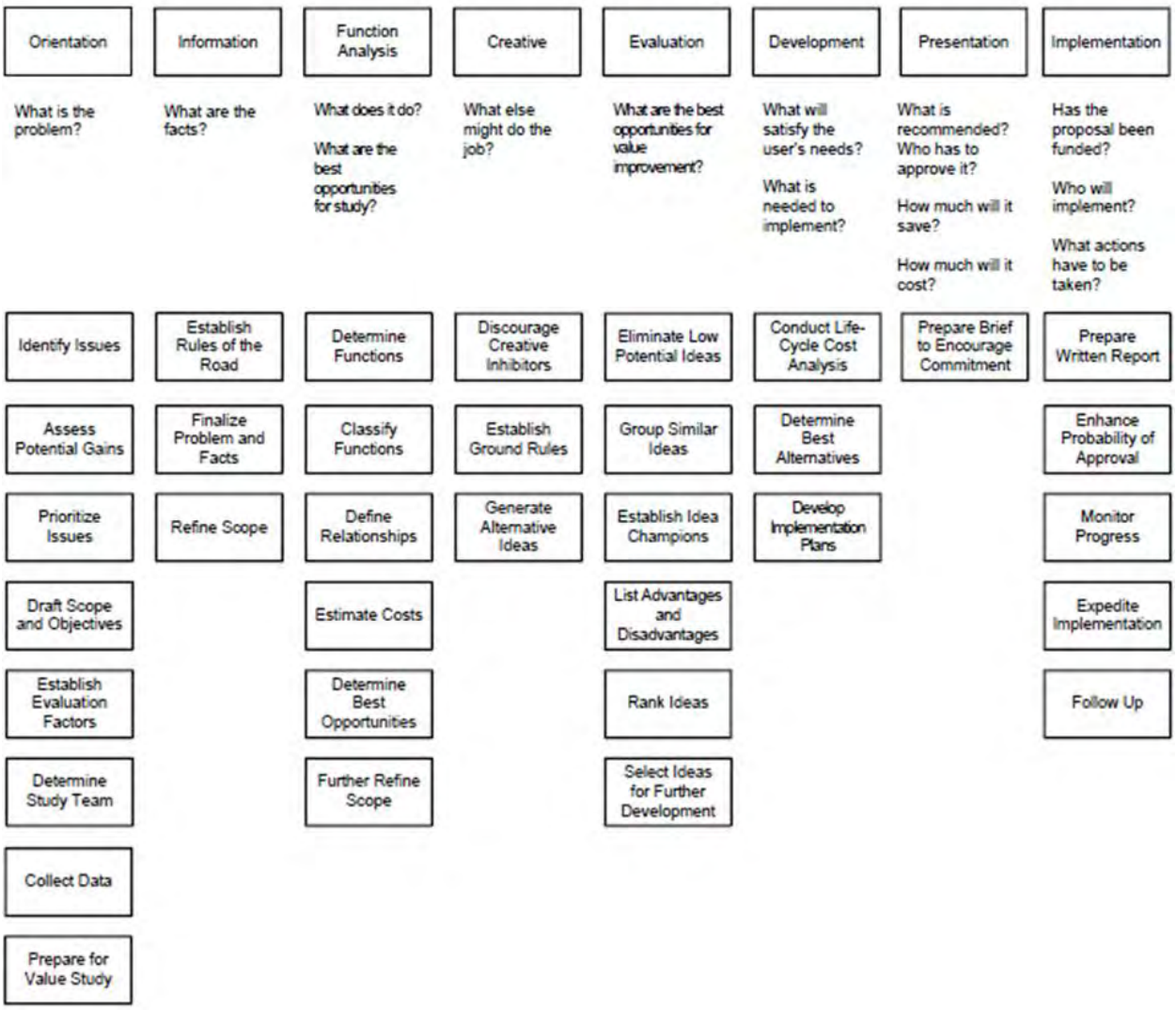
7. **Presentation**. Present the value recommendation to the project stakeholders.

8. **Implementation**. Report and monitor progress of the implemented proposal.

The best results are achieved by a multi-disciplined team with experience and expertise relevant to the project being studied. A certified value facilitator or specialist may lead the team to ensure the Value Methodology is properly followed.

There is also an important contractual element to VE. The FAR in parts 48 and 52 mandate the inclusion of a VE clause in many Government contracts. This clause incentivizes industry to enhance the Government's value proposition by allowing the contractor to receive a share of the cost savings generated from Value Engineering Change Proposals (VECP).

Figure 36: Value Engineering (VE) Job Plan



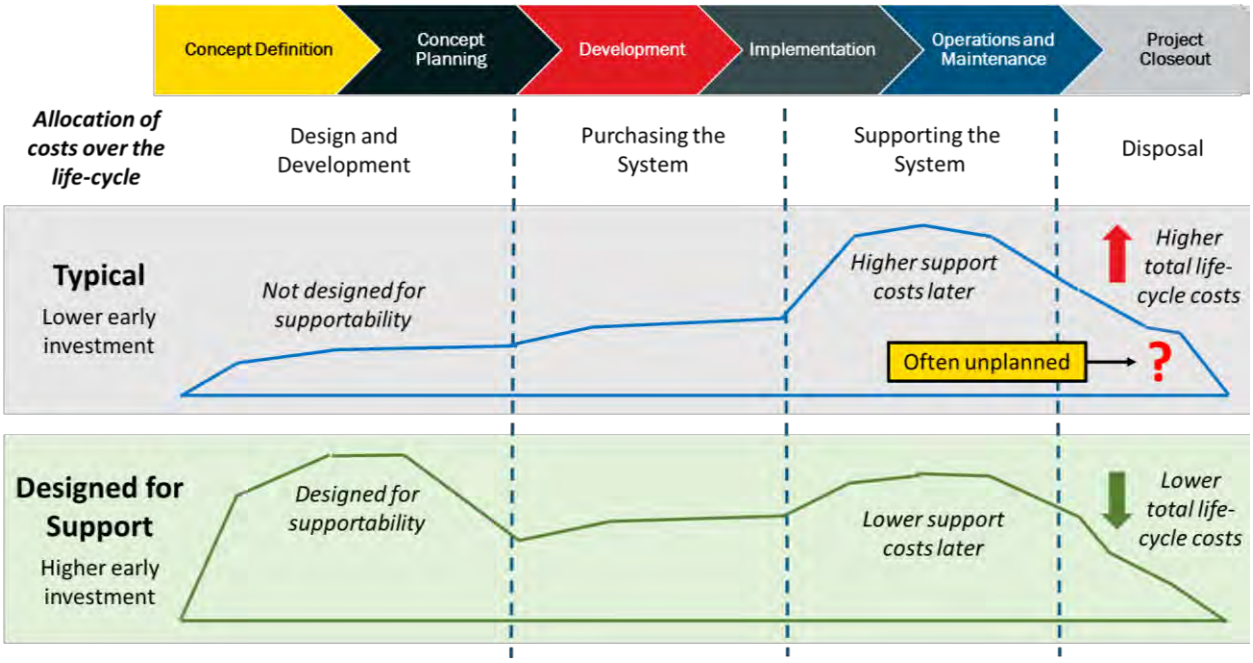
5. Life-Cycle Logistics

When you consider the total cost of owning a product for its entire useful life and dissect that cost into development (if not a COTS product), purchasing, and operations and maintenance, the majority of a product's ownership cost accumulates when it's being used to accomplish organizational goals and objectives. What can the PM and project team do to keep the product available to the user longer, at an affordable cost, and also reduce its total cost of ownership? By employing sound life-cycle logistics principles—that's how.

Life-cycle logistics, sometimes referred to as integrated logistics support (ILS) or more recently as product support, includes the infrastructure and funds needed to maintain the system in an operational state after the Implementation phase and throughout the system's expected useful life in the Operations and Maintenance phase. How much infrastructure, manpower, and supplies the customer will need to maintain the system is determined by how often the system or its components become non-operational and by how easy the system or its components are to return to an operational state (both known as "availability"). Also pertinent is how the customer allocates supportability resources. The ability of a system over time to fulfill its intended use or purpose is called product readiness.

The customer can choose to allocate more resources early in the design of the system to develop a very reliable system, thereby lowering the cost of maintaining the system throughout its useful life. Alternatively, the customer may not have the resources to develop a more reliable system immediately and may choose to allocate less resources early to develop a less reliable system, thereby distributing the financial burden later across the system's useful life in the form of maintenance costs. A best practice is obviously to invest in a more reliable system design early on, if that's affordable.

Figure 37: The Cost of Designing-In Supportability



a. Integrated Product Support

Product support considerations take an early look at the aspects of supporting the implemented system in the operational environment upfront when designing the system. These considerations are often described using a list of integrated product support (IPS) elements. IPS elements are so called because they each influence the other elements as well as how they are integrated into a product's design. The IPS elements include:

- **Sustainment engineering** is the selection of components or functions that promote longevity in the system when determining the system's design. Reliability is designed into the system to reduce the cost and frequency of maintenance activities. Systems engineers, in collaboration with the product support specialist, should consider sustainment engineering options continuously while designing the system.

- **Maintenance planning and management.** No matter how well-designed a system is, it will require maintenance and repair. During system design, systems engineers work with the personnel who perform maintenance activities to identify and keep track of what types of maintenance tasks are needed and when they should be performed to keep the system operational. The more complex maintenance is, the more money, manpower, and time it costs the customer to plan for and implement maintenance activities. Systems engineers should, to the extent possible, design a system that supports simple maintenance actions, reducing the frequency and complexity of maintenance activities.

- **Facilities and infrastructure** in the context of product support refer to the buildings and environment needed to store replacement parts and perform maintenance activities. It also refers to the customer's capacity and process for moving maintenance-related materials or systems in need of repair to the buildings or environments with the equipment needed to return the system to an operational condition. The system design should accommodate the facilities the customer has or can obtain, or it should account for the financial and time cost of having maintenance activities performed by the manufacturer or outsourced to another product support provider.

- **Support equipment** refers to the tools and equipment needed to perform maintenance activities and return the system to an operational condition. The system design should accommodate the tools and equipment the customer has or can obtain or account for the financial and time cost of having maintenance activities performed by the manufacturer. Buying special tools to maintain a unique design is not cost-effective but sometimes can't be avoided.

- **Manpower** in the context of product support refers to the personnel required to manage, track, and perform maintenance activities and the expertise required. The systems engineer should, to the extent possible, design a system that avoids using components that require specialized expertise to maintain unless the customer already has personnel with the requisite experience or can easily obtain or train such personnel.

- **Supply support** refers to the customer's ability to obtain, distribute, and store the materials needed to perform maintenance activities and return the system to an operational condition. The systems engineer should design a system that avoids using components that are likely to become obsolete during the useful life of the system or that will stop being manufactured or serviced during the life of the system. This can be a prime concern with COTS products. Likewise, the system design should

accommodate the limited resources of the customer to supply maintenance-related materials and infrastructure, preferably by being more reliable and therefore requiring less maintenance supplies.

- **Packaging, handling, storage, or transportation** factors must be factored into keeping the product operational and at affordable costs. Even if the system requires only standard packaging, handling, storage, and transportation, the customer may have limited resources for packaging and transporting the system. The project manager, product support specialist and systems engineer, and customer should work together to design a system with reasonable packaging, handling, storage, and transportation requirements given the customer's resources.

- **Design interface** refers to how the end-user interacts with and uses the system or how the other IPS elements interface with one another. Design interface can also refer to how the system interacts with existing systems, also known as interoperability.

- **Technical data** documents how the system was built and how it operates so that the customer can maintain, repair, update, or alter the system's design after Implementation. Without the right to access technical data about the system, the customer will be forced to rely on the manufacturer or contractor to perform maintenance instead of using its own personnel. This doesn't motivate the manufacturer or contractor to keep their prices reasonable for providing maintenance and update services for the system.

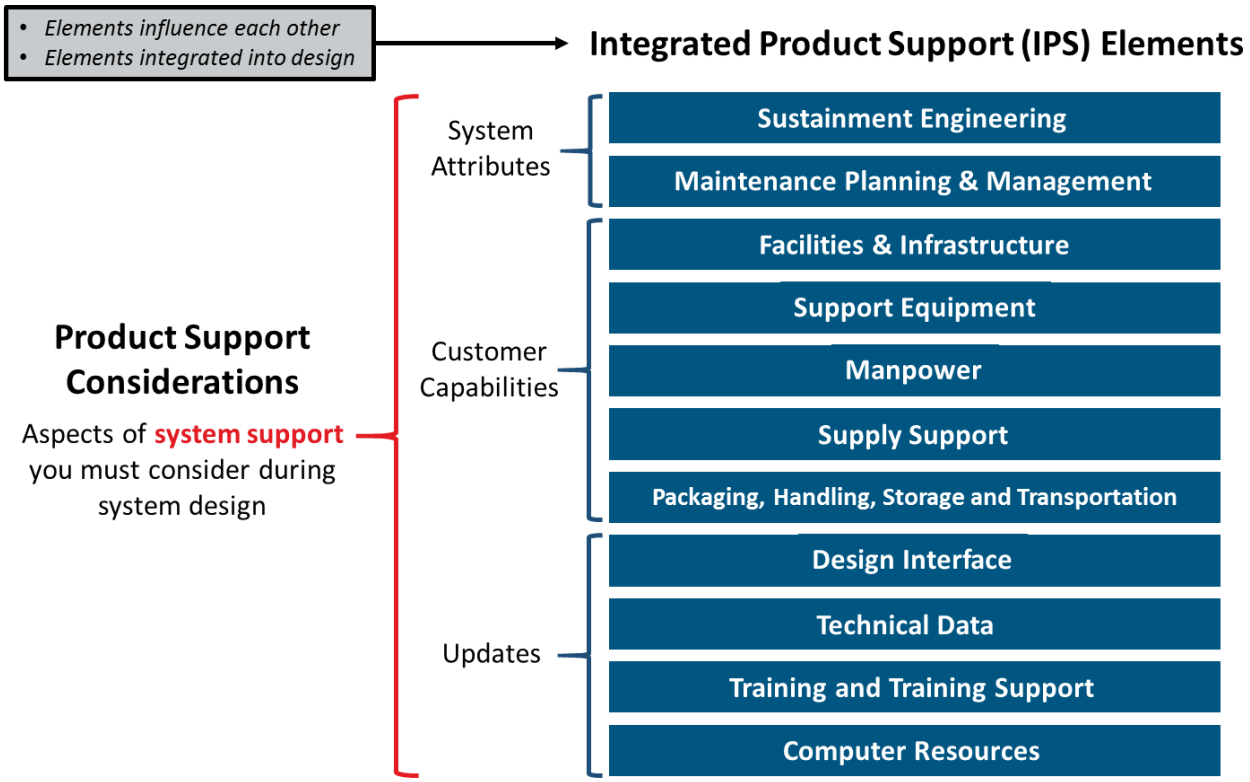
  Technical data is often expensive. The systems engineer and product support specialist should work to achieve a proper balance between not enough data and too much data by carefully analyzing what technical data is essential to perform adequate product support.

- **Training**. As new personnel arrive or new features are added to the system, the customer must train personnel on how to operate and maintain the system. The more complex the training needed to appropriately operate and maintain the system or the more frequently personnel must be trained on new features, the more expensive it is for the customer to maintain personnel who can use the system effectively. Conversely, the simpler the training and the less frequently personnel require training, the easier and less expensive it is for the customer to maintain personnel who can use the system effectively. The systems engineer should design a system that leverages the current training possessed by the end-user's personnel and accommodates the limited resources available to train personnel on using the system.

- **Computer resources.** Most systems today use some sort of computer technology, either to perform system functions or to support the product, such as a supply chain management software program. Computer technology is ever evolving, and the customer must expend resources to keep the system, and how personnel use the

system, up-to-date with emerging technology. The systems engineer should design a system that accommodates the customer's ability to use and support such updates.

Figure 38: Product Support Elements

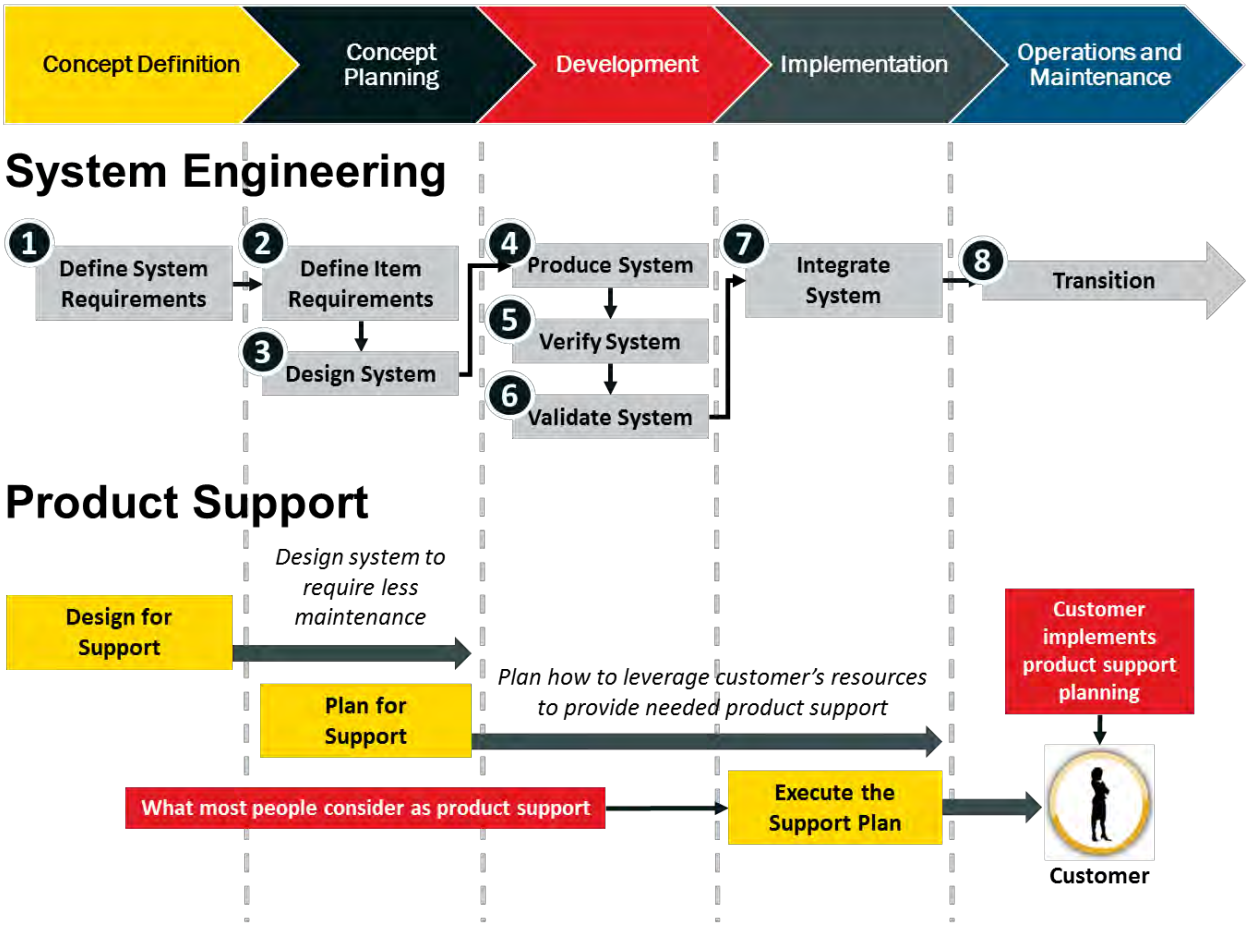


b. Product Support in the Life-Cycle

Product support occurs throughout the project life-cycle. Planning for and implementing product support can be described as a sequence of three steps: design for support, plan the support, and execute the support plan.

Designing for support means designing a system with characteristics that minimize the amount of maintenance and supply needed to keep the system operational. Designing for support occurs during the Concept Definition and Planning phases when you establish requirements and select the preferred solution approach. Planning the support means conducting trade-offs to make both system design and product support decisions during concept planning and analyzing the impact of those decisions on the customer's ability to both maintain the system and plan how to leverage resources accordingly. Planning for support continues during the Development and Implementation phases to verify design decisions through test and evaluation. Executing the support plan means during and after the Implementation phase, the customer leverages its resources as planned to support and maintain the system. This is what most people think of when they think about product support, but it is only one piece of product support planning.

Figure 39: Product Support across the Life-Cycle



c. Product Support Plan

Like most other project information, product support decisions and data must be documented in a product support plan, sometimes referred to as the "Integrated Logistics Support Plan." The product support plan may be included in the project management plan or it may be a separate document. The product support plan captures the product support strategy that details the requirements describing how each element will influence system design and identifies customer resource constraints related to each IPS element. This, in turn, limits how the system design can address product support considerations. In the context of this information, the product support strategy explains the approach for achieving requirements described in the plan while staying within customer limitations related to the IPS elements. The product support plan structure mirrors the IPS elements. Note that each project has different needs, so the elements included in a product support plan may vary by project.

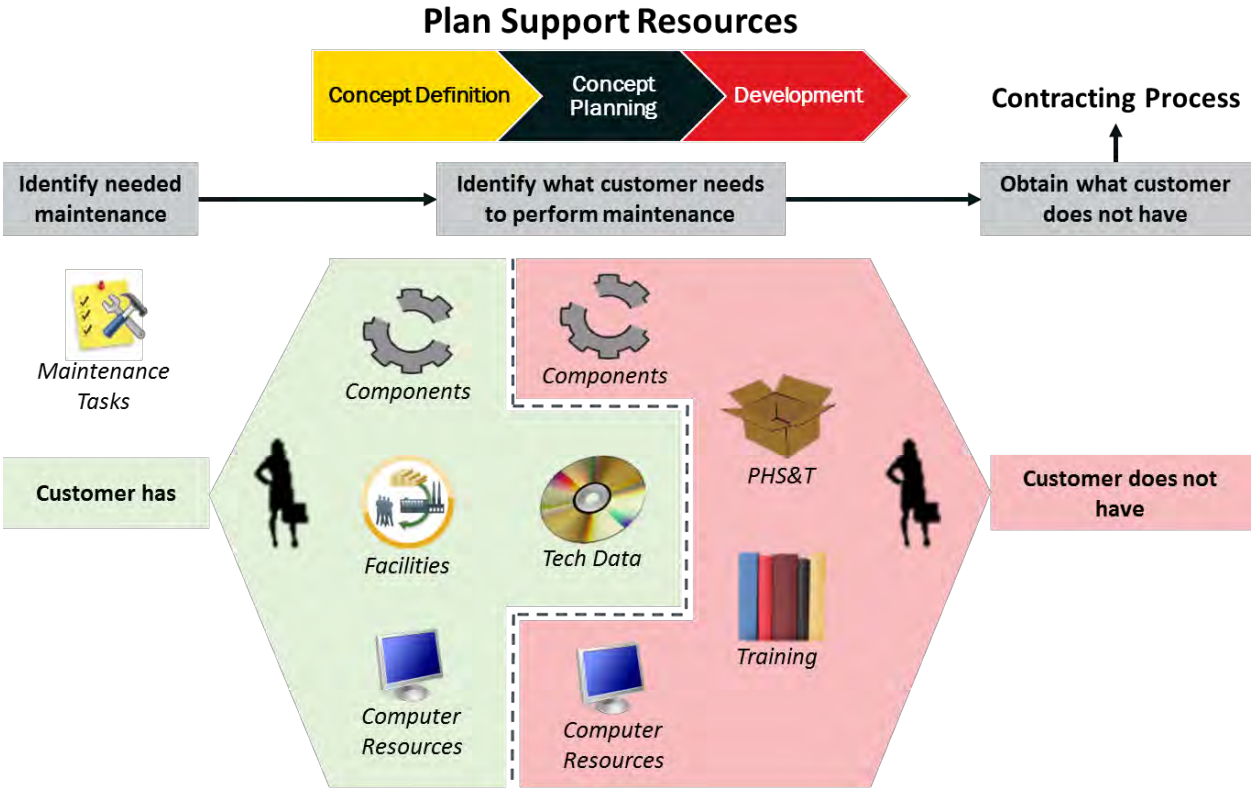
d. Planning Support Resources

To plan how to leverage the customer's resources, first identify the supply and maintenance activities required to keep the system operational. Based on the required supply and maintenance activities, identify the following:

- The supplies and replacement components required;
- Infrastructure (such as transport options in the supply chain and maintenance and storage facilities);
- Equipment (such as new tools and diagnostic equipment); and
- Personnel with the necessary skills needed to perform those activities.

Now identify what logistics capabilities the customer already has. Then, identify what logistics capabilities or elements the customer does not have but needs to perform required maintenance. Finally, obtain the needed logistics elements through the contracting process. Some items may require long lead times to acquire, possibly before the product itself is manufactured. If there is a critical gap in the customer's ability to support and maintain the system, this gap may evolve into a new requirements process, leading to a generation of stand-alone projects to acquire that needed capability.

Figure 40: Acquiring Product Support



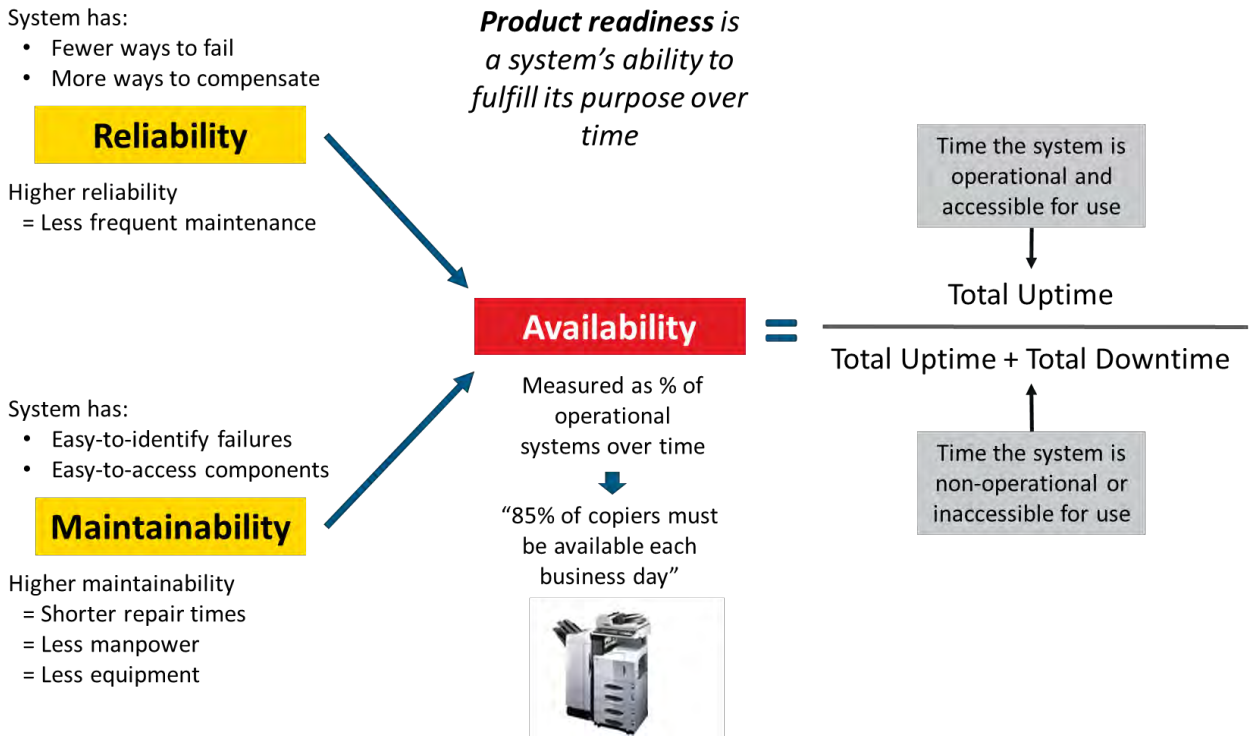
e. Reliability and Maintainability

Reliability is the length of time a component or system is expected to remain operational during normal use before a failure occurs. A component with better reliability requires maintenance less often to return it to operational status. Less frequent maintenance means less downtime and higher availability. When applying reliability to system design, design a system with fewer ways to fail and more ways to compensate for a failed component until it can be repaired. Maintainability is the amount of time and resources needed to perform maintenance on a component or system. A component with greater maintainability requires less time, manpower, and equipment to return it to an operational state once it has failed. Shorter repair times mean less downtime and higher availability. When applying maintainability to a system design, design a system in which failures are easier to identify and failed components are easier to access and repair. Designing a system with better reliability and maintainability is the essence of "Designing for Support."

f. Availability

Product readiness, or availability, is the ability of a system to fulfill its intended purpose over time and is therefore measured as the percentage of systems that are operational over a given period of time, or the measure of how many systems are operational, and therefore available for use. One simple formula for calculating availability is total uptime divided by total uptime plus total downtime. Uptime is time when a system is operational and accessible for use in achieving the mission. Downtime is time when a system is non-operational or inaccessible for use in achieving the mission. To remain operational and meet availability requirements, the system must meet reliability and maintainability requirements. Designing reliability and maintainability into the system supports achieving availability.

Figure 41: Product Readiness



g. Affordability

Customers have limited resources with which to achieve product support goals; therefore, affordability must be factored into system design decisions. Affordability is the trade-off between increased product readiness, as supported by reliability and maintainability, and the cost of obtaining such increased product readiness to meet requirements. The affordability trade-off is just one of the many trade-offs performed to achieve a balanced system design. More reliable components or systems have higher initial development, purchase, or production costs. Similarly, more easily maintainable components or systems typically require more system design iterations, which take time and money. Although they have a higher initial cost, more reliable and easily maintainable components or systems provide better product readiness because they require maintenance less often and take less time to repair, which results in a lower supportability cost across the life of the system.

h. Product Readiness

No matter how well-designed, to use the system effectively, the customer must be able to obtain the resources needed to operate and maintain the system. Traditional logistics planning was transaction-based and measured product readiness based on supply order transactions. Today, logistics planning is performance-based and measures product readiness based on outcomes, not a specified number of transactions.

In traditional transaction-based logistics, failures were predicted using reliability or condition-based strategies:

- **Reliability estimates.** Determine if maintenance is needed based on historical data that predicts the length of time, often measured in hours of operation or a similar factor, after which the system typically needs maintenance. For example, you should replace your car's engine oil after three months or 5,000 miles because, based on testing data, the manufacturer determined that to be the optimal interval at which to perform maintenance.

- **Condition assessments.** Determine if maintenance is needed by assessing the current state, or condition, of the system and either comparing it against criteria that describe an acceptable condition in which the system can operate or an unacceptable condition which requires maintenance before the system can operate. For example, you should replace the tires on your car if, upon measuring the depth of the treads, you find the treads are too shallow.

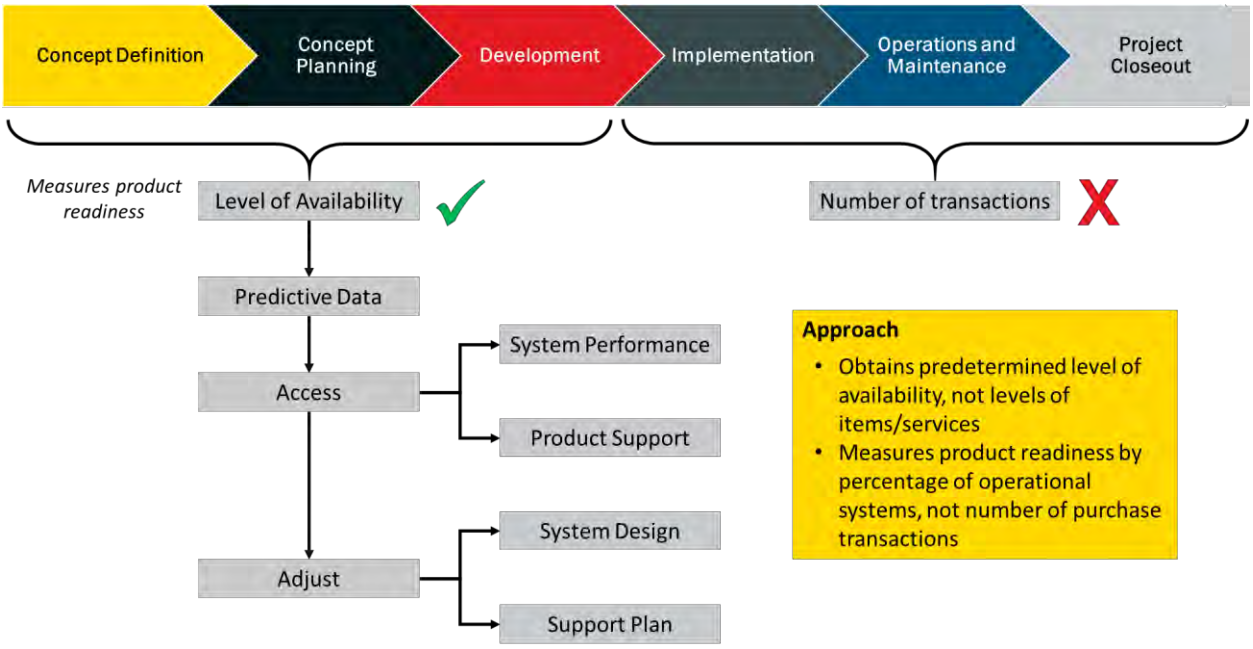
Transactions became the primary product support planning metric to measure a system's predicted product readiness. This was based on the logic that if enough transactions for product support items were scheduled, the customer should have sufficient materials to perform maintenance and support tasks, resulting in an acceptable level of product readiness. Unfortunately, this approach relied on purchasing set quantities of maintenance items and services that didn't accurately track the actual performance of maintenance tasks, only the materials needed for those tasks, and didn't track the percentage of operational systems.

i. Performance-Based Logistics

Performance-based logistics focuses on achieving a predetermined level of availability as part of system design and development instead of focusing on buying a set amount of goods or services to meet maintenance needs. Performance-based logistics measures product readiness based on the percentage of operational systems over a period of time.

The product support manager begins with the desired level of availability as the outcome; for example, out of a fleet of 100 trucks, a minimum of 90 trucks must be fully operational on any given day. The product support manager then uses predictive data to assess how well the trucks are designed and whether product support as it is currently planned will meet the desired outcome. For example, the product support manager identifies and plans all maintenance and supply tasks needed to keep at least 90 trucks operational. Based on the assessment of future performance, adjustments in the system's design are made to minimize the amount of maintenance needed to sustain it or the product support plan is adjusted to provide maintenance supplies and services more efficiently.

Figure 42: Performance-Based Logistics



j. Logistics Footprint

When applying performance-based logistics to system design, a goal is to minimize the logistics footprint of a system to the extent possible. The logistics footprint of a system refers to the physical space needed for the system itself and for the supplies, equipment, and personnel required to sustain the system.

k. Interoperability

Affordability and the logistics footprint place constraints on achieving product support goals. One way to alleviate these constraints is to increase a system's interoperability. Interoperability is the ability of a system to be physically or functionally compatible with, exchange information with, and operate effectively with existing systems. This ability makes it easier for the customer to get better performance from the system.

In the context of product support and logistics, when a system is interoperable with existing systems, the customer may be able to share resources (such as supply support), components, equipment, and technical skills with other organizations that operate and maintain similar systems.

6. Test and Evaluation

Test and evaluation by its definition has two obvious components:

1. **Test.** Assessing and collecting data regarding a product or systems performance characteristics through various methods, including demonstrations, inspections, design reviews, modeling and simulation, and analysis; and

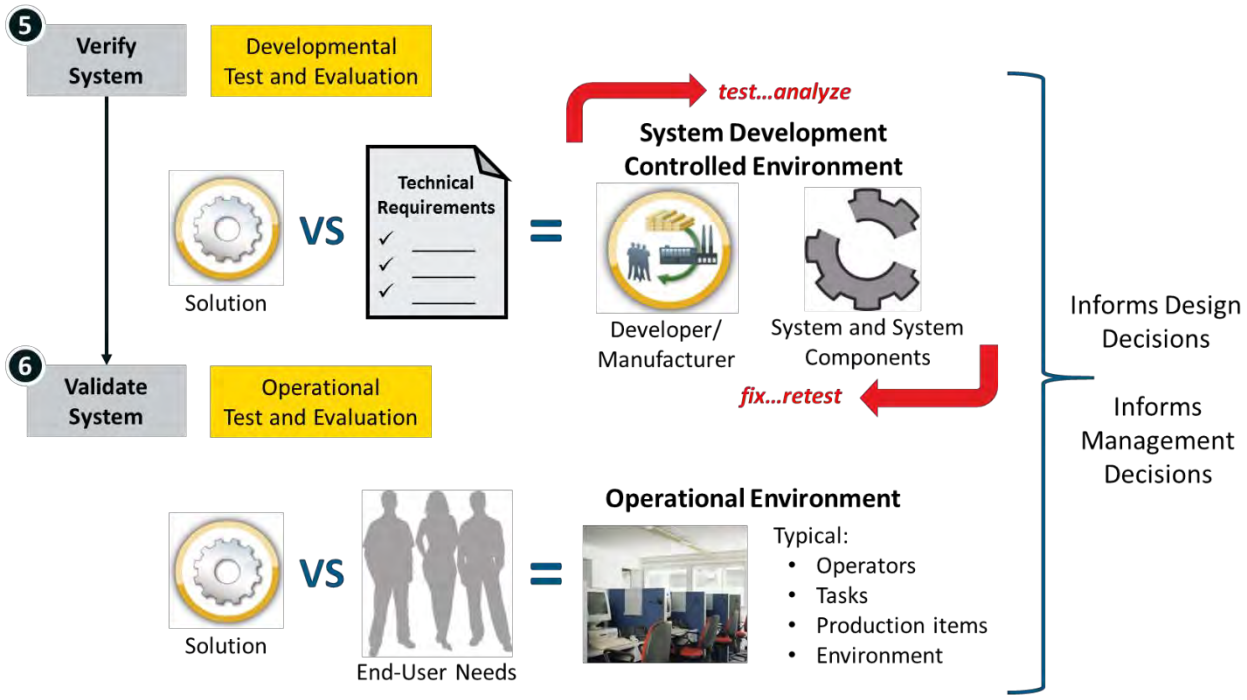
2. **Evaluation.** Analyzing and comparing the data collected from testing against the product's documented performance parameters to determine the degree to which product functions and attributes meet, or do not meet, its performance parameters.

T&E results are the primary means project managers have of assessing project risk, and they make design decisions by answering the questions, "Does the system perform technically as it was predicted to?" If not, "How can we improve performance?" T&E results are also used to determine compliance with quality standards, and they are a means for stakeholders to make management decisions by answering the question, "Is the system ready to transition to the next development phase?"

a. Types of T&E

T&E that measures, or verifies, how well the system performs against technical performance requirements is called Developmental Test and Evaluation (DT&E); this is Step 5 in the systems engineering process to verify a system's design. T&E that measures, or validates, how well the system addresses end-user needs is called Operational Test and Evaluation (OT&E); this is Step 6 in the systems engineering process to validate the system against end-user requirements. A way to remember the difference between these types of T&E is associating DT&E with the developer assessing the system iteratively while designing and developing the system and associating OT&E with the end-user operating the system within the system's intended operating environment.

Figure 43: Types of Test and Evaluation



In Agile development, T&E is continuous and built in as a part of the development cycle rather than its own phase. This reduces cycle times by collapsing the phases into a sprint cycle and creates a usable product at the end of the sprint.

The PM and project team approach T&E results and their use differently for developmental life-cycles and commercial-item life-cycles. Commercial-item life-cycles usually do not require the Government to conduct separate T&E since the majority of T&E has already been done by the developer or manufacturer. However, the PM and team may need to review the developer's test approach and results to ensure technical and operational risks have been adequately addressed by the developer. On the other hand, developmental life-cycles usually require the Government to conduct some measure of T&E in addition to the T&E conducted by the developer.

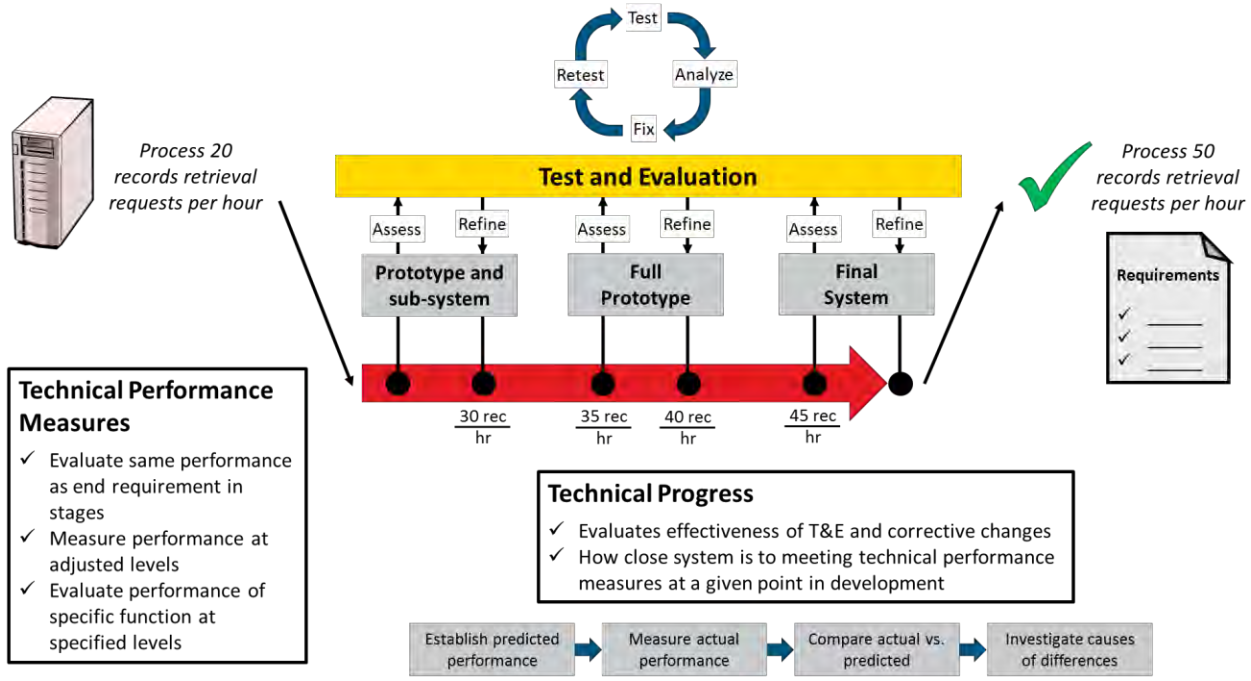
When acquiring COTS systems or system components, the manufacturer has typically already conducted DT&E. The PM works with the Contracting Officer's Representative (COR) to review the results of the manufacturer's T&E activities and determine that the product or service being acquired meets performance requirements. Even for a COTS solution, the Government may conduct OT&E to validate that the manufactured product or service addresses end-user needs in its intended operating environment. Examining the manufacturer's findings verifies whether the solution selection and resulting acquisition decision appropriately meet the need, if something was overlooked in the decision process and a poor selection was made, or if the manufacturer's product or service does not have the capabilities the system must possess.

b. Technical Performance

T&E is done either by the developer, the Government, or both throughout development to assess system design and performance against requirements. Early in iterative development, however, a system may not be able to meet performance requirements. To account for this, the testing organization compares performance against technical performance measures. Technical performance measures evaluate the same performance as the end requirement but at levels adjusted to reflect performance that is reasonable for earlier stages of development. Like the end requirement, technical performance measures evaluate a system's ability to perform a specific function. However, if the tester can't compare the system's performance against the end requirement, how do they know if the development process and associated T&E are effectively improving the system?

The tester assesses the effectiveness of the development process and associated T&E by evaluating the system's technical progress, or how close a system is to meeting the technical performance measures appropriate for a given point in development. To track technical progress, first predict the performance the system must achieve at various points throughout development in order to be able to meet the end requirement once development is complete. Then, measure the system's actual performance at each point. Next, compare the system's actual performance against predicted performance. Finally, investigate the cause of any concerning differences and make changes to system design or the development process to address design issues.

Figure 44: Measuring Technical Performance

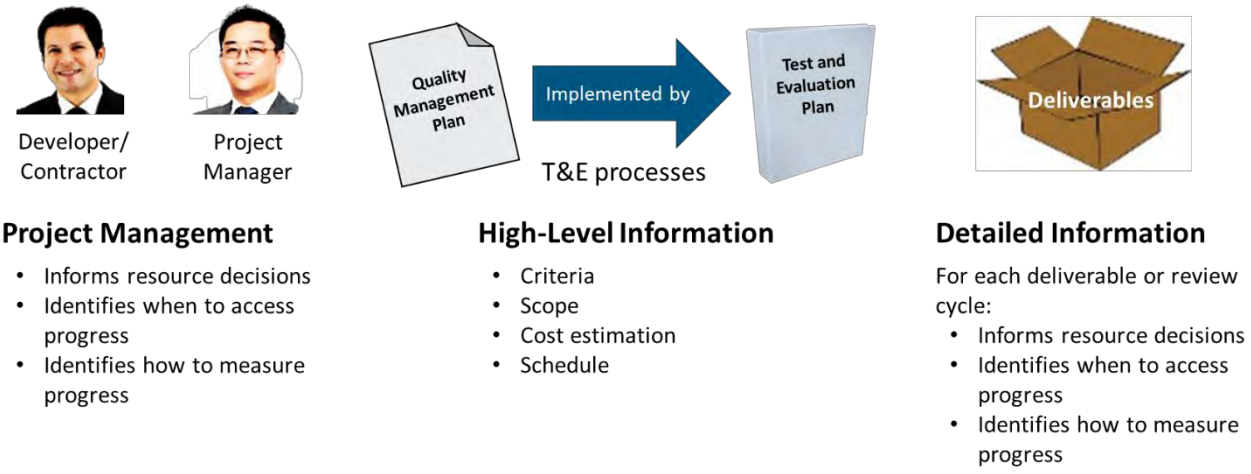


c. Quality and T&E Planning

If the Government is going to develop its own solution instead of acquiring COTS items, then the Government will need to conduct detailed T&E in addition to the manufacturer or provider. To conduct detailed T&E, the PM and team must strategize and plan for how that testing will be conducted. Recall the quality management plan or a separate T&E Plan may include high-level information about test criteria, the scope of T&E activities, and a cost estimate and schedule of when those activities should occur. It is through test and evaluation that you implement your quality management plan.

The PM and team need more detailed information than what is usually contained in the quality management plan to conduct T&E: thus the need for a T&E Plan. For each deliverable or review cycle, the T&E Plan identifies acceptance criteria and performance attributes, items to test, testing methods, and the resources needed to conduct test and evaluation activities. Both the quality management plan and the T&E Plan are used to manage project resources and decide when and how to evaluate system development.

Figure 45: Planning for Test and Evaluation



d. What to Test

Systems testing can be done on a number of system types including (1) components of developmental systems or full-up completed developmental systems when no COTS solution is available; (2) a primarily developmental system using a combination of COTS and developmental components; (3) a primarily COTS item requiring developmental components to meet a unique Government capability; (4) a full-up COTS item that hasn't been modified; and (5) a currently fielded system that is being modified to the extent that its original performance functions or attributes (sometimes called the "performance envelope") have changed significantly. To verify that the system meets requirements, the developer must first produce something to evaluate, which is Step 4 in the systems engineering process.

System production is either the manufacturing of components required to create the system if developmental in nature or the acquisition of COTS components or fully developed COTS items.

Production occurs in phases. For example, the developer may produce a prototype first, sometimes called an "engineering development article or model;" then an initial completed item, sometimes called a "pre-production article" or "first article;" and then a final completed item, sometimes called a "production article" or "model." Another way to look at phased production is developing or acquiring lower-level assemblies and components first, then using those lower-level items to develop sub-systems, and then using those sub-systems to develop the system as a whole.

e. Testing Methods

To gather the information needed to assess system performance, the following test methods are described in the T&E Plan:

- Inspections use quantitative, or measurable, set criteria to conduct structured evaluations of the system's performance. They can be scheduled or unannounced.

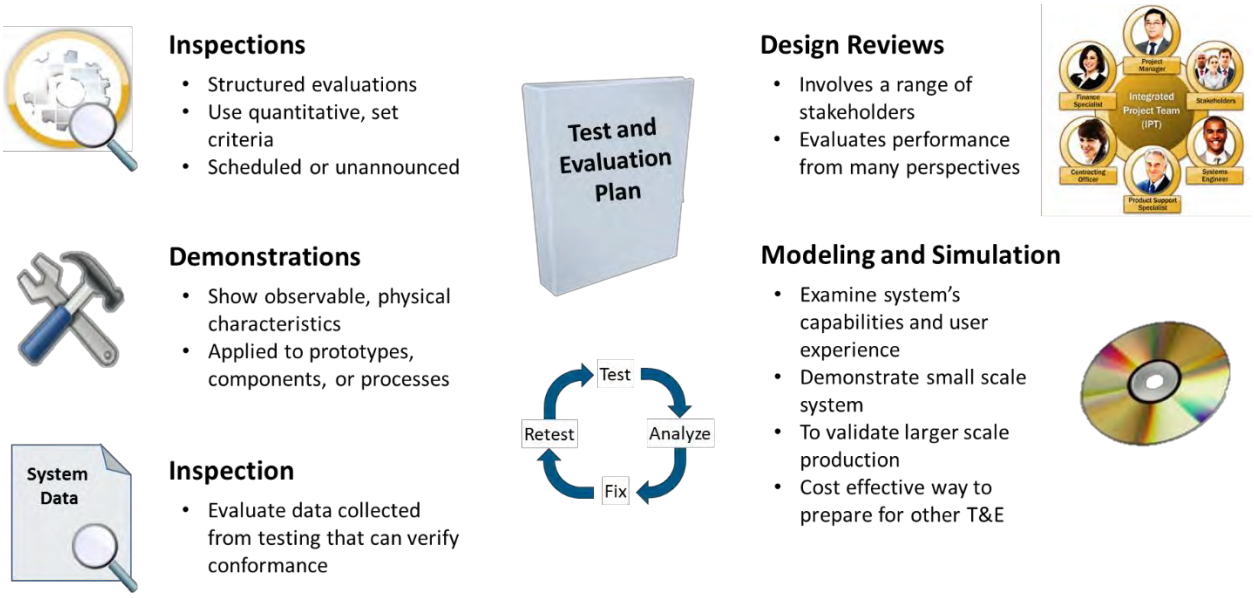
- Demonstrations are what most people think of when they think about T&E in general. Demonstrations involve showing, or exercising, the system and observing physical characteristics using prototypes, components, or processes.

- Analyses evaluate data collected from testing that can verify the system's conformance with requirements. Both demonstrations and analyses employ the test, analyze, fix, retest cycle.

- Design reviews include a range of stakeholders who evaluate the system's performance from many perspectives.

- Modeling and simulation examines the system's capabilities and the end-user's experience as demonstrated on a small scale, using physical models, sophisticated automation and software programming, or both. Modeling and simulation validates larger-scale system characteristics before investing resources in producing and testing the actual system. Modeling and simulation is a cost-effective way to prepare for more expensive T&E activities like inspections, demonstrations, analyses, or design reviews.

Figure 46: Test and Evaluation Techniques



f. When to Test and Why

DT&E activities can begin as early as Concept Planning if test items are available. However, the majority of DT&E will occur in the Development phase and may continue in some capacity throughout the life-cycle, even during the Operations and Maintenance phase. The majority of DT&E will be done by the product developer since these tests primarily access a product or its components against technical performance specifications. The primary discriminators between DT&E and OT&E is the design maturity of test items, test environment, and the personnel participating in or conducting T&E. DT&E is done on components or full-up prototypes that may not represent the product's final design or meet all performance requirements while providing information for design changes. DT&E is conducted by technical personnel in a controlled test environment, such as the manufacturer's facility or an independent laboratory. DT&E is what most people think of when they think of quality control testing. Conducting DT&E mitigates the risk of finding performance failures later in production, when they cost more to resolve.

Production occurs simultaneously with iterative verification, or the "test, analyze, fix, retest" cycle already discussed in systems engineering, and which comprises a major part of DT&E. In each phase of production in the system's hierarchy, DT&E is conducted to verify that the produced items were constructed according to the requirements outlined in the design specifications. For example, when acquiring COTS items, the developer might perform DT&E on the components to verify that they meet discrete requirements, and the Government might perform DT&E on sub-systems and the system as a whole to verify they meet system-level requirements. Based on the results of verification activities and DT&E, the system is iteratively refined until a fully developed system meets performance requirements.

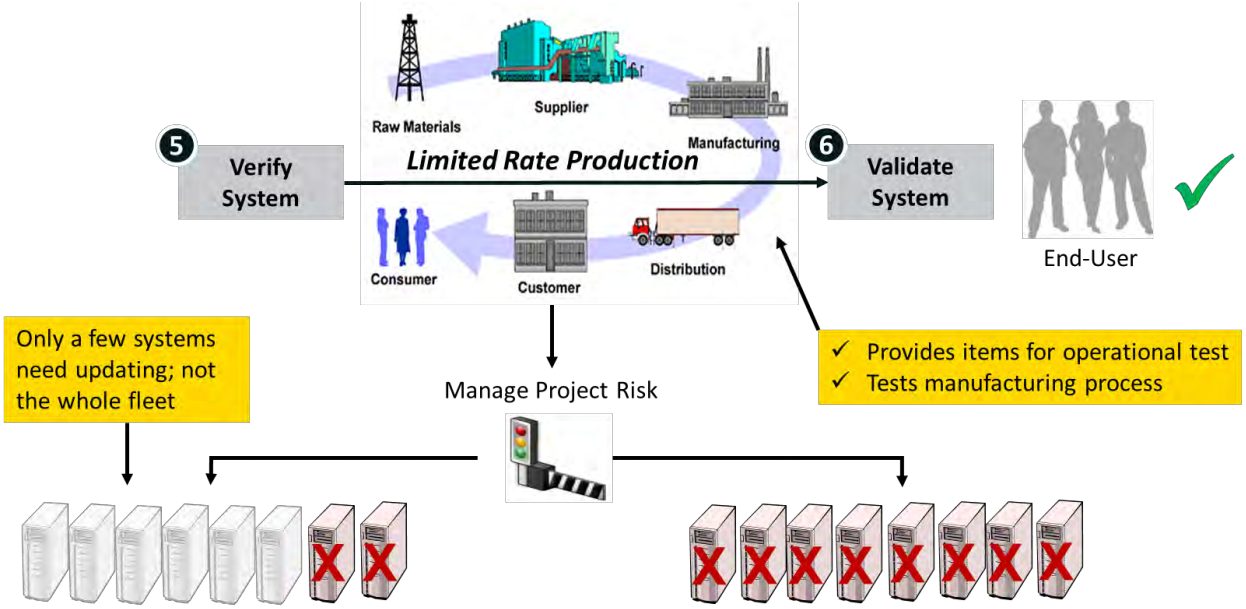
In contrast, OT&E is conducted in both the Development and Implementation phases and possibly in the Operations and Maintenance phase as well. OT&E assesses a product's performance when operated and maintained by typical end-users doing typical operational tasks and missions, using as-close-to-production representative systems as possible, in the product's intended operational environment. Early user OT&E may occur in the Development phase by typical end-users on prototypes but in a controlled test environment. Initial OT&E usually occurs during the Implementation phase using production or production-like items, typical users and maintainers, and in the product's intended operational environment. Follow-on OT&E may occur in the Operations and Maintenance phase on fielded systems to check design fixes on discrepancies found during earlier OT&E or to assess modifications to the final production system design that was originally accepted and fielded to the end-user during Implementation.

g. System Validation through OT&E

Once components or the full-up system is verified through DT&E, the PM and team work with the customer to conduct OT&E to validate (Step 6 in systems engineering) the system addresses end-user needs. Conducting OT&E requires a small number of near-final production items. These are often called limited rate production items because, while they are the finalized and developed system design, only a limited amount of them are produced. Limited rate production serves two purposes: to provide test items for OT&E and to test the manufacturer's capability to produce error-free production items where the first produced item is the same as the last production item.

Limited rate production and OT&E are critical to managing project risk. Imagine buying all the information enterprise servers you intend to buy only to discover after OT&E that the servers don't meet performance requirements or the training for using the servers is inaccurate, and the system fails testing because end-users performed equipment tasks or maintenance activities incorrectly. OT&E is done on a limited amount of systems so that if corrective changes are required, you only have a few systems to update instead of an entire fleet.

Figure 47: Limited Rate Production



As with DT&E, the system will likely require design changes or refinement based on the results of OT&E. After refining the system accordingly, the finalized system is integrated into the end-user's operational environment. This means full rate production of all the systems needed begins and all end-users receive the system for use in their respective operational environments.

7. The Work Breakdown Structure

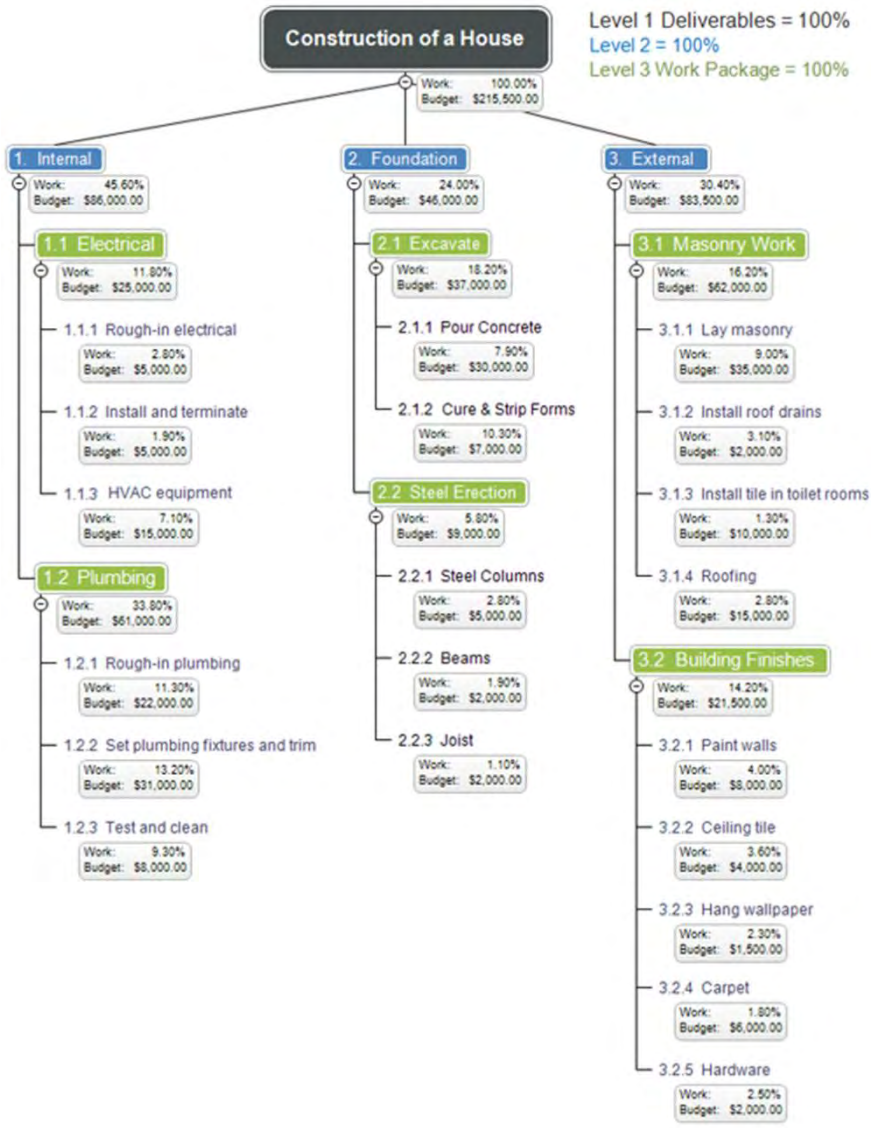
The Work Breakdown Structure (WBS) is a foundational planning document that contributes to most other planning procedures the PM performs, including cost estimating, risk analysis, resource assignment, and scheduling. PMs develop a WBS to organize project requirements and define the total scope of the project. The WBS can be oriented on: (1) the actual product or system; (2) the functions provided by the product; (3) the project office functions that must be performed in the overall management of the product acquisition; or (4) combinations of product and functions.

The WBS breaks project work down into smaller pieces that can be scheduled and resourced. The WBS is a hierarchical breakdown, or decomposition, of the project work to be completed by the team. Any work that is not included in the WBS is not considered part of the project. The WBS is not a project plan or a schedule. The WBS only specifies what will be done, not how or when.

One reference commonly used in Government and industry for developing a WBS is Military Standard 881C (MIL STD 881C), dated October 3, 2011. While this Standard is oriented toward military equipment and functions, it is widely used for other types of projects.

Numerous software applications are available that assist PMs in building a WBS and may be available from agency acquisition libraries or repositories (check with your agency Chief Acquisition Officer's (CAO) office). Given the wide availability of these software applications for developing a WBS, a logical place to start is on a whiteboard or sketching out the overall project on a piece of paper. The WBS can also be created on existing office software, such as Microsoft Word, Excel, or Project.

Figure 48: Example Work Breakdown Structure (WBS)



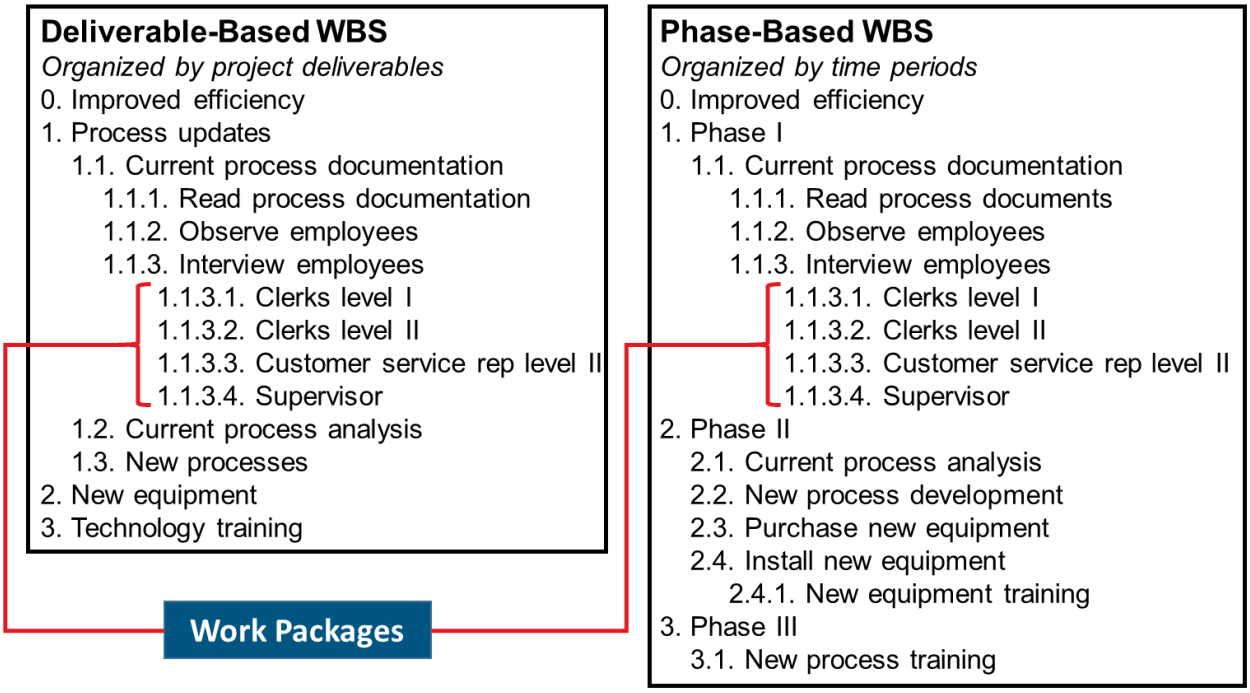
The process of developing a WBS is straightforward, but the result can become rather large and complex depending on the project. The PM is responsible for developing the WBS; however, it is a best practice to include the project team in developing the WBS to ensure it covers all possible project requirements and needs. The WBS is created through four steps:

1. List all of the project's requirements.
2. Identify the deliverables that are needed for each requirement.
3. Divide the work for each deliverable into small, manageable pieces, called work packages.
4. Review the WBS to ensure it includes all activities needed to complete the project.

The preponderance of time developing the WBS will be spent in Step 3: developing work packages. Work packages are the lowest level on the WBS. An individual work package comprises all activities needed to complete it. A work package: 1) can be scheduled, 2) its costs can be estimated, 3) the work can be monitored, and 4) the work can be controlled. If those areas cannot define a single work package, then the activity must be further decomposed until all work in that package can be defined and broken down no further. Additionally, the work products coming from each work package should be mutually exclusive and not overlapping. If work products are overlapping, it may result in duplication of efforts.

The WBS is typically organized in a product-oriented family tree format for a simple project and in an outline format as projects become more complex. Complex projects usually have more than three levels. Each element of the WBS is assigned a number for ease of tracking as well as for reference in the WBS Dictionary, discussed further below. The final outcome, product, or function is typically placed at the top level, which is numbered "0" and referred to as Level Zero. An example of a tree format WBS and numbering system follows:

Figure 49: Example Work Breakdown Structure (WBS) Examples



The examples above represent a WBS organized around deliverables or time phases, which are common WBS formats. There is no one correct way to organize a WBS. The WBS can be

organized by project deliverables, project phases (e.g., Phase 1, Phase 2, etc.) or life-cycle phases (e.g., Concept Definition, Concept Planning, etc.). If your agency has its own specific project management guidance, follow its recommended structure. Otherwise, use an organizational structure that works best for the project.

It is important to remember that the WBS includes 100% of the work defined by the project scope, including project management tasks, and includes all deliverables. This is referred to as the 100% rule. Subsequently, each subordinate level within the WBS should add up to 100% of the effort for that deliverable or phase.

WBS Dictionary. In addition to the WBS hierarchical view, a WBS Dictionary is an accompanying document that provides significantly more information than the WBS. For each element of the WBS, the WBS Dictionary briefly defines the scope and deliverables, lists associated activities, and lists milestones against which to measure and evaluate progress. Additional information can be included to guide project team members, such as organization or resources responsible for the work, scheduled start and end dates, charge codes, costs, and quality control protocols. Because it contains more detail than the WBS alone, the WBS Dictionary should continuously be consulted and updated during the project. Templates for the WBS Dictionary vary by agency. The following format can be used as a guide for defining each WBS element in the WBS Dictionary.

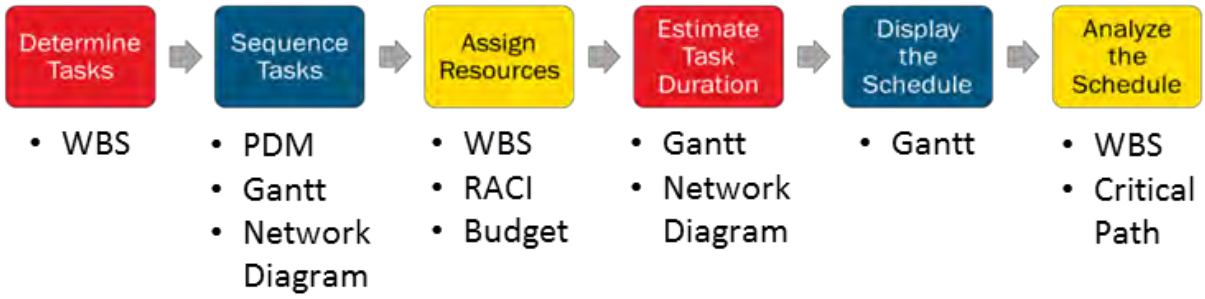
<table>
<tr><th>WBS Number:</th><th>WBS Name:</th></tr>
<tr><td colspan="2">Responsible Individual/Organization:</td></tr>
<tr><td colspan="2">Description of Work:</td></tr>
<tr><td colspan="2">Measures of Performance:
Inspection:
Demonstration:
Test:
Analysis:</td></tr>
<tr><td colspan="2">Performance Work Statement (PWS) Paragraph:</td></tr>
<tr><td colspan="2">Task(s): The section below will be used to breakdown each task associated with this WBS element and the resources required to complete each corresponding task.</td></tr>
<tr><td>
<table>
<tr><th>Related Work/Task</th></tr>
<tr><td>1. Outline all technical work related to WBS element</td></tr>
<tr><td>2. Item 2</td></tr>
<tr><td>3. Item 3</td></tr>
</table>
</td><td>
<table>
<tr><th>Resource or Labor Category</th></tr>
<tr><td>1. List the name of the resource assigned to the corresponding task</td></tr>
<tr><td>2. Item 2</td></tr>
<tr><td>3. Item 3</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Each section above should be repeated for each WBS element in sequential order. The section below should only be included with the last element in the document.</td></tr>
<tr><td>WBS Dictionary Prepared by:</td><td>Title of Preparer:</td></tr>
</table>

Approved by:	Title of Approver:
Date of Approval:	

8. Scheduling

The primary source for scheduling all the activities and tasks in a project is the project WBS. The WBS is constructed from the project's requirements, and it organizes and defines the total scope of the project. The WBS breaks project work up into smaller pieces, which will enable you to schedule and cost-out the work. The WBS may be deliverable-based and focus on when actual products, or "deliverables" in the scope, are developed and arrive at their point of use; or it may be phase-based focusing on the activities occurring in the life-cycle phases and milestones of the project. If agency policy does not have a required format for a WBS, use the format that makes the most sense for the unique requirements of the project. Once your WBS is created, there are six steps to scheduling project work logically and effectively:

Figure 50: Six Steps of Scheduling



1. **Defining the Activities and Tasks.** A task is an actual component of work to be performed that cannot be practically subdivided and can be assigned to a single entity, such as an individual person or small group of persons of similar skills. Tasks are created by breaking down the work package deliverables of the WBS. Project phases and milestones are significant events in the project that are marked by the completion of a deliverable. Use the deliverables in your WBS to create a milestone list.

2. **Sequence**. After identifying the tasks, put them in the order they will be performed. While doing this, determine which tasks depend upon other tasks so you can schedule them appropriately.

3. **Resource**. Once the tasks are organized in a logical order, assign people and resources to the tasks.

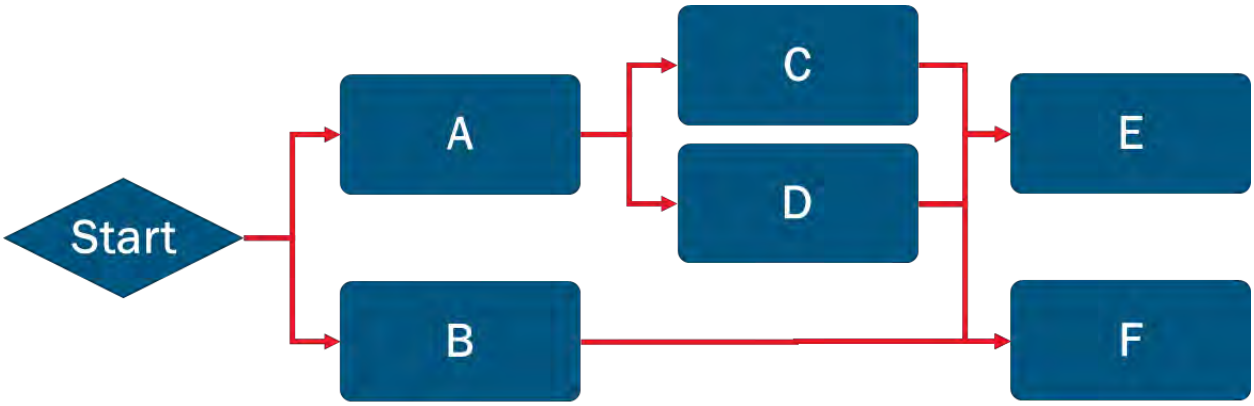
4. **Duration**. Next, estimate how long you think each task will take, or its duration.

5. **Display**. Display it in the format of your choice (Gantt, Milestone, Network).

6. **Analyze**. This analysis includes validating the schedule to ensure all tasks were included, identifying the end date of your project, and making changes to adjust the end date if needed. As with most planning processes, you will progressively elaborate the schedule, adding more and more details with each step of the scheduling process.

a. Scheduling Tools

Figure 51: Precedence Diagramming Method (PDM)



Precedence Diagramming Method (PDM)

Node	Visual depiction of an activity or task
Arrow	Connects nodes and shows dependencies
Predecessor	A node that occurs before another
Successor	A node that occurs after another

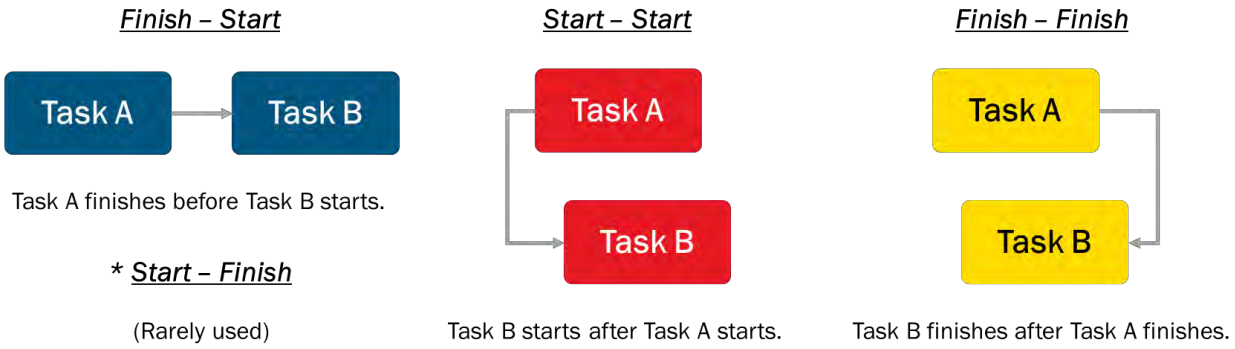
Rarely can a project be accomplished from start to finish without any tasks relying on others, and, conversely, schedule efficiencies can be gained by doing tasks concurrently. Flowcharting helps to visualize the dependencies between tasks and is often referred to as a schedule network diagram. On the network diagram, all tasks are represented by a rectangular shape called a node. Arrows connect the nodes and show the dependencies between tasks. The precedence diagramming method, or PDM, shows the relationships between tasks.

A predecessor is a task that happens before another task on the diagram. In this example, Tasks A and B can both start at the beginning of the project. They have no predecessors. Task A must be complete before Tasks C and D can start. This dependency is depicted with arrows starting at Task A leading to Tasks C and D. Tasks C and D are not dependent upon

Task B at all since there is no arrow leading from B to either of these tasks. Tasks E and F are dependent on Tasks B, C, and D.

A successor is a task that happens after another task on the diagram. Task F is a successor to Task B because it occurs after Task B. It is also dependent upon Task B because it cannot start until Task B is finished. Task A is a predecessor to Task C because it occurs before Task C.

Figure 52: Types of Dependency



When sequencing tasks to create the project schedule, identify the dependencies among tasks. The finish-start dependency is the most common. This is depicted with an arrow leading from the end of one task to the beginning of the dependent task. A simple example of a finish-start dependency is that you must finish washing your clothes before you can dry them. In other words, Task A must finish before Task B can start.

Start-start is another type of dependency. It is shown with an arrow from the beginning of one task to the beginning of another task. For example, when filling an open position in your office, you can't start interviewing candidates until you start receiving applications. The dependent task can start any time after the predecessor task starts; it does not have to wait for the predecessor to finish.

Finish-finish dependencies are depicted with an arrow from the end of one task to the end of another. This shows that the dependent task can't be completed until after the successor task is complete. For example, you can't finish testing the programming code you wrote until after you finish writing the code. The dependent task in this type of dependency can finish any time after the predecessor task finishes.

A fourth dependency, start-finish, is almost never used. In this dependency, the start date of one task creates the finish date of the other.

The third step in the scheduling process is to assign resources. To assign a resource to a task, first identify the resources that are able to perform the work. When creating the project's schedule, resources are the people, tools, machines, IT, or equipment assigned to do the work. Like most planning processes, the scheduling process is iterative. As the work draws nearer, identify the actual individual who will perform the work. Balance the skills and

experience of each person with his or her cost and availability to determine the best fit on the project. This may not always be possible as resources may be arbitrarily assigned to you.

A responsibility assignment matrix, or RAM, is a tool to match tasks to the people responsible for them. In its simplest format, a RAM is a grid with tasks listed down the left side and the names of project resources listed across the top.

RACI is one commonly used format for constructing a RAM-type matrix. In RACI, R stands for responsible, A for accountable, C for consult, and I for inform. In this example, Steve may be responsible for Task 1, but he must inform Beth of its progress and completion. Beth is responsible for completing Task 2, but she must consult with Clara and inform Steve of her progress. Task 3 represents a task where the project manager has assigned more than one resource in order to decrease the overall duration of the task.

Figure 53: Project Responsibility Assignment Matrix (RAM)

Task/Activity	Steve	Beth	Clara	Juan
Task 1	R	I		
Task 2	I	R	C	
Task 3	I	R	R	
Task 4	I			R

Key	Additional symbols
R=Responsible	S=Support
A=Accountable	V=Verifier
C=Consult	O=Out of the loop
I=Inform	

Update the RAM as you make further resource assignments on the project. Additional symbols exist, such as S for support, V for verifying a task, and O for those who should not be informed of the progress. The symbols are not as important as making sure everyone agrees to and understands them, and a key is present on the document itself.

b. Software Applications for Scheduling

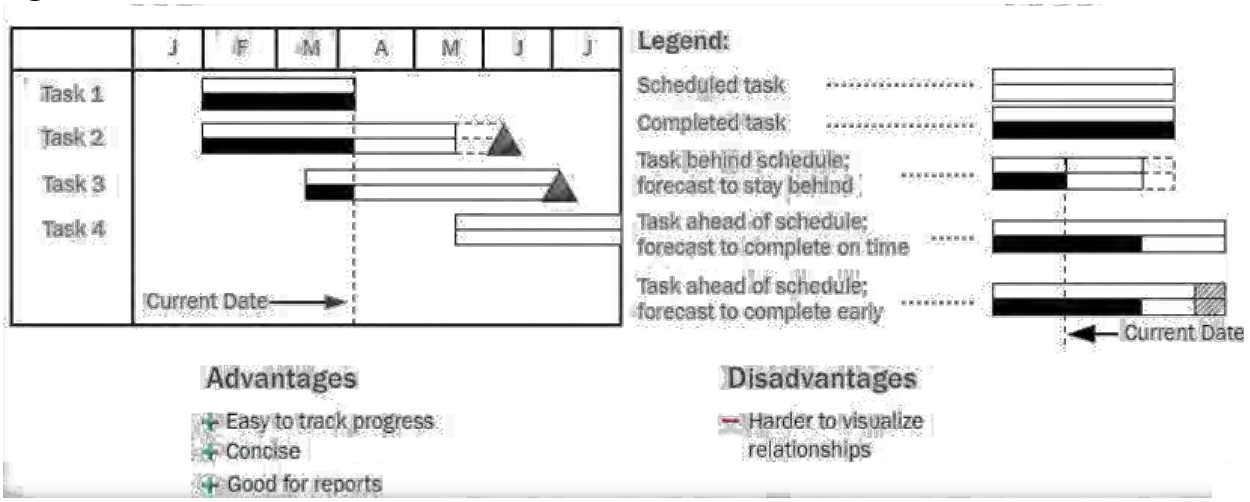
You are most likely using scheduling software to do all this. Which software you use is largely dependent on your agency's policy.

In addition to project-specific information, there is organizational information that feeds into your schedule. For instance, what units of measure are you using for the duration of a task? Does a task's duration of two represent two hours, two days, or even two months? How does the organization work? Do employees work five eight-hour days or four ten-hour days? Will overtime be expected, permitted, or maybe prohibited? What are the holidays when work will not be performed?

Once you enter all of this information into your scheduling software, you are ready to finish creating the schedule and view it. You may choose to display your schedule in one of many formats. The most commonly used formats are the Gantt chart, the milestone chart, and the network diagram.

c. Schedule Formats

Figure 54: Gantt Chart

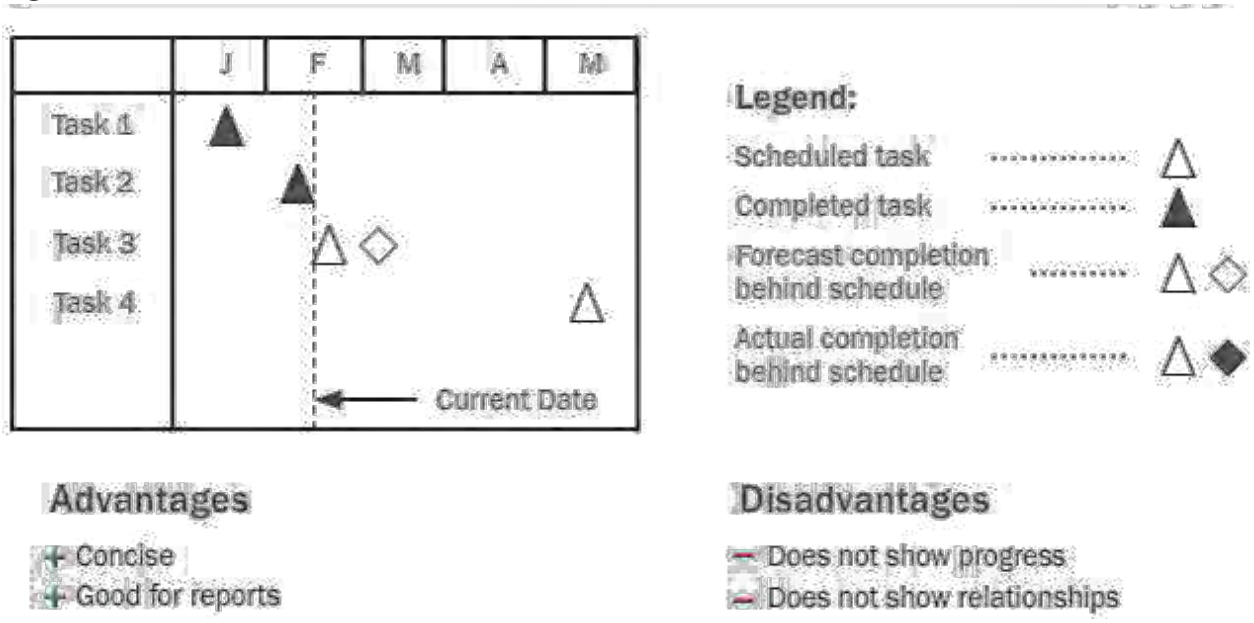


The Gantt chart is a type of bar chart that displays tasks along a timeline. The current date is shown with a dashed vertical line running from the top to the bottom. There are no standard symbols for a Gantt chart. Some versions simply show the planned beginnings and ends of tasks with the vertical lines on the task bar. Others add a symbol, usually a triangle, to denote the beginning or end.

You can visually track the progress of an activity easily using a Gantt chart. As the work progresses, the bar for the task fills to show the work being done. For example, you can see that Task 4 has not begun yet because its progress bar is not filled in at all. If a task is taking longer than expected, you can adjust the expected completion date. This will be represented on the task bar with a dashed outline. Project deliverables and milestones are also depicted on the Gantt chart. They are zero-duration activities usually shown with a triangle. Always create a key, or legend, so anyone looking at the schedule can determine what the symbols represent.

There are a few reasons the Gantt chart is widely used. First, it is easy to track the progress of tasks visually with the progress bars. It is a concise format that is relatively simple to read once you are familiar with it. It is also a great format to use for reporting progress to management because it allows for progress to be visualized. The drawback with using a Gantt chart is that it does not show relationships and dependencies between tasks.

Figure 55: Milestone Chart

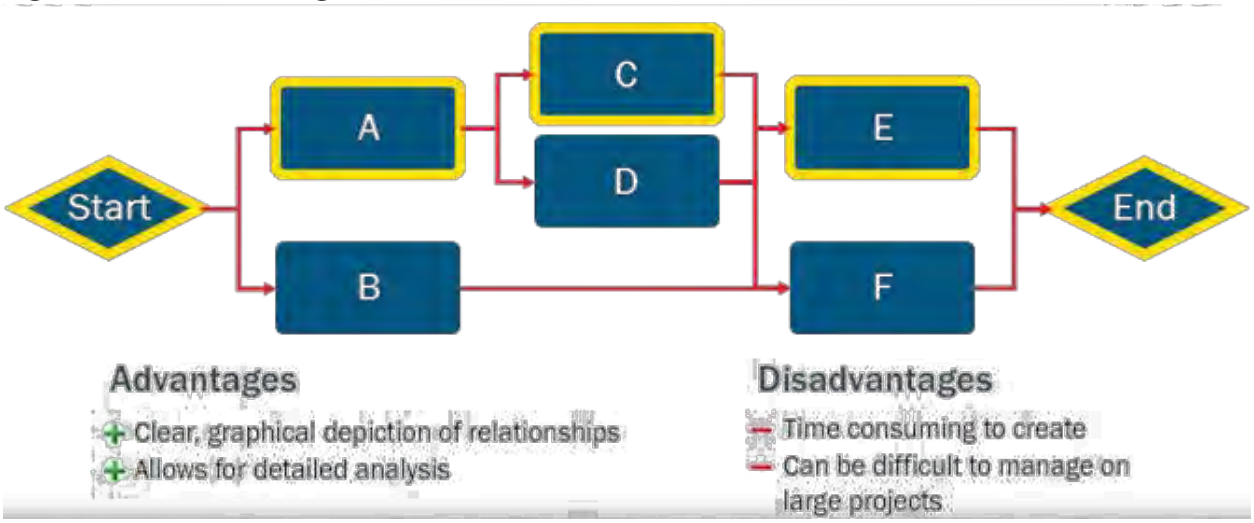


A milestone chart is a high-level schedule document that only shows key dates or milestone dates for the completion of tasks. Like on a Gantt chart, the current date is portrayed with a dashed vertical line. Projected completion dates are shown as outlined shapes, usually triangles. The date an activity was actually completed is displayed with a solid shape.

If an activity is taking longer than expected, you can show this on the milestone chart also. Use the outline of a shape other than a triangle to show the new projected completion date. Always include a legend showing the symbols used on the schedule for interpretation.

Like the Gantt chart, a milestone chart has the advantage of being concise and good for reporting task completion and management. Its disadvantages are that it does not show the completion status of each task or the relationships between tasks.

Figure 56: Network Diagram



Earlier in this lesson you saw a simple network diagram in the form of the precedence diagram. On this type of schedule, it is easy to see which tasks depend on other tasks. This level of detail allows for easy analysis because you see what potential changes may impact. Like all formats, the network schedule has disadvantages too. It can take a lot of time to create a schedule this detailed. If you are managing a large project, a diagram in this format can quickly become hard to use.

d. Schedule Analysis

There are three basic steps to analyzing the project schedule: review for validity, determine the project's end date using the critical path method, and adjust the schedule, if necessary. When reviewing the schedule for validity, ensure that all project tasks, deliverables, and milestones are included in the schedule. For each task, check that its duration estimate and dependencies are correct. For any tasks happening in the near future, confirm that resources are assigned and that those resources are available to do the work.

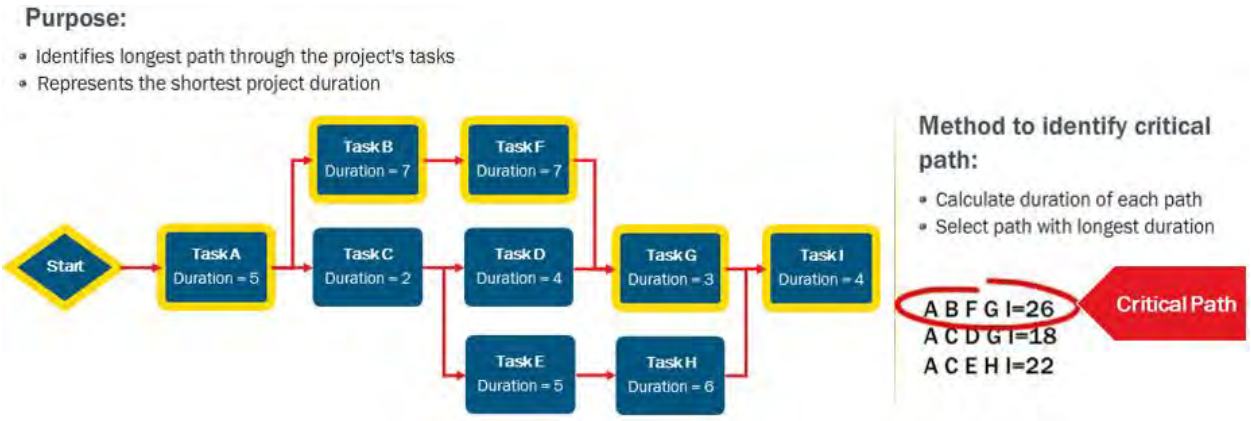
The next step in schedule analysis is to determine the project's end dates using the critical path method. Simply put, the critical path is the longest path through the network of the project's tasks. The critical path method calculates the earliest possible end date for all project tasks. Since the project can't be completed until all these tasks are done, the critical path is the shortest possible, or minimal, duration of the entire project. If the project's duration is too long for any reason, such as a client-dictated end date, look for ways to shorten the schedule. This is called schedule compression.

The critical path is the longest path through a project's tasks. The combined duration of the tasks on the critical path is equal to the project's shortest possible duration. Note that there is more than one way to determine a project's critical path. The following is one of the mainstream methods:

Start with a network diagram. Label each task with its unique identifier, in this case a letter of the alphabet in the center of each node. Below the label on each node, make a note of the task's duration. Now you are ready to identify the critical path by calculating the duration of each individual path on the diagram by adding together the durations of all tasks on each path.

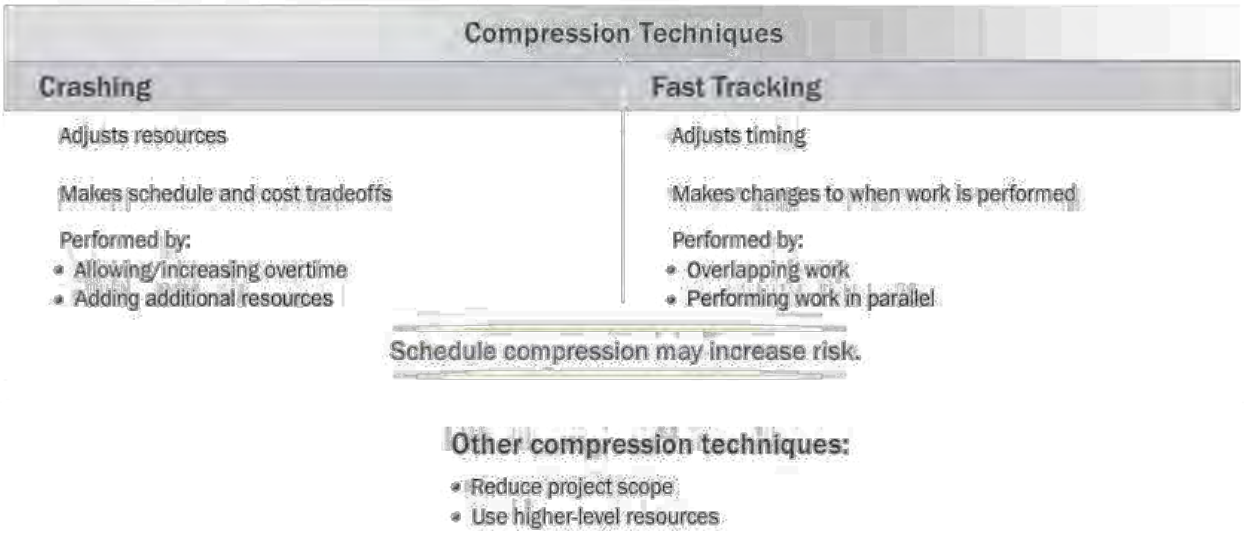
This diagram has three individual paths. Path one is Tasks A, B, F, G, and I. Path two is Tasks A, C, D, G, and I. Path three is Tasks A, C, E, H, and I. The sum of all task durations on path A, B, F, G, and I is 26. The sum of all task durations on path A, C, D, G, and I is 18. The sum of all task durations on path A, C, E, H, and I is 22. The path with the longest overall duration is the critical path. In this schedule, path A, B, F, G, and I is the critical path because its duration of 26 is the longest.

Figure 57: Critical Path Method



If the project's end date is later than desired, you may need to compress the schedule. This is best done either as soon as the schedule is created or as the project progresses and dates adjust. The two most commonly used schedule compression techniques are crashing and fast tracking.

Figure 58: Schedule Compression



Crashing the schedule is only possible where additional resources will shorten the length of a task. Crashing involves making schedule and cost trade-offs, such as adding overtime hours for some or all of your employees to allow the work to be finished by the requested deadline or adding employees to the project that would help finish the work in a shorter amount of time. If either of these are possible solutions, then determine if the associated cost trade-off is acceptable.

To fast track the schedule, make changes to when the work is performed. Look for tasks that are scheduled to start when other tasks finish. Is it possible to have the dependent task begin before its predecessor is finished? Are there any tasks occurring later in the project that could be moved sooner and performed in parallel with others? In other words, can you gain some schedule concurrency?

Both crashing and fast tracking can increase the project's risk and should be planned and managed carefully. If neither of these techniques can shorten the duration of your project, you may want to examine the project's scope. Look for any potential work included in the project that is not required to meet the project goals.

Finally, investigate if there are resources with higher skill levels to do the work. This is only helpful if the increased skill translates to an ability to do the work faster due to increased costs of higher-skilled labor. If the work cannot be completed in a faster time that justifies the increased cost, then this is not a cost-effective alternative unless the due date is more critical than budget.

9. Quality

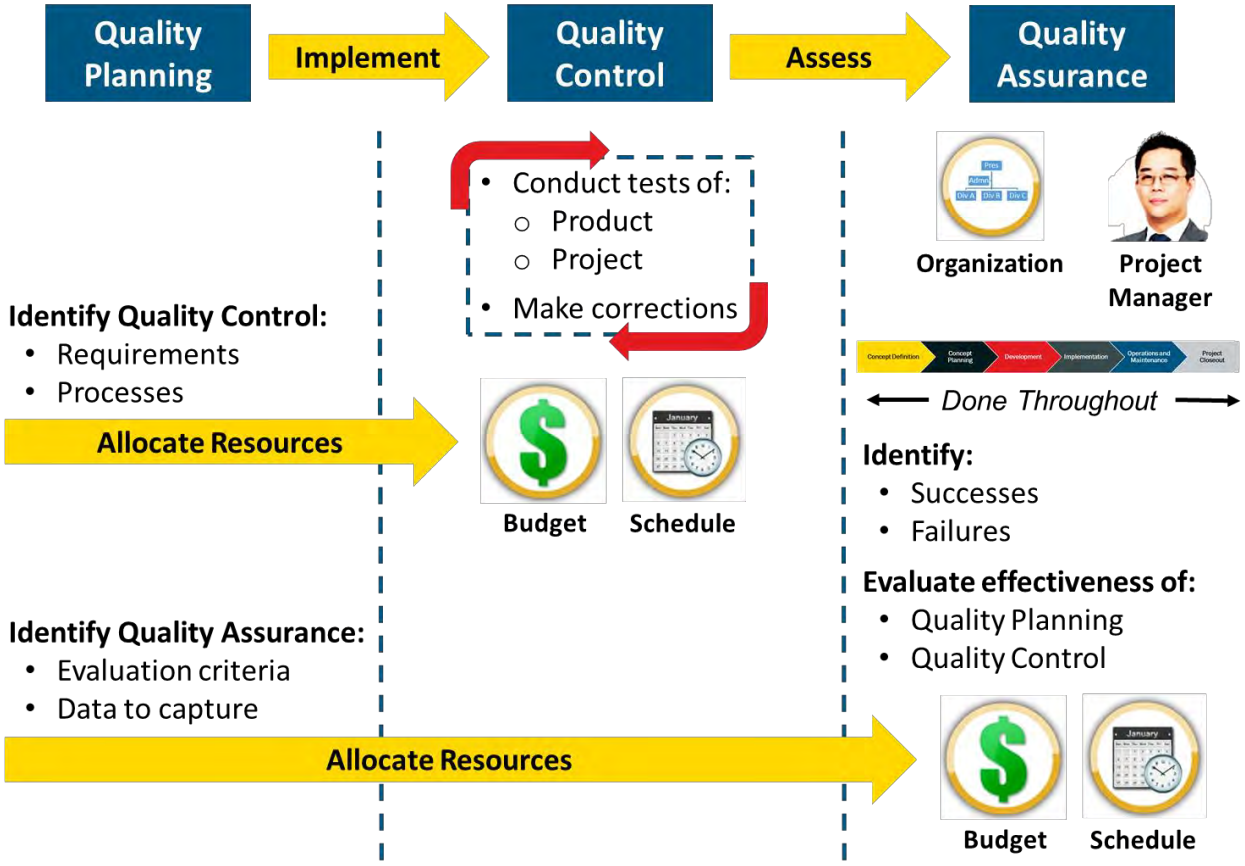
Quality products or services consistently perform as expected, are well-suited to providing capabilities the customer needs, are simple or intuitive to operate or utilize, provide a

benefit as valuable or more valuable than the cost of gaining the benefit, and are adaptable to changing operational environments and evolving processes.

In the context of project management, quality is measured in two ways: how well the solution meets requirements and how well your project performance conforms to constraints such as budget, schedule, manpower, and customer satisfaction. A quality project produces deliverables that provide customer satisfaction in a manner that is cost-efficient, timely, and utilizes available personnel effectively.

Quality cannot be inserted at the end of the project but must be planned from the beginning and incorporated throughout each project phase. Quality management requires resources and time to perform. Project quality management is typically the same as, or heavily influenced by, the organization's own general quality management processes and procedures. Quality management encompasses three processes: (1) quality planning, (2) quality control, and (3) quality assurance.

Figure 59: The Quality Management Process



a. Quality Planning

The customer, item developer, PM, and project team all participate in quality planning. Typically, these participants collaborate to establish quality requirements. The PM is responsible for communicating final quality requirements and for scheduling quality management activities and allocating resources in support of those activities. Planning for quality occurs in the Concept Definition and Concept Planning phases of the project life-cycle.

There are four steps in quality planning: (1) identifying requirements, (2) identifying quality standards and metrics, (3) selecting a monitoring and verification system, and (4) developing a quality management plan. The quality management plan may include the quality assurance surveillance plan, or QASP, or be the same thing as the QASP.

Identifying requirements starts with describing what quality means in the context of your solution and your project. The PM prioritizes requirements according to which ones are most critical to developing a quality solution and providing quality project performance. As requirements develop and change, the opportunity for "gold plating" can occur when requirements describe an outcome that is nice to have but not necessary or when the solution to meeting a requirement far exceeds appropriate performance. Gold plating increases cost and does not support developing an appropriate solution.

b. Measuring Quality

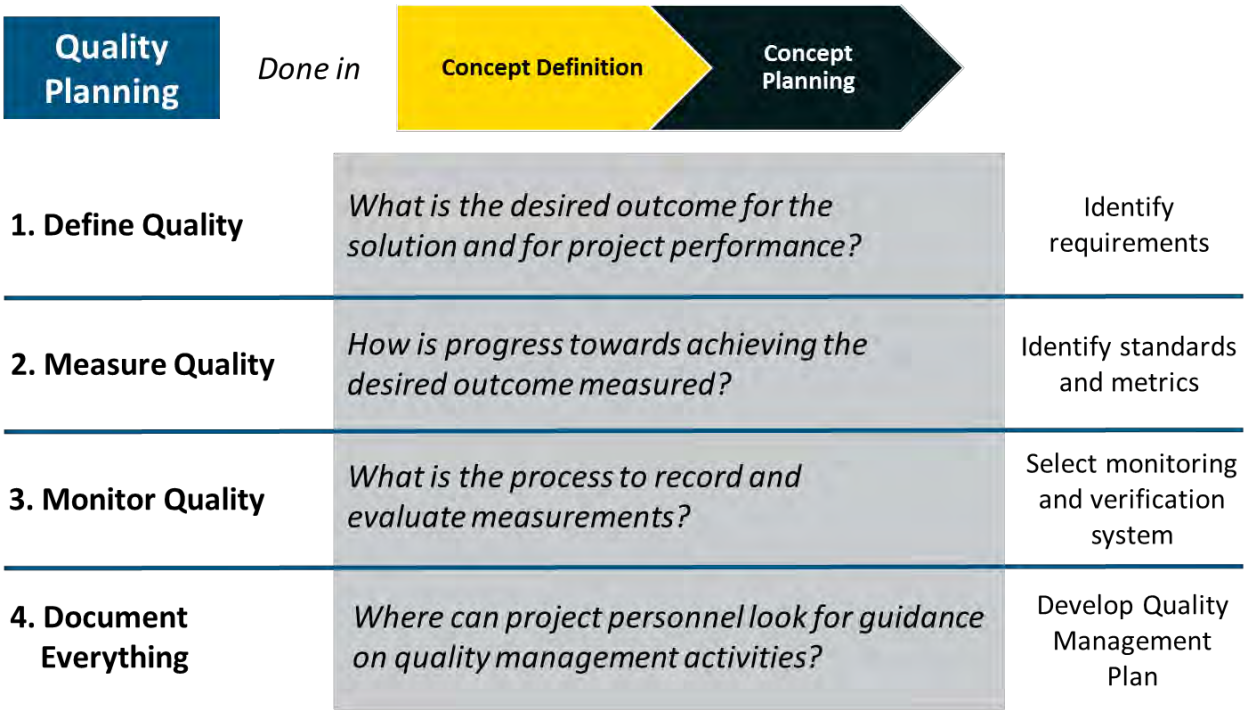
The PM must describe which aspects of the solution and project performance represent quality and can be quantified. Standards and metrics describe how quality can be quantified and should be included in the quality management plan. A standard is a target or threshold expressed in a unit of measure, and it is sometimes considered a requirement. Metrics are the data points collected that reflect performance. Often, simple data like number of complete deliverables, number of on-time deliverables, and number of late deliverables must be manipulated using an equation to determine a meaningful metric. You measure progress toward achieving a standard by comparing metrics against the standard.

Monitoring quality requires consistent evaluations of your product and project performance. Monitoring and verification systems detail the procedures and tools used to measure and evaluate quality and should be included in the quality management plan. The monitoring and verification system consists of the procedures and tools the PM and team use to collect the data necessary to assess quality, compare that data against requirements and the applicable quality standard, identify corrective changes to address any quality failures, and verify that corrective changes are not only performed appropriately but that they sufficiently address the quality failure.

Quality standards and metrics as well as monitoring and verification practices often come from the quality standard your organization has selected. Quality standards describe a system of best practices used by an organization to manage quality and evaluate how well an organization uses the proscribed quality management system. Quality standards are issued, updated, and maintained by a recognized, independent association, such as the

International Organization for Standardization, which issues the ISO 9001 Quality Systems Model for quality assurance, a well-known quality standard. These issuing associations examine an organization's adoption of their quality standard, and, if the organization complies with their standard, certifies the organization as meeting the standard.

Figure 60: The Quality Planning Process



c. Quality Management Plan

The quality management plan captures the information necessary to implement quality management. The quality management plan identifies the criteria used to evaluate quality, including product and project requirements, quality standards that apply to the project, and the metrics used to measure quality and compare performance against requirements and standards. The quality management plan describes the scope of monitoring and verification activities to include an overview of quality control and quality assurance items to be tested, high-level questions that quality control and quality assurance activities should answer, and a list of involved personnel. The project Quality Management Plan may include the vendor's Quality Assurance Plan if a contract is in place at specific points in the project life-cycle, and it may also contain the Government's Quality Assurance Surveillance Plan.

The quality management plan also details the cost of performing quality-related activities, such as the cost of personnel involved in planning for quality and the cost of personnel and equipment involved in conducting quality control tests and quality assurance audits. Another cost factor is the cost associated with failing to develop a quality product or service the first time around. These costs include the personnel, equipment, and materials wasted on

developing and disposing of failed deliverables and the personnel, equipment, and materials spent developing acceptable deliverables to replace the poor-quality ones.

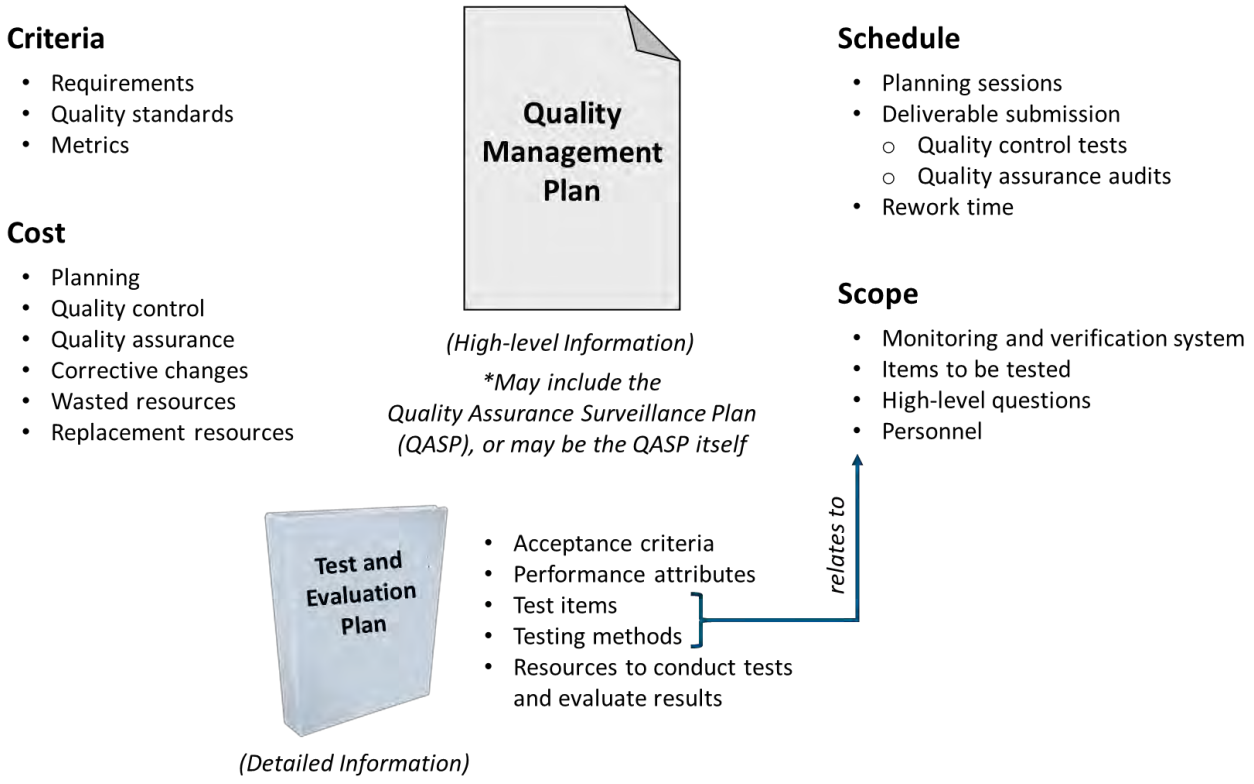
The quality management plan details a schedule of when quality-related activities occur. Such activities include planning sessions, providing deliverables, quality control tests, quality assurance audits, and time to address any quality failures. The quality management schedule should be incorporated into the overall project schedule and align with the project's deliverable due dates and review cycles.

d. Test and Evaluation Plans

The quality management plan contains high-level information. It would be unrealistic for the quality management plan to include information on how to perform quality control testing for every deliverable or review cycle, but this information is important nonetheless. That said, these processes are documented in the T&E Plan. For each deliverable or review cycle related to the product or service filling the need, the T&E Plan provides detailed guidance on acceptance criteria and performance attributes, items to be tested, testing methods, and resources needed to conduct tests and evaluate results. Most times, the T&E Plan will primarily document the developer's T&E activities.

While test and evaluation results are primarily a means of managing technical risk, quality management uses test and evaluation results as a key tool for identifying quality failures when the solution does not meet performance requirements.

Figure 61: The Quality Management Plan

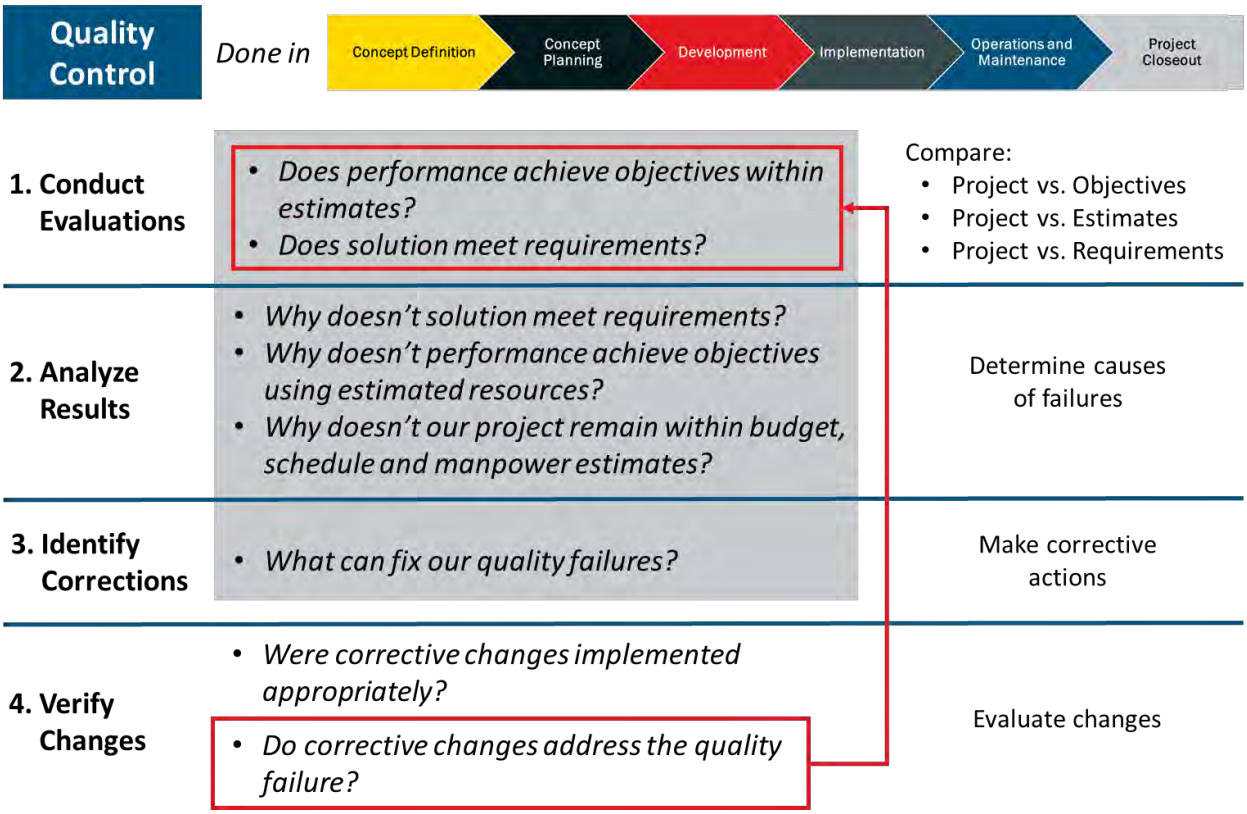


e. Quality Control

Quality control is the process through which the PM monitors quality and makes changes to correct poor quality. When performing quality control, it is the PM's responsibility to provide guidance on how to meet quality requirements for the product or service and project performance. It is the developer's responsibility, in cooperation with the PM and customer, to perform quality control activities related to the design, development, and implementation of the product or service and take any necessary corrective action to meet quality requirements. It is the responsibility of the project team and the PM to perform quality control activities related to the project performance and take any necessary corrective action to meet quality requirements.

Quality control occurs throughout the Concept Definition and Concept Planning phases when evaluating project performance and throughout the Development, Implementation, and Operations and Maintenance phases when evaluating both project and solution performance. To perform quality control, the PM and team evaluate project and solution performance from three perspectives: (1) if project performance achieves predicted project objectives; (2) if project performance meets objectives while remaining within budget, schedule, and manpower estimates; and (3) if the solution meets performance requirements. Based on the outcomes from quality evaluations, the PM and project team identify any quality failures and implement fixes to those failures.

Figure 62: The Quality Control Process



Inputs and Outputs of Quality Control. To evaluate quality, start with the criteria used to quantify what quality means in the context of the project. These criteria include solution requirements and project estimates for budget, schedule, and progress. Next, determine the test items to be compared against these criteria. Test items used for examining the solution include designs, prototypes, components, and developed systems. Such examinations fall under traditional test and evaluation in the context of performing systems engineering and managing technical risk. Test items used for examining the project include performance metrics such as budget expended to date and solution development achieved to date. Such examinations fall under EVM which tracks actual work performed and the budget and schedule expended to achieve that work, and then compares that data against estimates for work completed, schedule elapsed, and budget spent. Based on these results, the PM and team can identify quality failures and recommend corrective changes to address them.

Quality Control Testing. The PM and project team members examine deliverables and performance metrics to compare project performance against estimates for budget, schedule, and project status. This kind of testing is sometimes referred to as either EVM, or simply the project's internal controls process. The developer compares solution design, prototypes, components, and developed systems against requirements. This kind of testing is a form of developmental testing and is conducted in a controlled environment to varying degrees, employing an iterative cycle of test, analyze test results, fix or correct failures, and retest. The customer compares the performance of a developed solution in the environment in which the solution must function, known as the operational environment, against the

needs of its end-users. Operational testing is conducted under conditions as close to realistic as possible by typical users performing typical operations.

Regardless of the type of testing performed, there are tools and techniques the PM and the project team can use to measure and evaluate test items:

- A **testing matrix** is similar to a checklist and summarizes information from the T&E Plan. While formats may vary, all testing matrices include a few key components: the requirement or performance criteria, the method the tester should use to measure the test item's performance, and an indicator as to whether the test item met the criteria.

- **Inspections** are what most people associate with quality testing. Inspections are structured evaluations that use quantitative, set criteria. They may be scheduled or unannounced.

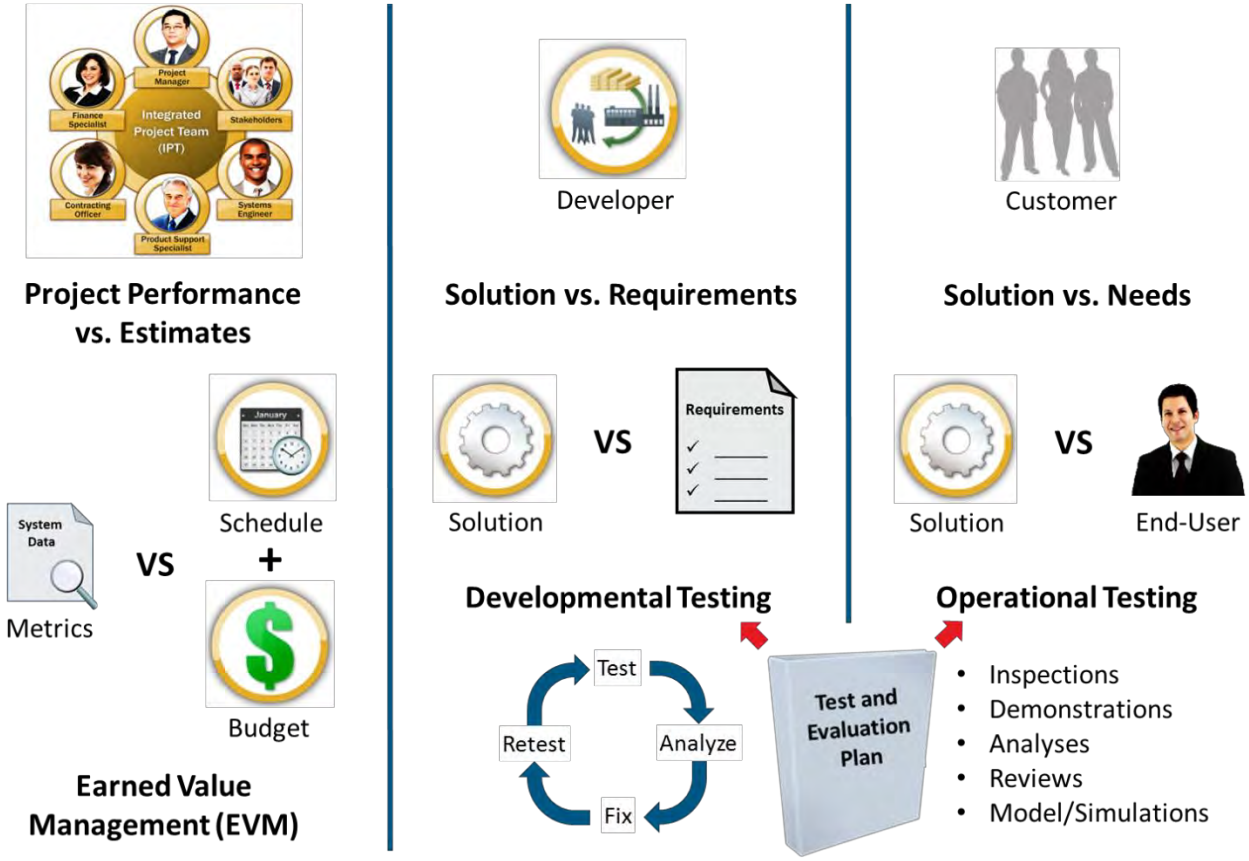
- **Demonstrations** test observable, often physical characteristics of a prototype, component, or process and typically employ the test, analyze, fix, and retest cycle.

- **Analyses** also typically employ the test, analyze, fix, and retest cycle. They evaluate data collected from testing that can verify conformance of solution or project performance with criteria.

- **Reviews** allow a range of stakeholders to evaluate solution and project performance from a variety of perspectives.

- **Models or simulations** allow testers to examine a solution's capabilities and user experience on a small representative scale before funding larger-scale activities or production.

Figure 63: Types of Quality Control Testing



f. Quality Assurance

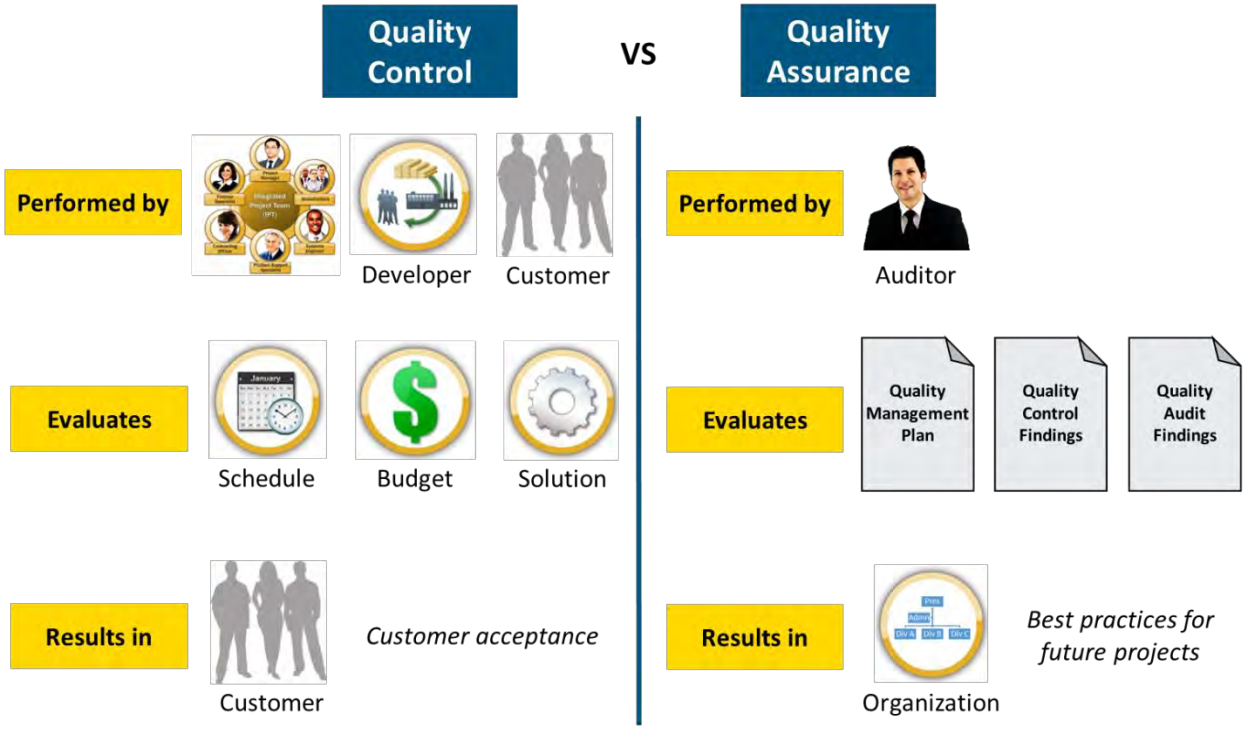
Quality assurance occurs throughout the project life-cycle, but the PM and project team do not conduct quality assurance. Quality assurance is the process by which a neutral party or auditor assesses the effectiveness of the project's quality planning and the implementation of that planning through quality control. For the product itself, the manufacturer or developer conducts quality control, and the Government conducts quality assurance. For performance-based acquisitions, the Government develops a Quality Assurance Surveillance Plan (QASP) to inform the developer of how it will measure and evaluate quality.

Quality assurance auditors evaluate the findings from quality control activities and the findings from their own audits to identify quality successes and failures and communicate them to the customer, project manager, and developer. In response to the auditor's findings, the customer, project manager, and developer collaborate to develop corrective changes to processes and procedures that will promote quality success and prevent quality failure on future projects.

If the auditor has correctly performed the quality assurance audit, the quality audit report should describe quality successes and failures and identify the causes of those successes and failures. In response to the auditor's findings, the PM, project team, and the

organization should implement changes to current quality practices, update procedure documentation accordingly, and plan training on improved quality practices.

Figure 64: Quality Control vs. Quality Assurance



10. Project Baselines

To determine if progress is being made on a project, it is important to measure project performance from a common start point: the project baseline. Baselines are important because they establish a benchmark against which to manage requirements and measure progress or regress in project cost, schedule, and performance (product scope) attributes.

a. Using Threshold and Objective Values

For complex projects, baselines are often times expressed in terms of a threshold and objective value. The threshold value is the minimum accepted value for maintaining overall viability of the project, and conversely the objective signifies the optimal goal to achieve. The range between the threshold and objective values can become the basis for making cost, schedule, and performance trade-off decisions or as a means to incentivize contract performance. For some functions or attributes, threshold and objective values may be the same value.

Threshold and objective values for project cost are based on some component of project cost, such as the total cost to develop, produce, and purchase the product. The threshold or minimum acceptable value for this cost component would be the highest possible cost

stakeholders would be willing to pay for the item being acquired. Conversely, the objective value would be the lowest possible cost that delivers a product that meets requirements. The range between the threshold and objective values, usually expressed as a percentage of the baseline cost component, provides the "trade-space" for managing cost trade-off decisions or to incentivize a manufacturer to be efficient in controlling costs.

Threshold and objective values for the project schedule are usually based on the date or time frame the first assets are available for actual use. A threshold value for schedule would be the latest date the user is willing to receive the new items without any decrement to the mission while addressing the capability gap the solution was meant to fill. The objective value would be represented by an earlier date that's advantageous to the user to receive the new capability ahead of schedule, assuming the user is ready to receive the asset ahead of schedule. The range between the threshold and objective values for schedule are usually expressed in terms of weeks or months.

Threshold and objective values for product scope or performance are expressed in terms of measureable performance attributes or functions, such as reliability, utility, ease of use, physical tolerance, or accuracy. A threshold value for performance represents the minimum acceptable level required by the user that delivers the needed capability. The objective value represents the performance level that delivers the best capability possible. The range between threshold and objective values for performance are expressed in various ways, depending on the nature of the performance attribute or function.

Figure 65: Example Project Baseline

Cost, Schedule, Performance (Product Scope) Threshold and Objective Values For Office Workstation:

Basis for Values:

- Cost: Unit cost of the total buy quantity of 1000 workstations
- Schedule: Month that first office (X) receives all authorized workstations
- Performance Attribute #1: Size/Footprint
- Performance Parameter #2: Interoperability with legacy workstations

Baseline	Threshold	Objective	Range
Cost	$1250 per station	$1050 per station	(-) 16% of Threshold
Schedule	October 2017	July 2017	(-) 3 months of Threshold
Performance #1: Size	250 cubic feet	275 cubic feet	(+) 10% of Threshold
Performance #2: Interoperability	Attaches to legacy system on one side	Attaches to legacy system on 2 or more sides	One additional multi-station configuration over Threshold

Threshold: The threshold value is the minimum acceptable value that, in the user's judgment, is necessary to satisfy the need. If threshold values are not achieved, program performance is seriously degraded, the program may be too costly, or the program may no longer be timely.

Objective: The objective value is that value desired by the user for which the PM is contracting or otherwise attempting to obtain. The objective value could represent an operationally meaningful, time-critical, and cost-effective increment above the threshold for each program parameter. If no objective is otherwise indicated, the objective is the threshold.

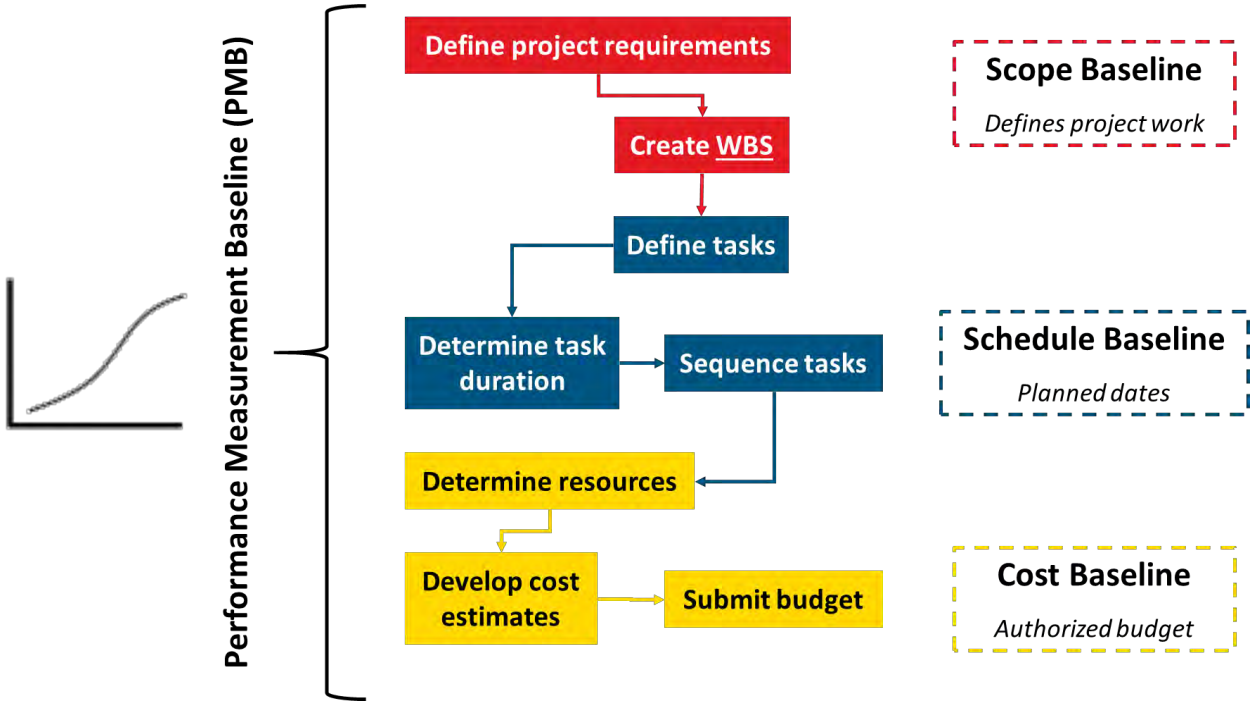
Baselines can be used as a binding agreement between the PM and stakeholders, such as the project sponsor, to track project progress. Unfavorable deviations or a "breach" from the threshold can generate additional project control measures or risk mitigation actions to bring project performance within desired values.

b. Performance Measurement Baseline

The performance measurement baseline (PMB) is the most common baseline and is the original project baseline outlined in the initial approved set of documents for project schedule, cost, and scope. Projects commence, the PM measures progress or makes changes to the project, compares the actual values to the baseline values, and evaluates project performance. The PMB is a vital component of EVM and is the basis for which EVM can actually be conducted.

Do actual values exceed baseline values and therefore exceed performance expectations? Or do actual values fall below baseline values and therefore do NOT meet performance expectations? Performance that falls below expectations usually requires corrective action by the PM. Figure 66 below shows the three baselines—Scope, Schedule and Cost—that comprise the PMB. Unless a significant change in direction occurs on a project, the baseline should never be changed.

Figure 66: Performance Measurement Baseline (PMB)



c. Integrated Baseline Review

The project documentation discussed previously is critical to measuring progress as part of the integrated baseline review (IBR) process. The IBR establishes the performance measurement baseline and provides an ongoing structure to evaluate the PMB against project plans and discuss project strengths and risks across the life of the project. Ultimately, any IBR establishes a mutual understanding between the PM and project stakeholders of the project performance measurement baseline. The first IBR should be convened early in the project, approximately 30 days into the project, before any project baseline data is gathered. This IBR is used to focus on establishing a baseline with the existing project documentation. Subsequent IBRs, convened every six months for multi-year projects or every quarter for shorter duration projects, focus on risks and events with potential impact on the established baseline.

The IBR involves:

- Project Manager
- Project Sponsor
- Contractors
- Stakeholders
- Systems Engineers
- Product Support Specialists

For the IBR to be meaningful, the PM must:

Prepare. Assemble the right team of stakeholders with the requisite leadership, management, and technical expertise to provide feedback in the IBR.

Execute. Facilitate a discussion around the following key questions:

1. Does the scope reflect the WBS?
2. Is a clear timeline provided?
3. Are milestones identified?
4. Is resource availability reflected?
5. Does resource availability complement scope?
6. Is the relationship between cost, schedule, and scope clear?
7. Can variance be objectively measured?
8. Are risks adequately identified?
9. Are project resources sufficient to manage unidentified risks?
10. Can the cost, scope, and schedule account for actualized risks?
11. Is there a plan for baseline support and maintenance?
12. Can the project afford execution of management processes?

Close. Ensure agreement among the IBR team and determine next steps (and, if needed, corrective actions).

11. Earned Value Management

EVM is a schedule and cost tool that integrates the value of the work with schedule and budget to objectively inform the status of a project. EVM represents project schedule, cost, and scope in monetary terms in order to answer the question, "How much is this project currently worth?" Per FAR Part 34.2, an EVM system is required for major acquisitions for development in accordance with OMB Circular A-11. The Government may also require an EVM system for other acquisitions. When required, the contractor should provide monthly EVM reports.

a. Managing Project Variance

How much of the budget and schedule should have been spent compared to the actual work completed? What is the cost estimate to complete all work, and when is it scheduled to be complete? These are some of the questions EVM attempts to uncover so that the PM and project team have insight into how variations (the difference between planned and actual) in the planned schedule and cost of the project compare to the actual progress and cost of project work. In other words, how much value (work completed) has been provided for a given amount of cost and schedule expended?

First – the Contract

Before you can obtain and use EVM data to assist in tracking cost and schedule variance, certain conditions must be in place:

1. You have to have a contract in place that is delivering project work, preferably work that relates to acquiring the end solution or asset, or portions thereof.

2. The contract you have in place must be the type of contract that can generate EVM data, and that requirement is a contract deliverable.

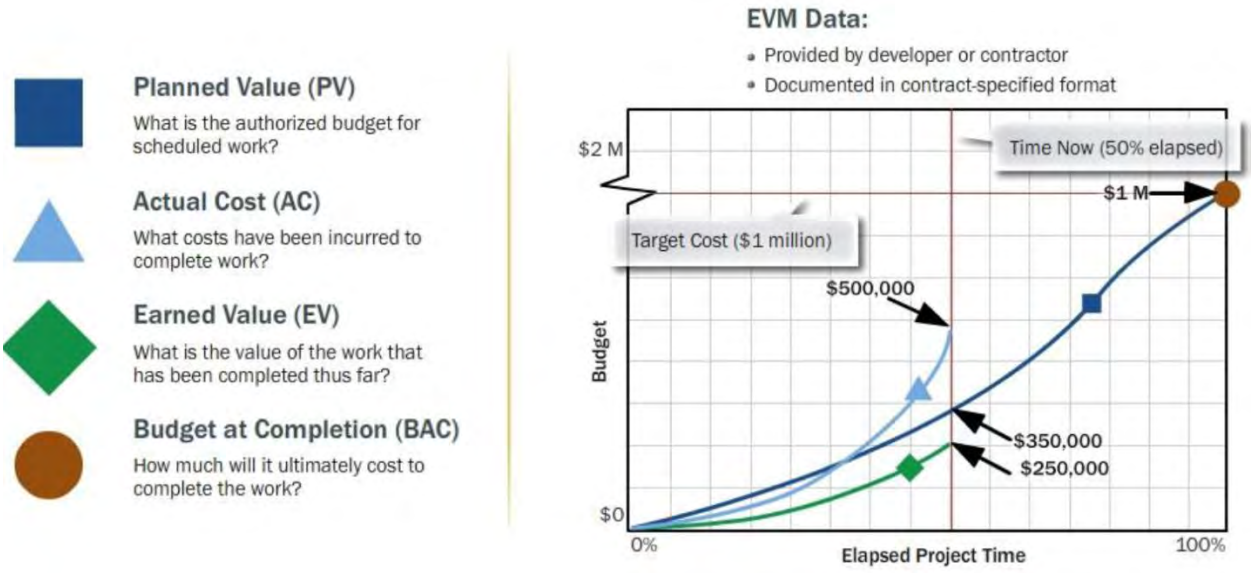
3. The vendor you have contracted with has a viable, verified, and validated process in place to collect and deliver EVM data.

Table 8: Measures of Earned Value Management (EVM)

Measure	Description
Planned Value (PV)	What is the authorized budget for scheduled work? Planned value (PV) represents the approved budget to complete scheduled project work (BCWS).
Actual Cost (AC)	What costs have been incurred to complete work? Actual cost (AC) is the cost actually incurred by accomplishing project work (ACWP).
Earned Value (EV)	What is the value of the work that has been completed thus far? The earned value (EV) is the value of the work completed thus far in the project schedule and budget. In other words, how does the value of completed work compare to how much project time and money has been spent (BCWP)?

Measure	Description
Budget at Completion (BAC)	How much will it ultimately cost to complete the work? The budget at completion (BAC) is the estimated cost of project work by project's end. While determined early in the project life-cycle, the BAC may change in later life-cycle phases based on actual work completed.

Figure 67: Measures of Earned Value Management (EVM)



The primary output of the EVM process is data derived from calculations of cost and schedule variance. Variance is then the difference between actual and planned performance values. Schedule variance (SV) is the difference between the value the project has earned and the planned value. In other words, what is the value of work performed thus far in the project schedule? How does it compare to the expected or planned value?
Cost variance (CV) is the difference between earned value and actual cost. In other words, does the value the project has earned reflect the amount of money actually spent on the project?

EVM data is not generated internally by the project team. EVM data is typically provided by the developer or contractor in whatever format is specified in the contract deliverables, typically during Development and later life-cycle phases. Some EVM data is represented by a graph, which depicts the four EVM measures based on budget, including the target cost, and elapsed project time.

Figure 68: Calculating Earned Value (EV) Variance

Variance: *Difference between planned and actual performance values*

b. Performance Index

Unlike variations, which are calculated in monetary schedule terms, performance index calculations provide a value of how efficiently project time and money have been spent, which reflects how well the project team is performing. Any performance index value less than 1 means the team is not meeting planned performance measures, while working at or above 1 indicates the team is working at or above planned performance.

The schedule performance index (SPI) indicates how well the project is staying within the planned timeline. SPI is the earned value of the project divided by the original value set by the performance measurement baseline. If the SPI is under 1, then the team is working less efficiently than planned and is behind schedule. The cost performance index (CPI) shows how efficiently the team is spending project funding. CPI is the earned value divided by the actual project costs incurred. If the CPI is less than 1, it indicates the value of the project is less than the costs incurred.

Figure 69: Calculating Performance Indices

Performance Index: *Measurement of project efficiency and team performance*

< 1: Behind schedule or over cost
= 1: On target
> 1: Ahead of schedule or under cost

Elapsed schedule = 50%
PV = $350,000
AC = $500,000
EV = $250,000
BAC = $1,000,000
SV = -$100,000
CV = -$250,000

Schedule Performance Index (SPI) = EV / PV

$$SPI = \frac{\$250,000}{\$350,000} = .71$$

.71 X 60 min = 43 minutes behind schedule for each hour

Cost Performance Index (CPI) = EV / AC

$$CPI = \frac{\$250,000}{\$500,000} = .50$$

.50 X $1.00 = 50 cents over cost for every $1.00

c. Forecasting Work Completion

When a significant variance or performance deficiency occurs, it is important to understand what impact those variances have on the future of the project in order to determine if the impact warrants corrective action. Using calculated EVM values and assuming performance continues at a constant pace, the project team can answer some important questions:

- If project performance trends continue, what additional cost will the project have incurred by the end of the project? What is the estimate at completion (EAC)? To calculate the EAC, divide the budget at completion by the cost performance index. Accounting for the costs already incurred by the project, the team can determine what additional costs are needed to complete the project. This value is called the estimate to complete (ETC).
- Given the original schedule, and the current schedule performance, how much longer will the schedule run? The team can forecast the schedule duration by dividing the original schedule by the schedule performance index.
- If the team is underperforming, at what level of performance will they need to work to complete the project? This is called the To Complete Performance Index (TCPI) and determines what percent of 1 the team must work at to complete remaining project work. Using the BAC, subtracting the earned value, and then dividing by the ETC, the team can determine how much they must increase their efficiency.

Figure 70: Forecasting Completion

Forecasting Completion: *The impact variances have on the project's future*

Schedule = 12 months
Elapsed schedule = 50%
PV = $350,000
AC = $500,000
EV = $250,000
BAC = $1,000,000
SV = -$100,000
CV = -$250,000
SPI = .71
CPI = .50

What will be the final cost at project end ?

Estimate at Completion (EAC) = BAC / CPI

EAC = $2,000,000 ($1,000,000 over final budget)

What costs are needed to complete work ?

Estimate to Complete (ETC) = EAC - AC

ETC = $1,500,000 ($1,500,000 needed to finish)

How long will the project run ?

Forecasted Schedule Duration = Planned Schedule / SPI

Forecasted schedule = 17 mo's (5 month schedule slip)

How efficient does the team need to be ?

$$\text{To Complete Performance Index (TCPI)} = \frac{\text{BAC - EV}}{\text{ETC}}$$

TCPI = .50 (Team performance must increase)

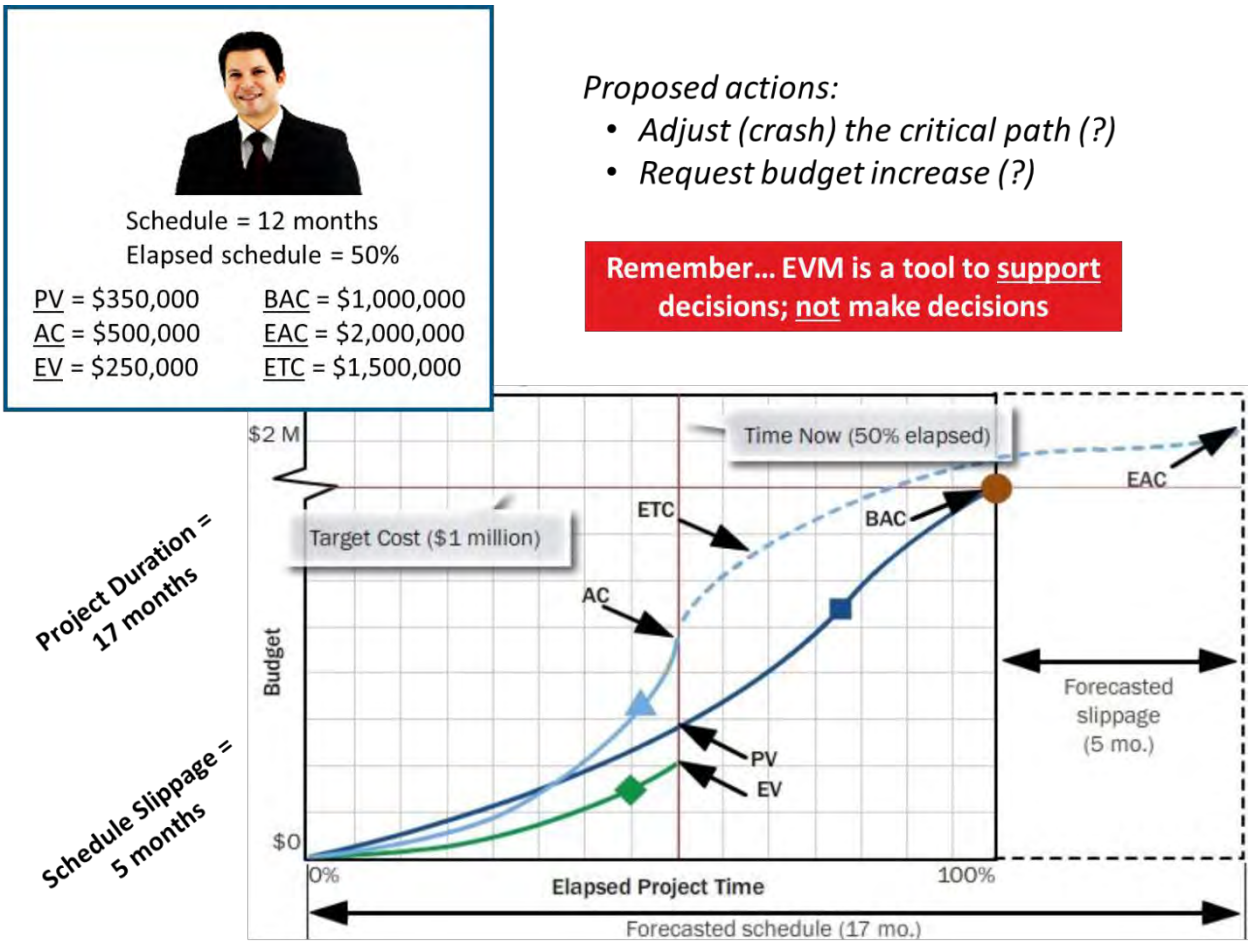
d. Forecasting with EVM

Forecasted values build upon the EVM data already charted. Recall that the planned value, which is represented by the performance measurement baseline, and the budget at completion, which was authorized before work began, remains unchanged unless a formal change request has been approved. The forecasted schedule duration is charted as an extension of the *x*-axis, or elapsed project time.

Finally, the team can chart the EAC. The EAC is depicted as the final ACTUAL cost of the project.

Remember, EVM is one of numerous tools the PM and project team can use to inform and support project decisions and predict what risks may affect project schedule and costs in the future. However, as EVM is not the only tool, final project decisions should not be made solely on what EVM data reflects about the cost and schedule status of the project.

Figure 71: Forecasting with Earned Value Management (EVM)



12. Risk Management

Risk is an uncertainty that, if it occurs, can have an impact on project cost, schedule, performance, or all three. Risk management is an iterative process used throughout the life of a project to identify, analyze, mitigate, monitor, and control project uncertainty. Risks can be positive in the form of opportunities and negative in the form of threats and detriments to the project. The majority of risk management activities target negative risk events. To maximize positive risks and minimize negative risks, risk must be identified and proactively managed through the risk management process.

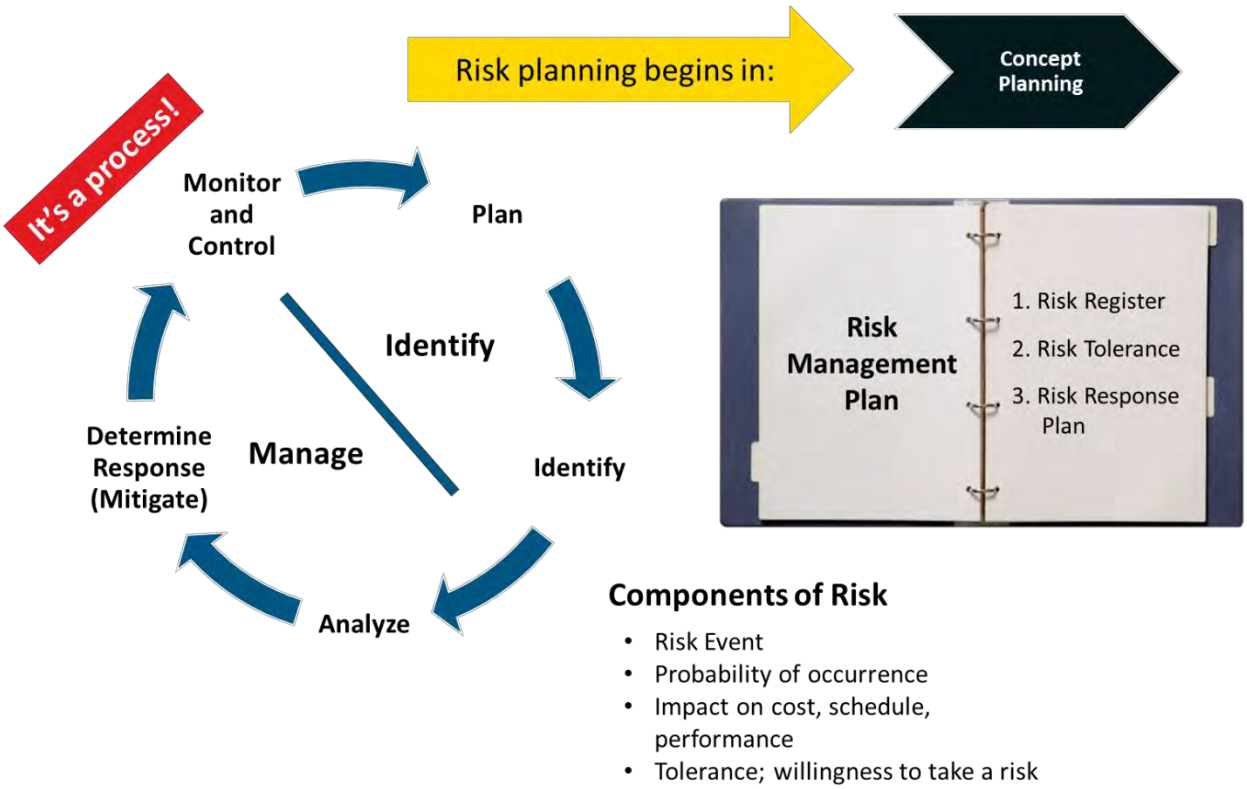
The primary components of risk include: (1) the risk event itself, either negative or positive; (2) the probability the risk event will occur; (3) the impact to the project if the risk event occurs; and (4) a measure of risk tolerance, or the willingness to take risks, among decision makers, groups, or organizations. Risk management is driven by these four attributes, which are key inputs into identifying, analyzing, mitigating, monitoring, and controlling project and product scope, cost, and schedule.

a. Risk Management Plan

In the Concept Planning phase, the primary objective is to plan for identifying all potential risks and the factors that contribute to those risks. Risk management then analyzes the probability and impact of each risk on project costs, schedule, and performance. After analyzing the risks, the PM and team plan for how to respond to and mitigate the risks if they occur. These activities get documented in a Risk Management Plan containing the basic approach to risk management. The Risk Management Plan also lists all identified risks and their analysis findings in the risk register. The Risk Management Plan is one of the most used and referred to plans among all the various planning documents in project management.

The risk register lists all identified risks, their analysis findings, and the established risk tolerance. Risk tolerance is the unique level of project risk the PM and project stakeholders are willing to accept and plan for. The Risk Management Plan also includes the Risk Response Plan, which aligns a risk response strategy, such as avoid or transfer, with each identified risk in the risk register (the risk register and Risk Response Plan may be the same document). These documents serve as an action plan to update and follow while you monitor and control project risk throughout the project life-cycle. The more time and effort the PM and team put into risk identification in the Concept Planning phase, the less of an impact these risks will have in later project phases.

Figure 72: The Risk Management Process



Project Complexity

The complexity of a project directly impacts project risk and how it's managed. Factors that affect project complexity include:

- Project scope, including duration, budget, number and type of funding sources, and number and location of team members;
- Team composition and personalities;
- Product or system complexity, and other systems the product must integrate or interoperate with;
- Maturity level of product technology;
- Levels of interest and involvement from internal and external stakeholders;
- End-user visibility into or participation in the project;
- Number and complexity of procurements actions; and
- Competing project constraints.

Each project complexity factor can create uncertainty for project cost, performance, schedule, or combinations of the three, and together they influence the risk of certain events taking place. Risk events rarely occur in isolation. Most risk events originate from a combination of the factors above and impact multiple project domains.

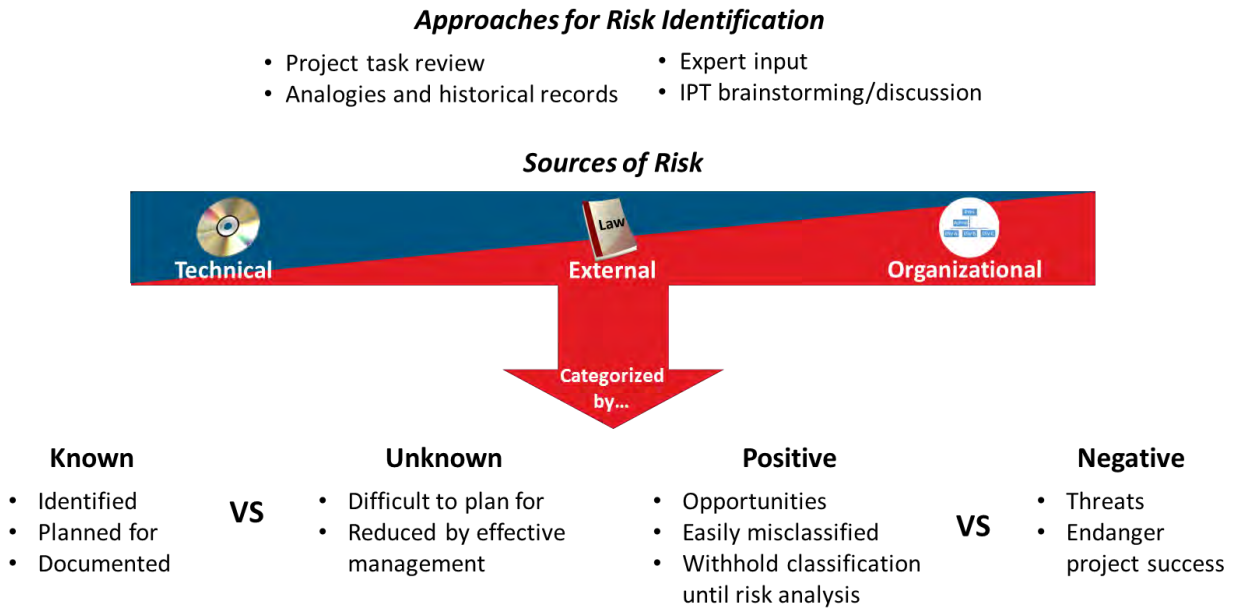
b. Risk Identification

The success of risk identification is impacted by numerous factors, such as project complexity and the other sources of risk. During risk identification, keep all dimensions of complexity in mind to create a comprehensive list of project risks. There are several ways to go about identifying risk. Whatever process is used, approach each method by first looking at each project constraint (cost, schedule, performance) singly, asking the same questions for each one, then recording the possible risks that may occur only in that dimension, and then recording the possible risks that may occur in the other two constraints as a result of a risk occurring in the one under review. This final list of identified "single" and "combination" risks can then be checked for re-occurring risks in order to eliminate the redundant risk events. Approaches for identifying risks include:

- Reviewing project tasks, deliverable, and milestones and their conflicts;
- Researching historical records of other projects;
- Seeking subject matter expert input;
- Collaborating, such as brainstorming among the project team and looking for common trends;
- Analyzing the technology and its maturity on how cost, schedule, and performance is affected;
- Noting external factors such as Federal laws, regulations, and special interests from stakeholders such as Congress; and
- Recognizing organizational structure and culture, specifically ambiguity within the lines of formal and informal authority that affect budget and resourcing.

Categorize risks. Once risks are identified, eliminate redundant risks and categorize them to help focus on particular risks that significantly impact schedule, cost, and performance. These become known risks. There are also unknown risks that are difficult or impossible to anticipate and prevent and are therefore difficult to manage. Identifying known risks helps reduce the possibility and presence of unknown risks. Positive risks are opportunities that, while still an uncertain occurrence, can expand the budget and schedule or improve technical performance. Be aware that not all positive risks will turn out to be positive after risk analysis. Classifying a risk as positive should be withheld until all risks are completely analyzed.

Figure 73: Identifying Risks



There are several roadblocks to complete and purposeful risk identification, including:

- The culture of project management that, with its propensity to think positively about the project and its outcome, can hinder the discussion of threats and negative risk;
- Incomplete, inaccurate historical information or questionable input from subject matter experts;
- A high degree of project complexity characterized by strict constraints, which determines how much time and how many resources are available to identify project risks;
- Unidentified risks, dangerous because they have not been planned for or analyzed and for which the impromptu risk response may not be effective; and
- Initially perceiving a negative risk to be positive (wait until after risk analysis to determine if a particular risk is positive or negative).

Identified risks are documented in a risk register: a list of identified risk events that are prioritized based on their probability and impact. Creating detailed risk statements is key to assembling the risk register. Including probable causes, trigger events (such as missed

milestones), and estimated time frames for when the risk event may occur help the PM and team to quickly and accurately prioritize each risk and plan appropriate management strategies. A risk statement includes:

- A statement defining the risk as an event; and
- Details regarding probable causes, trigger events, missed milestones, and estimated time frames.

c. Risk Analysis

Risk analysis includes the analysis and selection of appropriate responses for each risk event and implementation of the Risk Response Plan when necessary to mitigate the effects of the risk's impact. Begin with determining the priority of each risk event based on the analysis of risk probability and impact. Then, assign and document a value to the probability and impact of each risk based on an agency-specific scale that describes how probable the risk is and how much change, or impact, the risk will cause to the original project cost, schedule, and performance estimates. Multiplied together, the probability and impact values produce a risk score.

The PM and team use risk scores to prioritize documented risks and determine which are critical and require immediate attention. For example, untimely equipment delivery means increased costs and slipping the project schedule. Analysis findings, including the risk score, get documented in the risk register. Using the documented risk scores, determine if the identified risks fall above or below the established risk tolerance.

Figure 74: Analyzing Risks and the Risk Register

***Project**: Modified fork lifts for Warehouse Division*

Risk Statement	Analysis		
	Probability (P)	Impact (I)	Risk Score (P X I)
Fork lift delivery after scheduled date of 12/31 due to test failures of redesigned oil pump	2 (22%)	4 (25%)	8

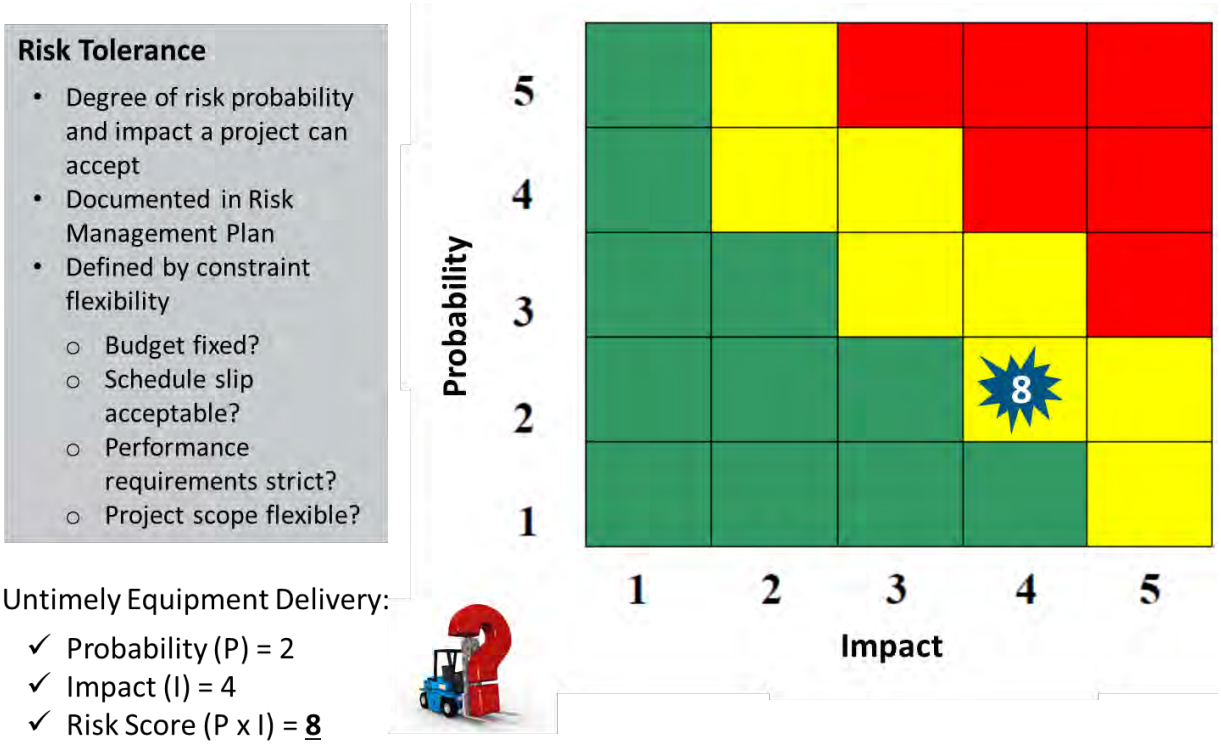
Risk value scales vary. Check with your agency for guidance.

Risk Value	Negligible 1	Low 2	Medium 3	High 4
Probability	1-20%	21-40%	41-60%	61-99%

Risk Value	Negligible 1	Low 2	Medium 3	High 4
Cost Impact	< 5% change	5 < 10%	10 - 20%	> 20%
Schedule Impact	< 5% change	5 < 10%	10 - 20%	> 20%
Performance Impact	< 5% change	5 < 10%	10 - 20%	> 20%

Risk tolerance is the degree of probability and impact on project objectives the PM, team, and other stakeholders are willing to accept and withstand. The risk tolerance for each project is documented in the Risk Management Plan and defined by the flexibility of project constraints, including (1) flexibility with the budget; (2) the degree that schedule slippage is acceptable; (3) restrictions with performance requirements; and (4) flexibility with project scope. Very little flexibility in project constraints defines a low risk tolerance, while constraints that are flexible characterize a high risk tolerance.

Figure 75: Risk Tolerance



d. Risk Response

Regardless of risk analysis findings and where risks fall in relation to risk tolerance, all risks, including positive risks, should be planned for and responded to. This is also known as risk mitigation. In the Concept Planning phase, the PM and project team consider risk analysis results, develop a plan of action to minimize the impact of all risks, and consider the impact of risk responses on project cost, schedule, and performance. The Risk Response Plan matches all identified and analyzed risks with an appropriate risk response or mitigation action.

There are four response strategies for devising risk mitigation actions:

1. Risk Acceptance. Concluding that the consequences of a particular risk have little to no impact on cost, schedule, and performance, and thus the risk can be accepted.

Alternatively, there is much flexibility in the project budget and schedule to accommodate this risk if it occurs.

2. **Risk Transfer**. Transferring the risk to a third party, such as an insurance company.

3. **Risk avoidance**. Eliminating the risk by changing plans for project cost, schedule, and performance requirements.

4. **Risk Mitigation**. Implementing a backup strategy or action that reduces the risk probability and impact to an acceptable level. Risk mitigation does not eliminate the risk. The backup plan can cause significant changes to project cost, schedule, and performance.

Figure 76: Example Risk Response Plan

Risk Event	Probability (P)	Impact (I)	Score (P X I)	Response Strategy	Surveillance Responsibility
Redesigned oil pump not available by FY-end	2	4	8	• Mitigate • Identify other suppliers	Systems Engineer
Dual-phase oil filter not available by Critical Design Review	2	2	4	• Mitigate • Identify 2nd/3rd tier suppliers that meet minimum spec.	Systems Engineer
Commercial control panel doesn't pass government water immersion test	1	3	3	• Transfer • Sensor and Controls Division market research alternate panel & budget for same	Sensor and Controls Division
Development funding cost overrun	4	4	16	• Accept • Absorb schedule delay until new FY funding allocation • Mitigate • Seek contingency funds from alternative sponsors	PM

e. Risk Classification: The Risk Cube and Tables

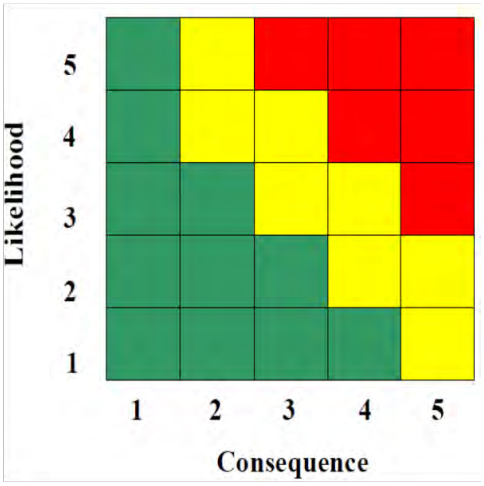
Throughout the project, the PM and project team will often be required to communicate with project stakeholders regarding the status and progress on a myriad of project plans and actions. Assigning a risk color to project events or tasks is a common method of conveying

overall risk associated with risk events. However, assigning a risk color derived from the classic 5x5 risk cube has little meaning unless the PM and team have determined what that classification of a color really means in terms of impact and consequences.

Figure 77: Risk Cube and Likelihood Table

Likelihood

Level	Likelihood	Probability of Occurrence
1	Not Likely	~ 10%
2	Low Likelihood	~ 30%
3	Likely	~ 50%
4	Highly Likely	~ 70%
5	Near Certainty	~ 90%



When considering possible risk events for cost, schedule, and performance impact, the PM and team assign their best estimate of the color and corresponding impact score to specific risk events in the risk register. Understand that risk events will change, and the corresponding scores will change as the project evolves. When an impact score is derived, the score's corresponding consequence is determined from the predetermined set of consequences. This information then aids in deciding how to respond and mitigate the risk event and to what degree.

Figure 78: Consequence Table

Level	Technical Performance	Schedule	Cost
1	Minimum or no consequence to technical performance	• Minimum to no impact	• Minimum to no impact
2	Minor reduction in tech performance or supportability, can be tolerated with little or no impact to program	• Able to meet key dates • Slip < __ month(s)	• Budget increase, or unit production cost increase • < __ (1% of budget)
3	Moderate reduction in tech performance or supportability with limited impact on program objectives	• Minor schedule slip; able to meet key M/S with no schedule float • < __ month(s)	• Budget increase, or unit production cost increase • < __ (5% of budget)
4	Significant degradation in tech performance or major shortfall in supportability, may jeopardize program success	• Program critical path affected • Slip < __ month(s)	• Budget increase, or unit production cost increase • < __ (10% of budget)
5	Severe degradation in tech performance. Cannot meet key performance parameter or supportability thresholds; will jeopardize program success	• Cannot meet key program milestones • Slip > __ month(s)	• Exceeds program threshold • > __ (10% of budget)

f. Risk Monitoring and Control

Regardless of the response, all risks are monitored and controlled throughout the life of the project. Early risk management activities are based on speculation and hypotheses because the PM and team are planning for risks that have not yet occurred. Over time, as more information becomes available and as the project evolves, the understanding of risk probability and impact of project risk increases, and the risk responses adjust accordingly. Risk monitoring and control is the process of using the Risk Management Plan to implement risk responses, track identified risks using a surveillance process for risk awareness, assign responsibility for monitoring and control, identify new risks, and evaluate risk processes. The primary task the PM and team will complete during monitoring and control is to revisit the Risk Response Plan and implement the appropriate response should the risk cross the tolerance level set by project stakeholders. To determine whether or not the risk has crossed the level of risk tolerance, the PM and team must plan a process for risk surveillance by assigning a team member to monitor, or track, the risk event's probability and impact. This team member will be responsible for reassessing or reanalyzing the risk to determine if the original levels of risk and impact have changed.

In the end, it's the PM's responsibility to evaluate the effectiveness of risk responses and other risk management processes.

Figure 79: Monitoring and Controlling Risk

"The Risk Management Plan should be one of the most referred to plans among all project management plans and documents"

Implement

- How will you respond?

Track

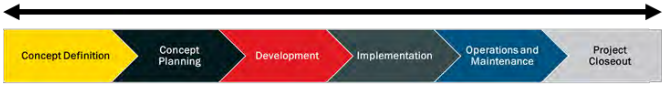
- How will you track and survey risks?
- How are you informed when a risk occurs?
- Who will track risks?

Evaluate

- How will you evaluate risk responses?
- How will you evaluate other management processes?

Update

- Continually update the risk management plan



13. Change Management

Project change is inevitable. Because the PM and the project team cannot anticipate every aspect of a project, it is not a matter of IF project change will occur; it is a matter of WHEN project change will occur and what aspects of the project will be affected. Change can occur anywhere in a project.

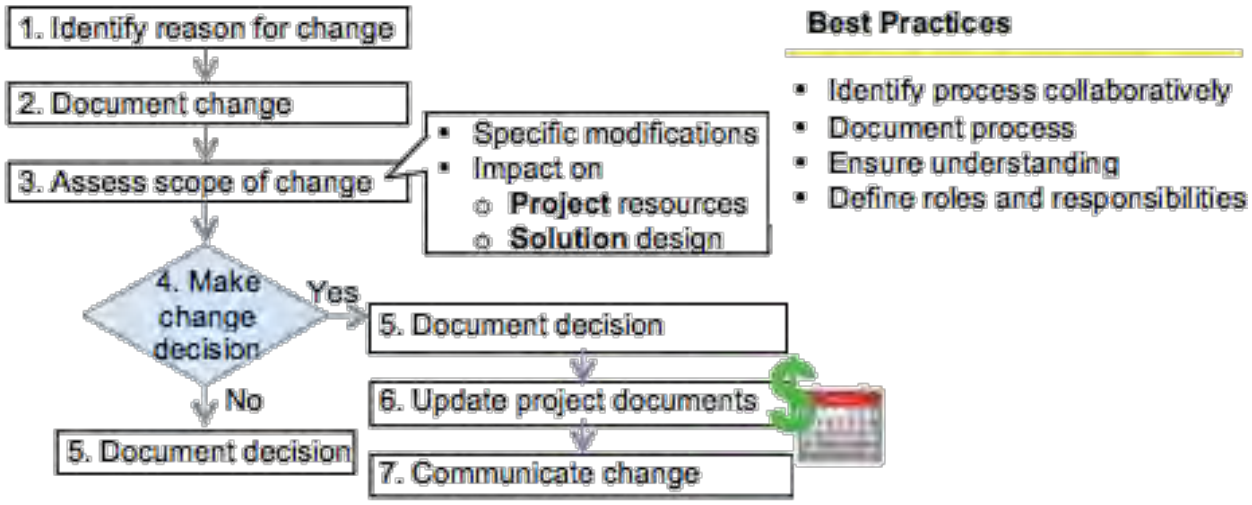
It is critical to manage change because failing to manage change leads to expanding scope, pushing out schedule deadlines to accommodate new work and rework, and insufficient resources to cover such work. The further along in the project life-cycle a project is (and therefore the more developed the solution), the more costly changes to scope, schedule, processes, and manpower become.

While change cannot be eliminated, clearly identifying the scope early in the project and establishing clear, accurate, and complete requirements that define the optimal solution within the defined scope can minimize the potential for costly changes. Establishing and following a change management process also helps minimize the potential for costly project changes.

Change Management Plan

A Change Management Plan describes how the team will identify, track, and respond to changes. From the beginning of the project cycle, the PM and his/her team should identify potential changes to begin preparing and planning for the effects on the project. Tracking of the changes can occur through version control or configuration management. Depending on the size and scope of the project, Change Review Boards (CRBs) may determine what changes will be made and what changes will not proceed. Figure 80 outlines the change management process.

Figure 80: The Change Management Process



14. The Federal Information Technology Acquisition Reform Act (FITARA)

The Federal Information Technology Acquisition Reform Act (FITARA) legislation of 2015 is the most significant federal IT reform to come along in two decades. PMs need to understand its significance to ensure project planning and execution are aligned with FITARA's impact on their respective agencies. To further interpret this legislation for implementation, the Office of Management and Budget (OMB) released its signed guidance on June 10, 2015: Memorandum M-15-14, "Management and Oversight of Federal Information Technology". For PMs managing information technology (IT) projects, their agency Chief Information Officer (CIO) is a prime stakeholder and point of collaboration. OMB's guidance memo contains a "Common Baseline" matrix found in Attachment A. The table below outlines the key tasks and interface points between the CIO organization and the PM:

Table 9: Key Tasks and Interface Points between the CIO and the PM

Matrix Reference	Description of Roles and Responsibilities
A1	The CFO and CIO shall define the level of detail with which IT resource levels are described distinctly from other resources throughout the planning, programming, and budgeting stages. This should serve as the primary input into the IT capital planning and investment control documents submitted with the agency budget (formerly Exhibits 53 and 300).
B1	The agency head shall ensure the agency-wide budget development process includes the CFO, CAO, and CIO in the planning, programming, and budgeting stages for programs that include IT resources (not just programs that are primarily IT oriented).
C1	The CIO shall be included in the internal planning processes for how the agency uses IT resources to achieve its objectives. The CIO shall approve the IT components of any plans, through a process defined by the agency head that balances IT investments with other uses of agency funding. This includes CIO involvement with planning for IT resources at all points in the IT life-cycle, including operations and disposition or migration.
D1	Agency budget justification materials in their initial budget submission to OMB shall include a statement that affirms the CIO has reviewed and approves the major IT investments portion of this budget request.
E1	The CIO should establish and maintain a process to regularly engage with project/program managers to evaluate IT resources supporting each agency strategic objective. It should be the CIO and project/program managers' shared responsibility to ensure that legacy and on-going IT investments are appropriately delivering customer value and meeting the business objectives of programs. Project/Program Managers shall work with the CIO to define IT performance metrics and strategies to fulfill agency strategic objectives.
G1	The CIO defines the development processes, milestones, review gates, and the overall policies for all capital planning, enterprise architecture, and project management and reporting for IT resources. At a minimum, these processes shall ensure that the CIO certifies that IT resources are adequately implementing incremental development (agile).
I1	The CIO reviews all cost estimates of IT related costs and ensures all acquisition strategies and acquisition plans that include IT apply adequate incremental development (agile) principles.
J1	The CIO shall conduct TechStat reviews or use other applicable performance measurements to evaluate the use of the IT resources of the agency. The CIO may recommend to the agency head the modification, pause, or termination of any acquisition, investment, or activity that includes a significant IT component based on the CIO's evaluation, within the terms of the relevant contracts and applicable regulations.

Matrix Reference	Description of Roles and Responsibilities
K1	The CIO reviews and approves acquisition strategies and plans. Agencies shall not approve an acquisition strategy or acquisition plan (as described in FAR Part 724) or interagency agreement (such as those used to support purchases through another agency) that includes IT without review and approval by the agency CIO. For contract actions that contain IT without an approved acquisition strategy or acquisition plan, the CIO shall review and approve the action itself. The CIO shall primarily consider the following factors when reviewing acquisition strategies and acquisition plans: - Appropriateness of contract type - Appropriateness of IT related portions of statement of needs or statement of work - Appropriateness of above with respect to the mission and business objectives supported by the IT strategic plan - Alignment with mission and program objectives in consultation with program leadership

F. Acquisition Governance, Part 2

1. Contracting

a. FAR Introduction

The FAR is the principal set of rules that govern how the Federal Government acquires goods and services. An online version of the FAR can be accessed at Acquisition.gov. The Contracting Officer (CO) is the only employee warranted to obligate funds on behalf of the Federal Government. The CO has an intimate knowledge of the rules and processes found in the FAR. The FAR is divided into 53 Parts. Those 53 Parts are grouped into the following chapters:

- Subchapter A – General (Parts 1–4)
- Subchapter B – Competitions and Acquisition Planning (Parts 5–12)
- Subchapter C – Contracting Methods and Contract Types (Parts 13–18)
- Subchapter D – Socioeconomic Programs (Parts 19–26)
- Subchapter E – General Contracting Requirements (Parts 27–33)
- Subchapter F – Special Categories of Contracting (Parts 34–41)
- Subchapter G – Contract Management (Parts 42–51)
- Subchapter H – Clauses and Forms (Parts 52–53)

Because the FAR is large and complex, it is critical for the PM to work closely with the CO in developing, awarding, and administering effective contracts. The PM is not expected to know

the FAR at the same level as the CO but should be familiar with general requirements and frequently used Parts.

b. Procurement Integrity

Integrity of the procurement process is of utmost importance, and is the responsibility of each federal employee to ensure that integrity is maintained. Agency employees are governed by multiple statutes and regulations which:

- Prohibit the offer or acceptance of a bribe or gratuity.
- Preclude a Government employee from participating personally and substantially in any particular matter that would affect the financial interests of any person from whom the employee is seeking employment.
- Restrict certain post-employment activities.
- Restrict the release of information related to procurements and other contractor information.
- Restrict acceptance of information from contractors, such as a statement of work written by a contractor that intends to submit a bid for the work.

When PM functions intersect with the acquisition process, especially in the receipt and evaluation of proposals, PMs will be required to sign Non-Disclosure Agreements and statements that no conflict of interest exists in the PM's participation in the evaluation of proposals.

FAR 3.104 contains detailed information on procurement integrity and can be accessed at Acquisition.gov.

c. The Procurement Cycle

The acquisition cycle has shared responsibilities between the acquisition and program offices. It is a mistake to think that the PM and program office do not have a major role in the development, award, and administration of contracts. In fact, every phase within the acquisition cycle relies on the PM and program office. The acquisition cycle can be divided into four major phases: 1) Pre-Solicitation, 2) Solicitation, 3) Source Selection, and 4) Administration.

Figure 81: The Acquisition Cycle

Pre-Solicitation. During the pre-solicitation phase, the PM and program office are the drivers of all acquisition activities. Similar to the project life-cycle, the procurement cycle begins with identifying the need for contractor products or services, ensuring funding exists for

contractor products or services, understanding the market, and developing documentation the acquisition office will need to issue a solicitation. This includes the Statement of Work (SOW), Performance Work Statement (PWS), Evaluation Criteria, Independent Government Cost Estimate (IGCE), and other documents required by the acquisition office. These are known as the requisition package documents. Always check with the acquisition office for approved templates for the required documents.

If the requirements include IT products or IT-related services, the Chief Information Officer (CIO) has authority for review and approval of any IT requirements before issuance of a solicitation. Review your agency's processes for these IT reviews. Processes will likely change in FY2016 with the implementation of FITARA, as FITARA increased the authority of the CIO over IT acquisitions.

At this point in the process, communication with industry is encouraged so that the PM/program office understands the current market conditions and available solutions. Communication can come from a variety of methods, including one-on-one meetings with vendors, RFIs, sources-sought notices, and industry day conferences.

Once the requisition package documentation is developed, the acquisition office and PM/program office work together to develop the acquisition strategy. This includes determining if the acquisition will be set-aside for small businesses, if it can be a General Services Administration (GSA) Schedule buy or a full and open competition, and other key strategy decisions. The acquisition office will also inform the PM/program office that they will become the sole communicator with industry at that point in the process to ensure fair and impartial communications during the solicitation and source selection phases.

Solicitation. In the solicitation phase, the acquisition office begins developing the Request for Proposals (RFP) or Request for Quotes (RFQs) based on the documentation developed by the PM/program office. The solicitation is then published for competition. Next offerors are allowed to ask questions, the Government responds to those questions, and proposals are submitted. The PM/program office's involvement includes answering offerors' technical questions as well as any questions or requests from the acquisition office.

Source Selection. The PM/program office will nominate three to five technical experts to review and evaluate proposals. This requires availability to thoroughly review proposals; document strengths, weaknesses, and deficiencies in accordance with the evaluation criteria; and come to a consensus on the apparently successful offeror. Sufficient time must be dedicated for the technical experts to ensure a positive acquisition outcome. Different agencies use different terms for the technical experts that evaluate proposals, which may include a Technical Evaluation Board, Technical Evaluation Committee, and Source Selection Committee.

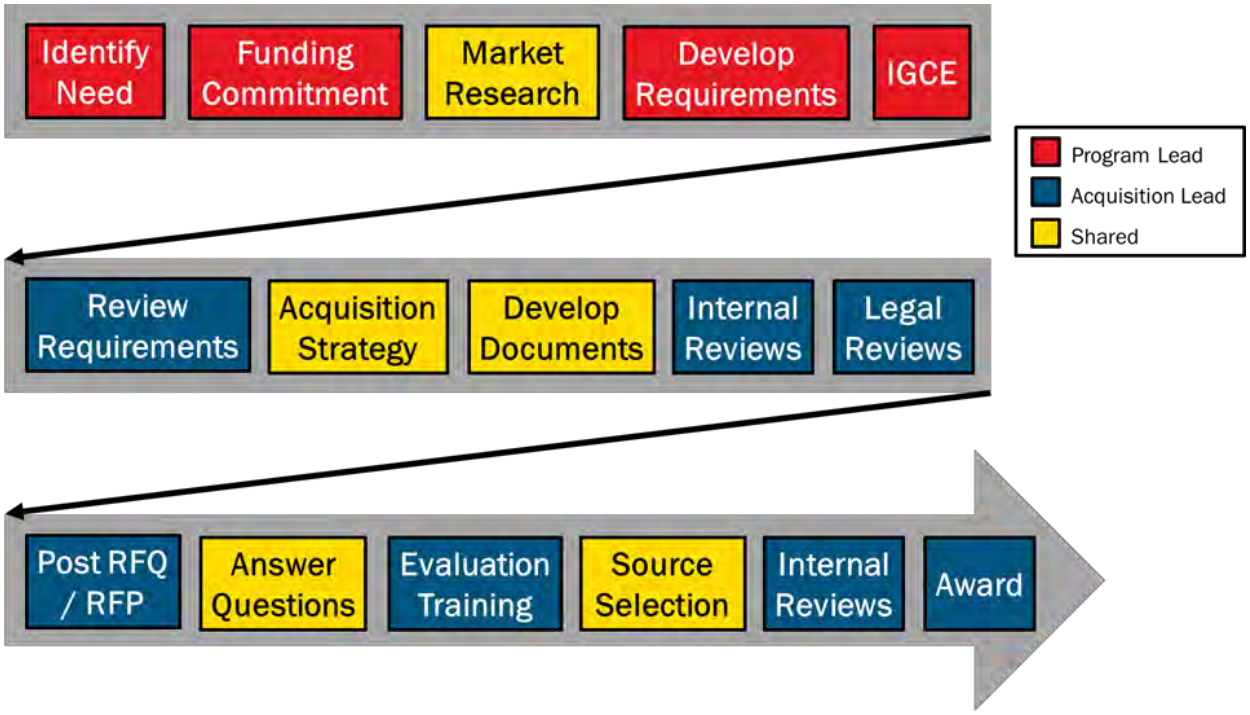
The process typically includes: 1) individual review and documentation of strengths, weaknesses, and deficiencies; 2) meeting to reach consensus on each proposal and recommendation of the apparently successful offeror; and 3) conducting price/cost realism of the price or cost proposals.

The Contracting Officer typically serves as the Source Selection Authority and has responsibility for making the final decision based on the technical and price/cost trade-off. The CO then develops and issues the contract.

Administration. As part of the award documentation, the Contracting Officer drafts a Contracting Officer's Representative (COR) designation letter. The COR may be the PM or another representative from the program office, who must be COR I-, II- or III-certified based on the dollar value of the contract. COR duties are specified in the designation letter and typically include the day-to-day interface with the contractor, approval of the project plan, and acceptance of the deliverables. Any contractual changes must never be made or committed to by the COR. The COR must ensure they do not inadvertently direct the contractor outside of the awarded requirements. Only the CO can make a commitment on behalf of the Government or change the scope, period of performance, or terms of the contract.

The following figure provides a generic overview of the procurement cycle, including responsibilities between program and acquisition offices.

Figure 82: The Procurement Cycle



Gate Reviews in Industry Business Development

While the Federal Government is developing its project, industry is also employing gate reviews to determine if the project is one that they will invest business and proposal (B&P) resources to pursue.

Industry is always listening and searching for opportunities to pursue work with the Federal Government. Industry typically learns of new projects/programs through Congressional requirements, budgets, and speeches and presentations given by senior agency leadership on priorities, procurement forecasts, market research requests, industry days, and other sources.

In industry's business development cycle, it creates multiple gates in the "capture phase." Similar to a Federal project, the number and types of gates depend on the size and complexity of the potential procurement. Industry evaluates if it knows enough about the project, if it has the right solution to solve the problem, how the agency views the organization, and its chances against the competition. If the green light is received, industry will move into the "proposal development phase" when enough is known about the requirements or when the solicitation is issued. Industry also has multiple gates, called "color review teams," who review the proposed solution, proposal language, and proposal pricing to ensure the submission presents the organization's best effort to win the contract.

d. Pre-Solicitation Phase Highlights

Needs vs. Wants

As requirements are developed, it important to separate needs from wants. Each task, meeting and deliverable has an associated cost. Closely review requirements to ensure that only what is needed is included in the requirements.

Organizational Conflicts of Interest

Because Government and contractors interact and a variety of day-to-day tasks, some of which may include the procurement process, it is important for PMs to be able to identify and monitor potential Organizational Conflicts of Interest (OCIs).

Potential types of OCIs, as stated in FAR 9.5 and Government Accountability Office (GAO) decisions are:

- **Unequal Access to Information:** This type of OCI issue arises in situations when a firm has access to non-public information as part of its performance of a Government contract and where that information may provide the firm a competitive advantage in a later competition for a Government contract. FAR 9.505-4: "In these 'unequal access to information' cases, the concern is limited to the risk of the firm gaining a competitive advantage; there is no issue of bias."

- **Biased Ground Rules:** This type of OCI issue arises in situations when a firm, as part of its performance of a Government contract, has in some significant sense set the ground rules for Government procurement, for example, by preparing the statement of work or the specifications. FAR 9.505-1, 9.505-2: "These situations may also involve a concern that the firm, by virtue of its special knowledge of the agency's future requirements, would have an unfair competitive advantage in the competition for those requirements."

- **Impaired Objectivity:** This type of OCI issue arises in cases when a firm's work under one Government contract could entail its evaluating itself (or a competitor), either through an assessment of performance under another contract or an evaluation of proposals as part of another contract. FAR 9.505-3: "In these 'impaired objectivity' cases, the concern is that the firm's ability to render impartial advice to the Government could appear to be undermined by its relationship with the entity whose work product is being evaluated."

In developing requirements, the PM must evaluate the potential for OCIs, which may result from defining the requirements or in the execution of the work and the potential of any follow-on work. The PM should document any potential OCIs to the Contracting Officer to address in the solicitation.

See FAR Part 9.5 for additional information via Acquisition.gov.

Determining Contract Type

The FAR provides three main types of contracts: 1) fixed price, 2) cost-reimbursable, and 3) time and materials/labor hours.

Fixed Price. Many agencies have a preference for fixed-price contracts as it can shift contract risk from the Government to the contractor. Fixed-price means that the Government agrees to pay a set price for a particular service or deliverable. The price is fully burdened and inclusive of all contractor costs, such as direct costs, fringe benefits, overhead, and profit/fee. If the contractor is able to complete the work faster and cheaper, the contractor is still paid the same price, which means that they were more profitable. Poor or inefficient performance reduces the contractor's profit on the contract. This incentivizes the contractor to produce the required product or service as efficiently and effectively as possible.

Because the risk is shifted to the contractor, fixed-price contracts are often viewed as the least risky for the Government. However, if the Government's requirements are not firmly established, or if the requirements, technological environment, or other key conditions are likely to change, a fixed-price contract may actually increase the Government's risk. When using fixed-price contracts, the Government must be able to accurately and thoroughly define its requirements to allow for accurate pricing by industry. When the Government lacks specificity with its requirements, the Government may pay a "risk premium" as industry must account for unknown requirements or factors in its bid.

Per OFPP guidance noted in the Contracting Guidance to Support Modular Development, "Fixed-price arrangements should be used for the acquisition of COTS and development services for software projects or increments where the Government knows the specific functional characteristics that will satisfy its objectives." Fixed-price contracts do not provide flexibility needed if requirements are unclear or if the IT environment is quickly shifting.

Cost-Reimbursable. This contract type pays the contractor for all allowable, allocable, and reasonable costs the contractor incurs for the project, plus a fee, up to a certain agreed-upon ceiling. Cost plus fixed fee (CPFF), cost plus award fee (CPAF), and cost plus incentive fee (CPIF) are all types of cost-reimbursable contracts with the difference being how fee is provided. Cost-reimbursable contracts are used when costs cannot be accurately estimated at the beginning of the project. In cost-reimbursable contracts, the Government pays direct costs, such as salaries, equipment, supplies, and travel expenses. It also pays for indirect costs, such as fringe benefits for the contractor's employees, overhead costs, and general and administrative costs. Indirect costs are typically based on a percentage of the direct costs. Indirect costs are determined through extensive Government-led audits of the contractor's accounting records and systems. The Government then enters into an indirect cost rate agreement with the contractor, which includes provisional indirect rates. Annually or at the completion of the project, a close-out audit must be conducted to finalize the indirect rates that applied throughout the project, and the Government and contractor must reconcile the difference.

As described above, the Government and contractor share the risk in a cost-reimbursable contract. However, the administrative burden of a cost-reimbursable contract to the Government is much higher than fixed-price contracts.

Time and Materials (T&M)/Labor Hour. T&M/labor hour contracts are a mix between cost-reimbursement and fixed-price contracts. They are contracts used when it is not possible to estimate the costs or duration of the work. T&M contracts can increase risk to the Government because they allow the contractor to be paid for all reasonable effort, even if that effort does not result in successful delivery of the contracted service or product. However, if properly managed, they can represent an effective way to develop solutions in an iterative manner, especially when requirements are not fixed or conditions are likely to change.

Similar to fixed-price contracts, daily or hourly rates are fully burdened to include all direct and indirect costs and profits/fees. The contractor is able to work up to an agreed-upon ceiling. The Government has more onus to manage the contractor under a T&M/labor hour contract to ensure that the Government is receiving the appropriate level of services. In choosing a T&M contract, the Government must make the conscious choice to increase internal management costs to gain the value of flexibility.

Contracting Methods

Depending on the project requirements and the contracting approach, one of three contracting methods will be used: 1) simplified acquisition procedures, 2) sealed bidding, or 3) contracting by negotiation. Additionally, using contracting instruments already established

by a buying agency such as omnibus contracts, interagency agreements, and schedule procurements, such as the General Services Administration contract schedules, are other methods to consider.

The Contracting Officer will determine which method to use. The CO will apply the following order of preference when determining the contracting method:

1. If the total cost of the acquisition does not exceed the current simplified acquisition threshold (SAT), follow the simplified acquisition procedures. The current SAT is defined in FAR Part 13.
2. If the total cost of the acquisition exceeds the SAT, first determine if sealed bidding can be used.
3. If the total cost of the acquisition is above the SAT but the acquisition does not meet the requirements for sealed bidding, contracting by negotiation is used.

Simplified Acquisition Procedures. Simplified acquisition procedures are the methods provided in FAR Part 13 for purchasing supplies and services that do not exceed the SAT. Simplified acquisition procedures include methods of purchase such as blanket purchase agreements and Government purchase cards. These procedures promote efficiency and economy in contracting, reduce administrative costs, and avoid unnecessary burdens on the Government and contractors. They also streamline the solicitation, evaluation, and payment processes. If the acquisition is at or below the simplified acquisition threshold, the FAR requires it to be set aside for small business concerns.

Sealed Bidding. Sealed bidding works best for acquisitions that can be awarded solely based on price-related factors, without the need for technical information or discussions with bidders. When using sealed bidding, contractors submit sealed competitive bids, the bids are opened publicly, and a contract is awarded to the qualified contractor offering the lowest priced bid.

Contracting by Negotiation. If the acquisition exceeds the simplified acquisition threshold but does not meet the requirements for sealed bidding, contracting by negotiation is used, which is defined in FAR Part 15. With this method, the Government may communicate with offerors beginning from the early stages of requirement identification through the actual receipt of proposals. Negotiations with offerors help the Government establish the acquisition requirements, clarify contractor performance requirements, and identify the best technical approach at the best price. Contracting by negotiation balances the risk to the Government against price, the technical approach, and past performance considerations to award to the best value.

Procurement Action Lead Time (PALT) Incorporated into Project Timing

Procurement Action Lead Time (PALT) is a term that acquisition offices across Government use to estimate the amount of time it will take to award the contract. This is only the timeframe from when a full requisition package is submitted to the acquisition office to begin solicitation development. It does not include the time the PM/program office needs to complete the requisition package documents. While PALT varies by Federal agencies and is

only an estimate, PMs must incorporate the PALT, as well as their own time to develop the requisition package documents, into their timeline for when support is needed.

Table 10: Procurement Action Lead Time (PALT) Estimates by Procurement Action

Procurement Action	Range in Days
Simplified Acquisitions	
$3,000 and under	4–6
$3,000 to $25,000 non-competitive	15–19
$3,000 to $25,000 competitive	18–22
$25,000 to $100,000 competitive	49–61
$25,000 to $100,000 non-competitive	39–47
Negotiated Procurements	
Competitive under $10 million	175–215
Competitive $10 million to $100 million	211–259
Competitive over $100 million	243–297
Non-Competitive under $10 million	126–154
Non-Competitive $10 million to $100 million	144–176
Non-Competitive over $100 million	162–198
Competitive Commercial Items	72–88
Non-Competitive Commercial Items	99–121
GSA Schedule Orders	
Competitive Orders	76–94
Non-Competitive Orders	36–44
Sealed Bidding	112–138
R&D Competitive	243–297
R&D Non-Competitive	157–193
Sealed bid Construction	
Competitive under $10 million	130–160
Competitive $10 million to $100 million	144–176
Competitive over $100 million	157–193
Negotiated Construction	
Competitive under $10 million	184–226
Competitive $10 million to $100 million	220–270
Competitive over $100 million	252–308
Non-Competitive under $10 million	126–154
Non-Competitive $10 million to $100 million	144–176
Non-Competitive over $100 million	162–198
A–E Procurement	166–204
Modifications	
Unilateral-Admin. Change or Incremental Funding	9–11
Unilateral-Change Order	18–22
Unilateral-Option Exercise	36–44
Bilateral	81–99

Communication with Industry

As mentioned earlier, the pre-solicitation process provides various opportunities for the Government to communicate with industry to pull and/or push information. OFPP in OMB initiated multiple efforts over the last five years to improve Government-industry communication during the industry process. That has included a Mythbusters campaign as

well as Acquisition 360 assessments. These various initiatives can be access through OMB's website.

The most frequent communication methods are:

- **Requests for Information (RFI).** To understand new capabilities or gather information for a potential acquisition, an RFI can be issued that asks questions about technical considerations, pricing, and acquisition strategies. This is a method to pull information while also alerting vendors to the possibility of a Government need.

- **Sources Sought Notice.** To understand the current market providers and determine if the requirement can be a set-aside, a sources-sought notice can be issued. This is a method to pull information while also alerting vendors to the possibility of a Government need.

- **One-on-One Meetings with Vendors** (also known as Due Diligence Sessions). This allows for a frank discussion of project objectives and vendor capabilities. While PMs/program offices must be fair and impartial, no requirement exists to take meetings with every vendor. To streamline the number of one-on-one meeting requests, meetings can be tied to RFI responses that are meaningful and provide the Government with a reason to request the meeting. The meetings can be used to both push information to interested vendors as well as obtain information from vendors.

- **Publish Draft RFP/RFQ.** To gather feedback on the Government's requirements documents, draft RFPs/RFQs can be published to gather industry feedback.

- **Pre-Solicitation Conferences** (also known as Industry Days). When requirements have been drafted, the Government can host a pre-solicitation conference to share additional information on its requirements as well as gather information from industry through written questions and answers in advance of the conference and/or live questions and answers at the conference. The key to such conferences is the participation by the PM/program office to provide in-depth information on the project. For industry, it is helpful to share the registration sheets so that potential offerors can find teaming partners and assess the competitive landscape.

- **Pre-Proposal Conference.** These are typically held when Government wants to ensure its RFP/RFQ is well understood. These sessions push information to potential offerors and also provide a networking opportunity for potential offerors to establish teams.

For more information on Government-industry conferences, please see the Industry Day Best Practices White Paper developed by the Government-industry association, ACT-IAC.

e. Solicitation Phase Highlights

The CO is the lead in the solicitation phase. The CO receives the requisition package from the program office and begins formulating the full solicitation that will be issued to industry.

In addition to the statement of work developed by the program office, the full solicitation includes cost/price instructions, terms and conditions, proposal instructions, and evaluation criteria. The solicitation undergoes a review process within the contracts office, which varies based on the type of action and dollar value of the acquisition.

Posting Solicitations

Once approved, the CO posts the solicitation as required by the action type. This may be to FedBizOpps for FAR Part 15 solicitations or may be to another source, such as GSA's eBuy for GSA Schedule purchases, FAR Part 8. Depending on the type of action, COs may request proposals within a few days or up to a month or longer. It is important for the Government to provide industry with sufficient time to develop thorough and accurate technical and price proposals.

Answers to Questions

While the PM/program office has the least involvement in the solicitation phase, its key role is an important one: answering questions raised by potential offerors. While the solicitation is open, industry has the opportunity to send questions to the Government. Written questions from industry indicate a lack of clarity in the requirements or solicitation document. Questions should be thoroughly addressed to clarify ambiguities rather than a generic "see the RFP/RFQ" answer.

Because answers to questions affect the solutions proposed by the offerors, answers to questions need to be treated with urgency. Answers to questions should be provided to offerors at least a week before proposals must be submitted. When numerous technical questions are raised or when the Government makes a major change to its requirements, additional time may be needed so that offerors can fully incorporate the change into their proposed solutions. If the PM/program office needs more time to answer the questions, they should alert the CO and provide a reasonable extension of the proposal due date. It is troubling to industry when questions have not been answered, but the extension of the due date is not provided until the day before or the day of the required proposal submission. Answers to questions are provided to all interested offerors publically so that all offerors benefit from the answers as well as to ensure an impartial process.

Receipt of Proposals

Within the solicitation, the Government specifies how it will receive the proposals, via e-mail or hardcopy, and the due date and time. Due dates and times are strictly enforced. Once proposals are received, the CO conducts a compliance review of the proposals to ensure that they are complete and ready for review by a Source Selection Committee.

f. Source Selection Phase Highlights

As part of the source selection phase, the program office nominates personnel, typically an odd number, to serve as the Source Selection Committee. This group may take on different names depending on the agency, such as Technical Evaluation Board or Technical

Evaluation Panel. The CO typically serves as the Source Selection Authority and officially appoints the chair and members of the Source Selection Committee. The CO also provides a briefing and documentation to establish the roles, responsibilities, and expectations of the members. Each member must sign non-disclosure and conflict of interest agreements to ensure they are impartial members and have no conflicts with the offerors or proposed subcontractors.

The Source Selection Committee, led by an appointed Chair, is responsible for individually evaluating each proposal against the evaluation criteria published in the solicitation. Comparing proposals against each other is not allowed. Using strengths, weaknesses, and deficiencies, the individual members assign ratings to the evaluation criteria and then meet as a group to determine a consensus rating for each of the proposals. The Source Selection Committee may formulate questions or clarifications that need to be addressed by the offerors if required to satisfy the technical requirements before moving to award. The Contracting Officer is the only person authorized to communicate with the offerors and will determine the process for entering into discussions or negotiations, if required.

While the Source Selection Committee reviews the technical proposals, the Contracting Officer reviews the cost or price proposals. The CO analyzes the costs or prices to determine their fairness and reasonableness. Upon completion of the technical review, the CO will share the cost or price proposals with the Source Selection Committee to determine the realism of the costs or prices. Since the Source Selection Committee has read the detailed technical approach for each offeror and its members are technical experts, the Committee can determine how real the costs or prices are in comparison to the scope and approach. Based on this review of both the technical and cost/price proposals, the Source Selection Committee is able to help the CO conduct a trade-off of technical superiority and cost/price effectiveness.

Protests are often filed as a result of the source selection phase. The protests frequently result from:

- Evaluators not following the published evaluation criteria; and
- Insufficient documentation to support the evaluation ratings and award decision.

Both issues are within the control of the program office since its personnel serve on the Source Selection Committee. PM/program offices should ensure that they only evaluate each proposal against the published evaluation criteria. Proposals are not allowed to be compared to each other and must only be evaluated against the evaluation criteria. Protests cannot necessarily be prevented, but they can be defended by proceeding as stated in the solicitation.

Contracting Officers typically provide a briefing to the Source Selection Committee prior to commencing with the evaluations. Ask the CO to review requirements for sufficient documentation. Each rating must be substantiated with documented strengths, weaknesses, and deficiencies.

g. Contract Administration Phase Highlights

Understand Limitations and Avoid Ratifications

Only the Contracting Officer is authorized to make changes to the contract. Changes in scope, level of effort, period of performance, or to the terms and conditions of the contract should only be made by the CO. As previously discussed, PMs are not allowed to make a commitment on behalf of the Government or change any aspect of the contract. Review the COR designation letter to ensure appropriate understanding of responsibilities. Because change is happening at all times, it is important to understand the limitations of the PM and cases in which the CO must provide support. Ratifications occur when an unauthorized person makes a purchase or a change to a contract that results in a commitment by the Government. This could be the use of a Government purchase card for an unauthorized purchase or a contractor making a change to the contract based on a request from the COR. When in doubt about a request from the contractor, ask the CO if the request constitutes a change to the contract.

Constructive Changes

A constructive change is sometimes called a "change by implication" and occurs when the Government, by its actions, changes the contract without specifically adhering to the requirements of the Changes clause. These types of changes may be because of an omission or an erroneous requirement that was included in the contract. The addition or removal of this type of change does not impact the overall cost, schedule, or performance of the contractor but ensures that the appropriate products or services are provided. A constructive change is likely to be provided in a less formal method, such as an e-mail or verbal instruction to the contractor.

Regular Meetings and Reports

SOWs/PWSs should include a contractor project management task that includes regular status meetings or progress reports. Ensure that the meetings and reports are manageable and provide appropriate information to provide oversight. Each meeting and report costs the Government. Evaluate the COR's time and the management needed to ensure that required meetings and reports are necessary.

Termination

For a multitude of reasons, the Government may be required to terminate the contract. It may be for convenience that the Government terminates (i.e., its program has changed and the services are no longer needed). The Government may also terminate for default because of the contractor's actual or anticipated failure to perform its contractual obligations. FAR Part 49 governs the types and processes for termination. Termination processes vary based on the type of contract. The Contracting Officer leads all termination efforts.

Contract/Project Closeout

Often overlooked, closing out the contract or project is a very important step to documenting achievement of results and capturing lessons learned for future contracts and projects. During the Closeout phase, the PM should:

1. Verify that all elements of the scope were completed, any discrepancies were resolved, and all deliverables were completed;
2. Assess customer satisfaction with the product or service through a survey or desk-side interviews;
3. Close out any support contracts by providing evaluations of the contractor through the Contracting Officer and the Government's official system, the Past Performance Information Retrieval System (PPIRS)/Contractor Performance Assessment Reports System (CPARS);
4. Conduct a lessons learned review;
5. Complete a project file with the history of the project;
6. Prepare a final project report that includes recommended changes for similar projects, new techniques developed or tailored, and project organizational recommendations; and
7. Celebrate success! Involve everyone who had a role in the project, and recognize outstanding performers.

G. Tools for Managing the Project

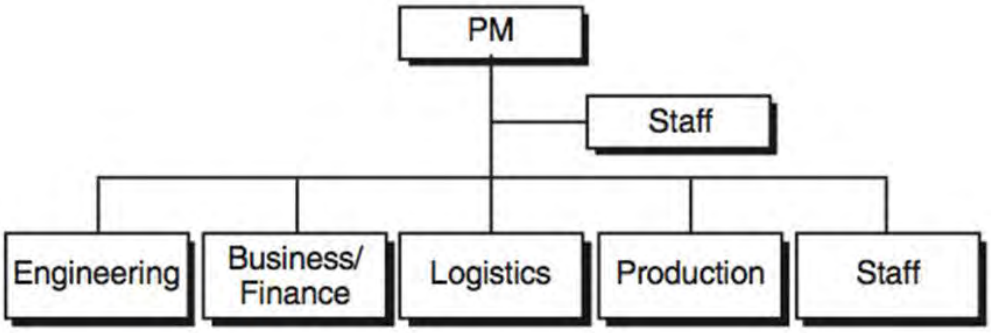
The following section contains tools and techniques for PMs to use in managing projects.

1. Managing People

a. Organizational Structures

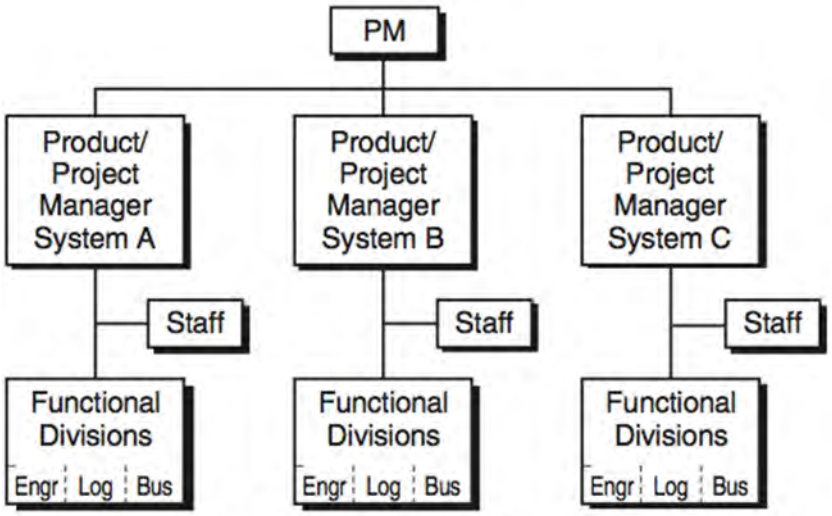
Project management teams vary based on the type of the overall organization, the type of project, and the length of the project. The following are organizational structures that may be employed.

Figure 83: "Traditional" or Functional Structure



Note: Functional divisions shown are notional.

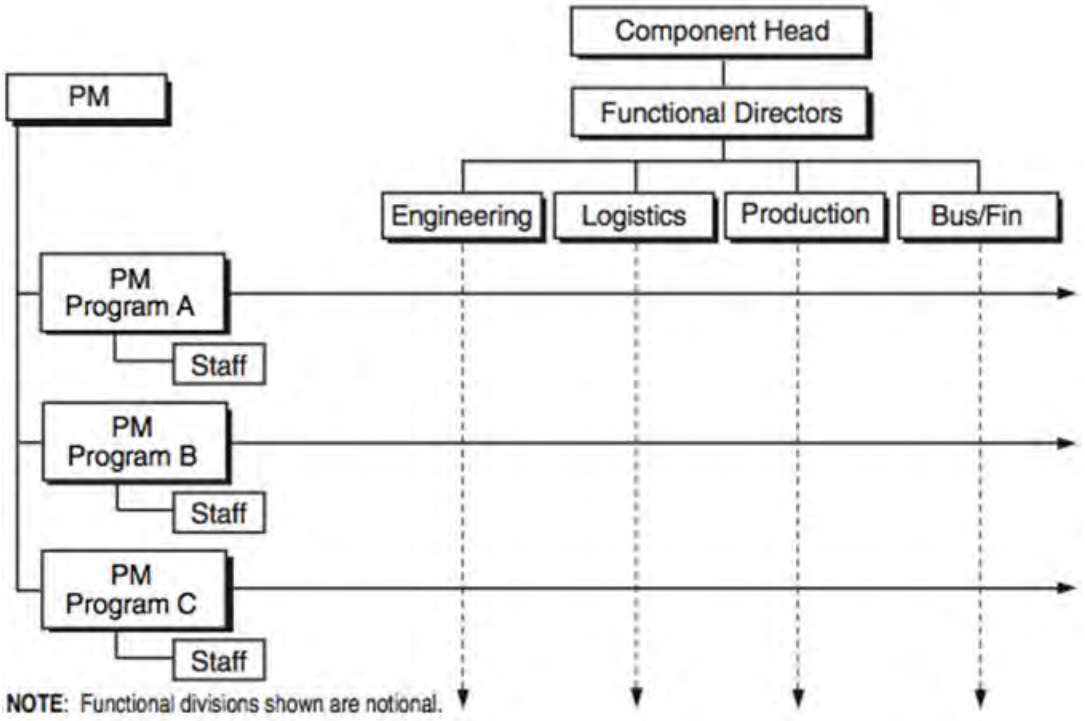
Figure 84: "Pure" Product Structure



Note: Functional divisions shown are notional.

LEGEND:
Engr—Engineering Log—Logistics Bus—Business

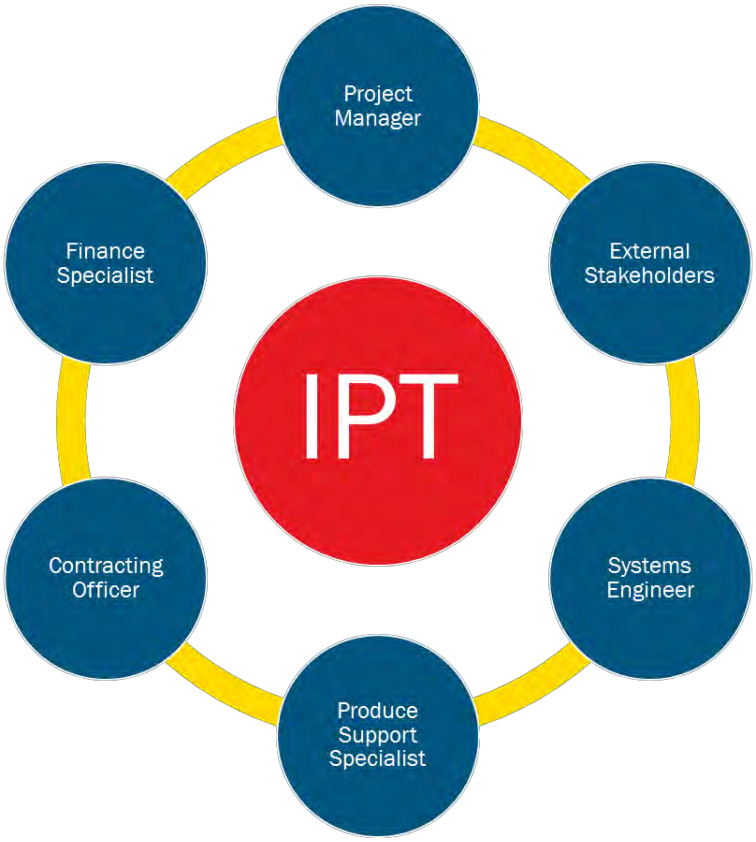
Figure 85: Matrix Structure



b. Integrated Project Teams

Integrated Project (or Product) Teams (IPTs) bring together all stakeholders who share a common goal or objective for the project/product. IPTs are especially successful because decisions and reviews are completed as a team. Rather than one office being responsible for building the requirements and sending the package over to acquisition, acquisition, finance, and other offices are part of the early conversations and contribute their expertise from the commencement of the project life-cycle.

Figure 86: Integrated Project (or Product) Team (IPT)



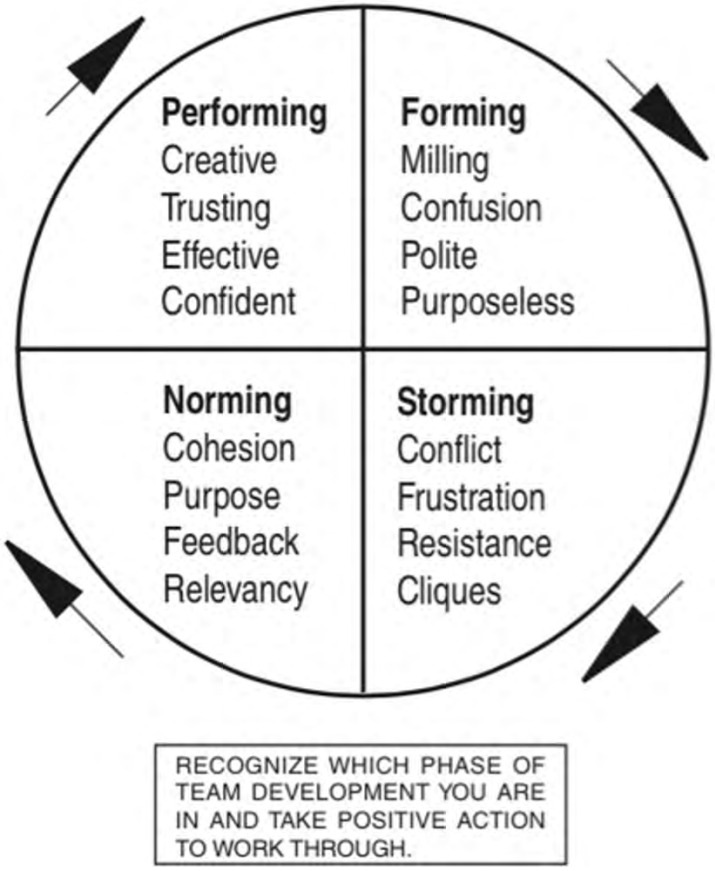
c. Team Charter

In forming the IPT, it's important to create a Team Charter to document what standards and rules the team will work by. The Team Charter should consist of responsibilities and authorities of team members and the procedures for making team decisions. This includes a tie-breaking process for times the team is unable to reach consensus.

The PM should ensure that the Team Charter supports an effective working team and project goals. It is often most effective for the team to create the Team Charter together. Getting input from team members generally increases their buy-in and support of the Team Charter and, ultimately, the project.

By definition, teams are formed for the purpose of the project and do not always have an established history of working together. Consequently, these team members do not have shared norms and behaviors or well-defined roles. The Team Charter can help provide those standards and rules from which to work.

Figure 87: Team Development Wheel



Tip: There can be an additional phase—"Adjourning"—when the team disbands, says goodbye, and reflects on lessons learned. This is a celebration phase.

d. RACI Chart

With teams of people who possess different communication styles and levels of interest, team members will hear or have slightly different understandings of responsibilities and action items. RACI charts assign clear ownership of tasks or decision and ensure that nothing falls through the cracks.

RACI stands for Responsible, Accountable, Consulted, and Informed. Slightly different terminologies exist, but the general concept is the same. By creating a RACI chart, team members understand their respective roles and the expectations of them. The Project Manager may be responsible for developing evaluation criteria, but the Contracting Officer should be consulted. A table or matrix is used with activities listed on the left and people or positions listed across the top. R, A, C, or I is then inserted into each cell as appropriate. Not all letters must be used for each task.

Table 11: RACI Chart

Tasks	PM	CO	CFO	Deputy Assistant Secretary
Task 1		R		I
Task 2	R	C	A	I
Task 3	I		R	A

e. Empowerment, Delegation, and Coaching

Empowerment is assigned to an employee or team, giving them the responsibility and authority to take actions and make decisions in pursuit of the project's goals.

Delegation is assigning an employee a specific task or tasks to complete.

Coaching is providing employees with the tools, knowledge, and opportunities they need to develop their potential and increase their effectiveness.

Empowerment, delegation, and coaching:

- Allow managers more time for managerial and leadership roles;
- Increase employee capability and innovation;
- Enhance employee career growth;
- Improve teamwork;
- Maximize limited resources; and
- Push responsibility and accountability further down into the organization.

Steps to Empower, Delegate, and Coach

1. Select the task or tasks to be assigned.
2. Select the person or team; evaluate their current capabilities to complete the task or tasks.
3. Provide training and/or coaching, if necessary, to improve their capabilities.
4. Solicit input from the person or team regarding the task or tasks.
5. Agree on the tasks, objectives, responsibility, authority, and deadline.
6. Provide guidance, assistance, and support as necessary.
7. Establish metrics to measure progress.
8. Monitor progress.
9. Provide feedback.
10. Identify lessons learned.
11. Evaluate performance.

Figure 88: Empowerment and Delegation Attributes

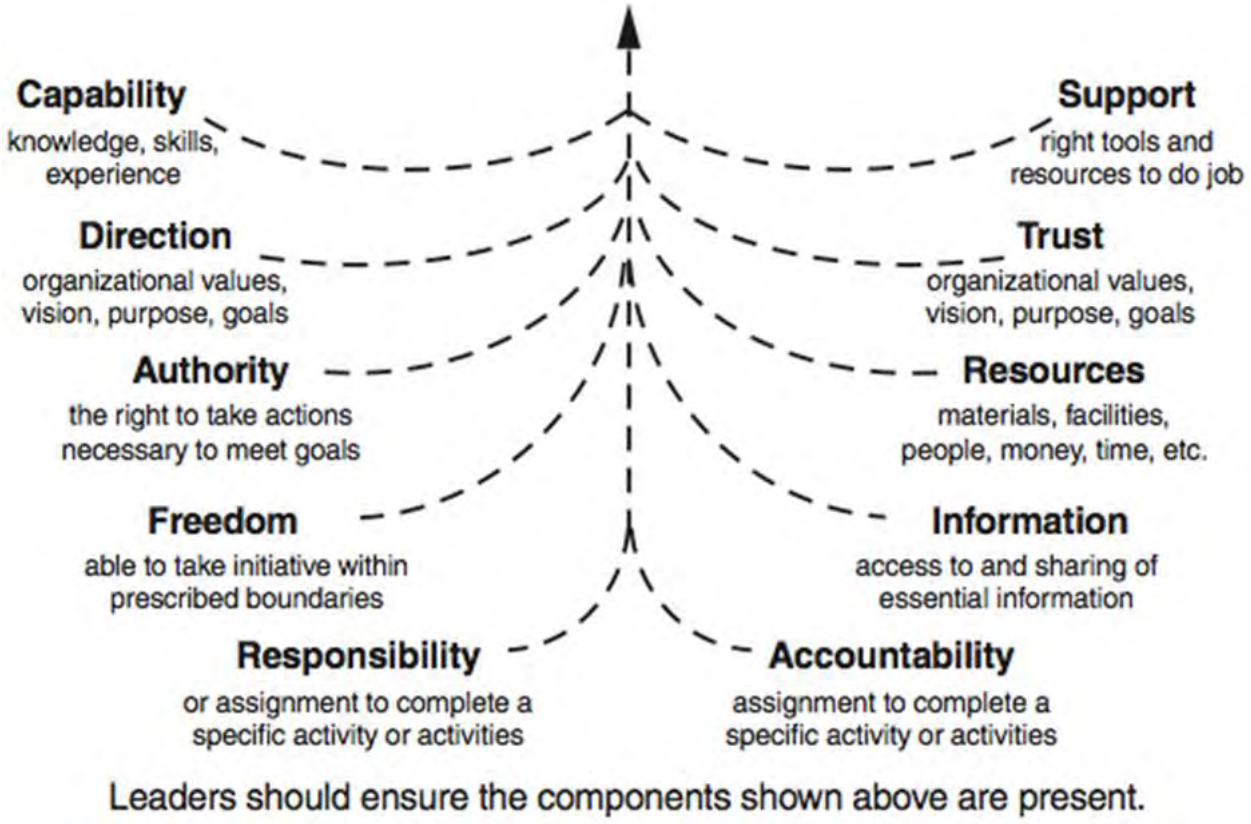


Figure 89: Coaching Skills

- **Active Listening.** Give your ***full attention***. Focus on the message, not formulating your response to it. Establish and maintain eye contact, paraphrase key points, and avoid making judgments.

- **Questioning.** Ask questions to promote discovery of new knowledge and stimulate thinking. Use open questions that require some thought to complete.

- **Giving Feedback.** This is one of the most valuable yet least used tools in communication. People are often uncomfortable giving feedback to others, particularly when they believe it could be perceived as negative. Offer factual, specific, but non-judgmental (and unemotional) feedback.

- **Sharing.** Share your experiences. Make suggestions on overcoming difficulties or how to proceed.

2. Processes

a. Meetings

Professionals frequently complain about too many meetings and dread another meeting added to their calendars. However, it typically is not the idea of the meeting and interacting with colleagues that is off-putting but that meetings are typically poorly planned and ineffective. To make meetings as effective as possible:

- Ensure everyone knows the purpose of the meeting;
- Create an actionable agenda and share it in advance of the meeting;
- Start on time;
- Allow for discussion throughout, but manage the discussion to be respectful of time;
- Create a visual record of the meeting decisions, and share with the team following the meeting;
- Agree on and assign next steps and timelines; and
- End on time.

In addition to meetings, the PM should consider huddles as part of daily or weekly project check-ins. Huddles are short (five minute) standing morning meetings (if you sit down the meeting will last 20 minutes). The small group should discuss three questions:

1. What happened yesterday that we need to celebrate?
2. What do we need to do today—absolutely no excuses?
3. What do we need to pay attention to over the next week so it does not become a problem?

The huddle begins on a positive note—there is always something to celebrate. It then turns to a commitment—a shared understanding of what is essential today. Then the conversation turns to what issues might present a problem in the near future.

b. Decision-Making

Within the project, decision-making may take a variety of forms.

- **Unilateral.** One person makes the decision, usually the project manager. Variations on unilateral decision-making includes:
  - Directive or Authoritative. The person making the decision does so primarily using his/her knowledge, experience, and program guidelines/constraints but is also influenced by his/her own reasons and motives.
  - Consultative. The person making the decision may seek input from other team members, but ultimately he/she still makes the decision on his/her own.

- **Majority.** Each team member votes, and the majority decides the course of action.

- **Consensus.** Team members may not completely agree with the most preferred approach, but they have the opportunity to express their point of view, understand the logic behind the decision, and support it. Consensus is generally the preferred decision-making method for most team issues, especially when the commitment of all team members is important.

Guidelines for Achieving Consensus

- Don't try to force consensus. Listen to other positions and reactions before expressing your own point.
- There are no winners or losers. Don't assume that someone must "win" and someone must "lose" if the discussion reaches a stalemate.
- Don't avoid conflict. Don't change your mind simply to reach agreement and maintain harmony.
- Avoid majority votes, compromises, or horse trading to reach an agreement.
- Avoid group think. Disagreement is not a negative. Differences of opinion are natural and expected.

c. Project Communications

One way to ensure the right people get the right information at the right times is to develop a project communications plan. The plan may include:

- Key entities (program management leadership, IPTs, customer, contractor(s), and key stakeholders);
- What information they should provide;
- What information they should receive;
- How it is provided/received;
- Format, frequency/interval, and other factors considered important for the particular program/situation;
- Types of meetings, such as regular status meetings and program management reviews;
- Reports (e.g., status reports, cost/schedule performance reports, action item lists);
- Issues and the policy for elevating them to higher levels; and
- Other forms of communication, and how and by whom they are used.

d. Continuous Process Improvement

Lean Six Sigma is frequently used to describe continuous process improvement. Lean and Six Sigma are actually two distinct process improvement ideas. Lean is a process that can be shortened by eliminating added steps. Sigma is the term used for standard deviation—a statistical measure of variation. Variation can be decreased through Standard Operating Procedures (SOPs) and training. Six Sigma means that the process produces a 99.99966% defect-free yield or 3.4 defects per million opportunities. The following table provides guidance on whether Lean Six Sigma, Lean, or Six Sigma should be used.

Figure 90: Lean Six Sigma Decision Points

Decide Which Opportunities Require Lean Six Sigma and Which Require Just Lean or Six Sigma

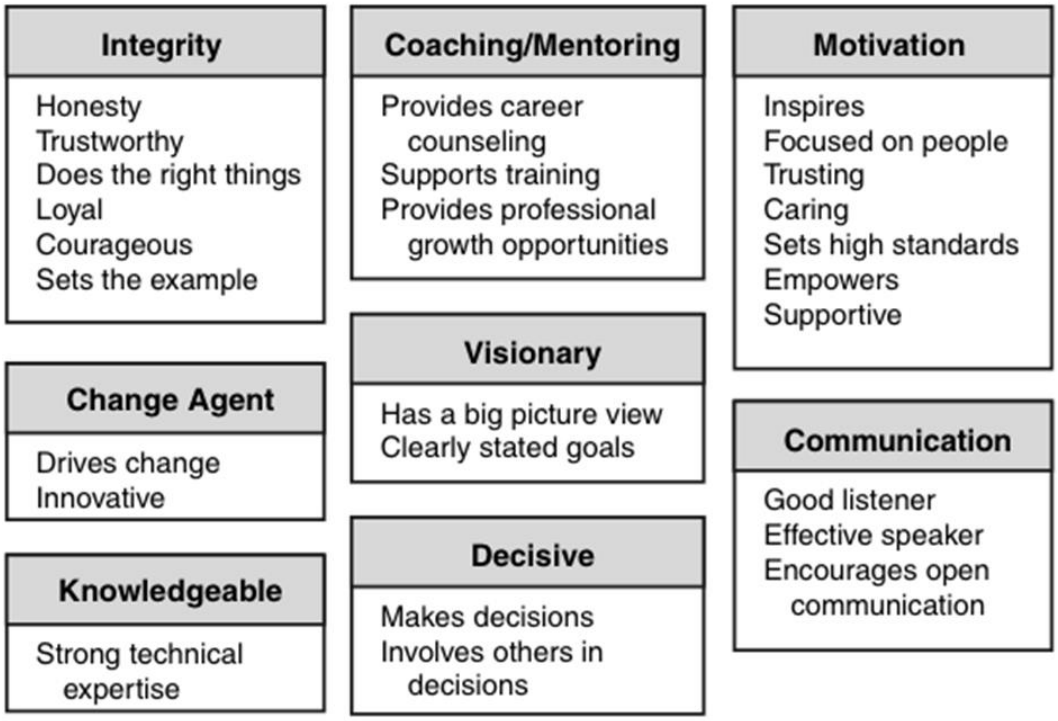
If …	Then …
• Slow, wasteful business processes are the problem • Little or no historical process data • **GOAL: Process speed**	• **Focus on Lean** — Elimination of "non-value added" activities — Workflow simplification
• Streamlined, highly efficient business processes • Process variability identified as a problem based on statistically significant historical data • **GOAL: Process consistency**	• **Focus on Six Sigma** — Elimination of variation factors and lack of control — Data-driven management
• Slow, wasteful business processes combined with low performance or quality variability • **GOAL: Speed and consistency**	• **Focus on integrated Lean and Six Sigma** — Methodology as a total performance solution — Total process view with embedded measurement and assessment capabilities leading to positive performance management

3. Tools

The following tools should be used by PMs in managing projects. PMs should evaluate these and other tools to determine what will best support the project.

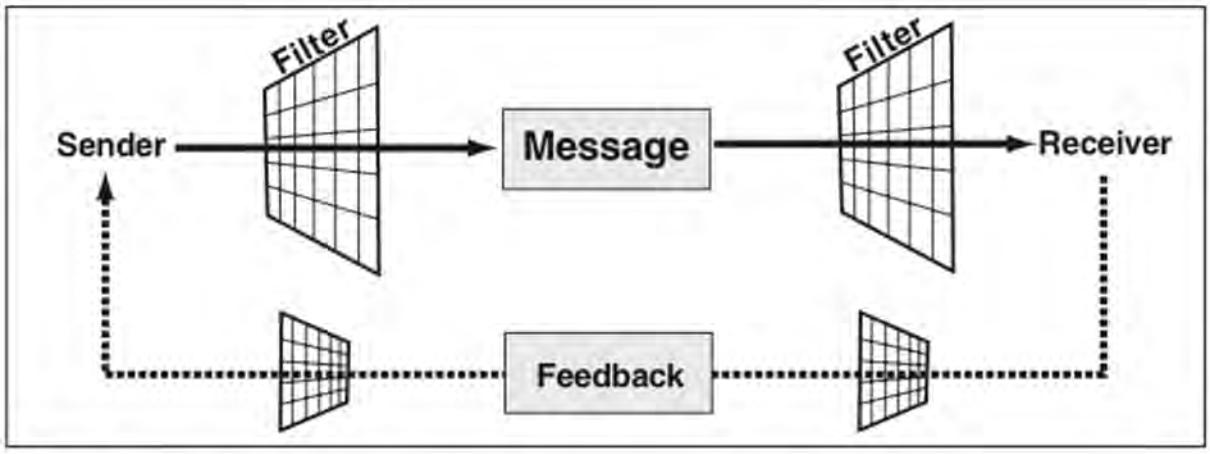
a. Leading People

Figure 91: Attributes of an Effective Leader



Communications

Figure 92: Communications Filter



Messages pass through filters—first through the filter of the person sending the message and then through the filter of the receiver. Filters sometimes act to enhance the message, and, at other times, they can be barriers. Filters consist of factors such as personality, tone

of voice, body language, facial expressions, accents, perceptions, attitudes, emotions, knowledge, functional background, the medium of communication used (verbal, written, e-mail, etc.), and much more. Each person's filter is different, sometimes resulting in the receiver interpreting the message differently than the sender intended.

One of the most important communications skills (and often a barrier to effective communications) is listening. Learning to "actively listen" can increase communications effectiveness significantly.

Active listening involves:

- Establishing and maintaining eye contact;
- Focusing on what is being communicated;
- Not making judgments about the sender's information;
- Not formulating your reply before the sender has finished sending his/her message; and
- Paraphrasing key points the sender makes (only when the sender pauses—don't interrupt to paraphrase what's being communicated).

Effective program management requires that the right people get the right information at the right time. Program communications must take place vertically (up and down), horizontally, and externally.

Communications Plan

One way to ensure the right people get the right information at the right times is to develop a program (and/or team) communications plan.

The plan may include:

- Key entities (program management leadership, IPTs, customer, contractor(s), and key stakeholders);
- What information they should provide;
- What information they should receive;
- How it is provided/received;
- Format, frequency/interval, and other factors considered important for the particular program/situation;
- Types of meetings, such as regular status meetings and program management reviews;
- Reports (e.g., status reports, cost/schedule performance reports, action item lists);
- Issues and the policy for elevating them to higher levels; and
- Other forms of communication, and how and by whom they are used.

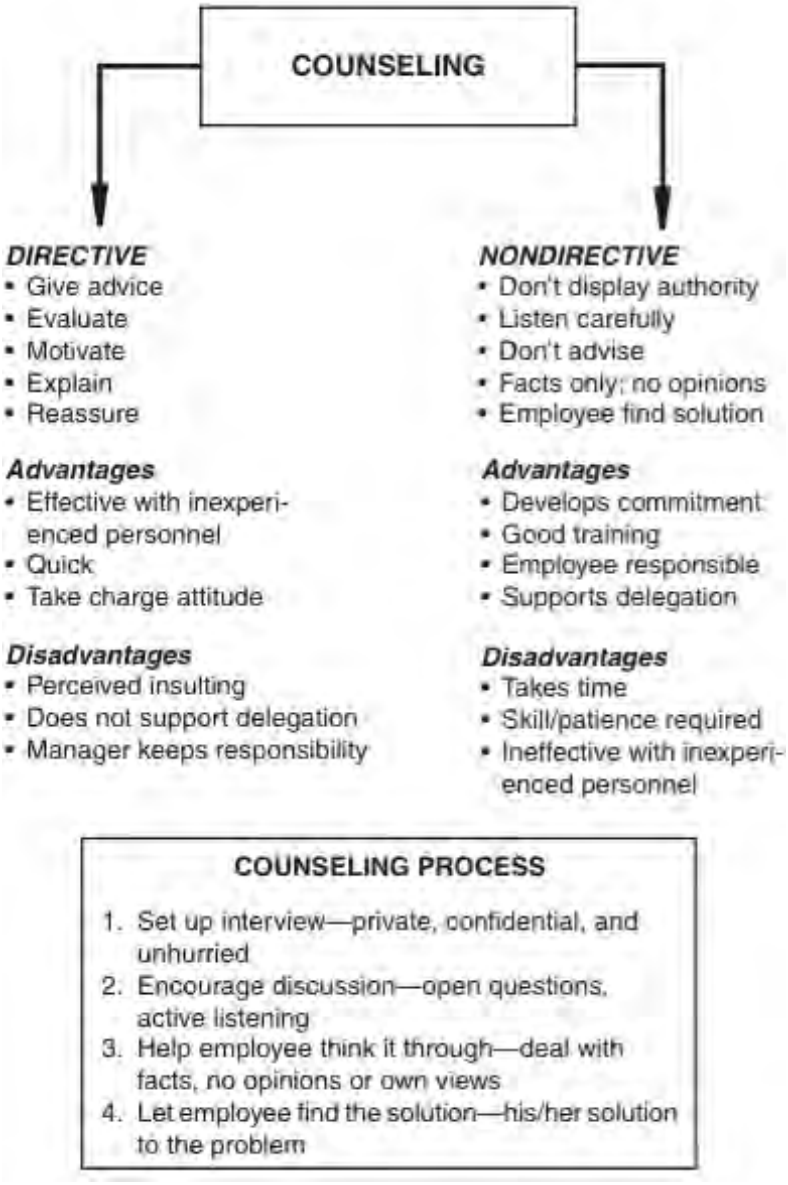
Interpersonal Negotiation Techniques

Interpersonal negotiation techniques can be used to resolve conflicts in a manner that satisfies both parties' interests.

How to use them:

1. Acknowledge the conflict and its effect on performance.
2. Separate people and emotions from the issue.
3. Present issues in terms of the underlying interests or requirements (i.e., the most important aspects of what you need to achieve).
4. LISTEN to the other party's interests/requirements; be able to restate their interests to their satisfaction (indicating you understand what interests they are trying to achieve).
5. Agree on what the issue is.
6. Look for common goals and common interests.
7. Identify as many possible alternatives to resolve the issue and satisfy the interests of both parties.
8. Resist the urge to compromise ("meet in the middle"). Instead, look at the issue from different perspectives—challenge assumptions and constraints.
9. Agree on the alternative that best meets both parties' interests.
10. Obtain the commitment of all members of both parties on what will be done to implement the solution.

Figure 93: Counseling



b. Performance Management

Writing Goals and Objectives

SMART is a technique for writing effective goals and objectives. SMART:

- Specific – requires a specific goal or objective versus a broad or general goal. To do this, it must answer the five "W" questions.
  - What will be accomplished?
  - Why is it being accomplished?
  - Who will be involved?

- Where will it occur?
- Which requirements or constraints affect the goal?

- Measurable – develop quantifiable indicators that are tied to outcomes.

- Attainable – specify objectives that are reachable. Know your team and their abilities, availabilities, and motivations to determine what is attainable.

- Relevant – identify only what seems worthwhile and applicable.

- Time-Based – state when results can be achieved. A deadline helps focus attention on the goal or objective.

Tip: When drafting goals and objectives, use a table to ensure you've addressed all of the SMART tenants.

Table 12: SMART Goals and Objectives Table

Goal/Objective	
Specific	
Measurable	
Attainable	
Relevant	
Time-Based	

Monitoring Techniques

Table 13: Monitoring Techniques

Technique	Impact
Desk Checking	• Ineffective • Better than nothing • Individually done
Walk-throughs	• May have defined procedures • Team-oriented review • Results may be recorded • Around 40% defect removal
Formal Inspections	• Use specially trained teams • Formal process • Team attitude critical • Rigid entry/exit criteria • Basis for metrics • Genesis for process improvement • Around 70% defect removal
Joint Reviews	• Preparation critical • Entrance/exit criteria key • Frequently abridged • High-level review • May not be high-leverage

Technique	Impact
Computer-Based Testing Activities	• Process-driven • Test and integration planning key • Includes qualification testing • Software item/configuration item • White vs. black box testing

Decision Briefing

Elements of a Decision Briefing:

- Outline – Agenda
- Purpose of Briefing/Issue(s)
- Background
- Assumptions
- Alternatives Identified
- Evaluation Criteria/Process
- Analysis of Identified Alternatives
- Recommended Alternative
- Rationale for Recommendation
- Recommended Implementation Plan
- Key Risks for Recommended Implementation Plan

What to Expect from the Person/People Receiving the Briefing:

- Challenges to assumptions, definitions, methodology
- Questions concerning compliance with or changes to policy
- Sensitivity of the issue and/or recommended alternative to change
- Questions or challenges to analysis, trade-offs, rationale for recommendations, and implementation plan
- Questions concerning risks for the recommended implementation plan

Tip: Questions may be open-ended or closed (e.g., yes/no answers).

c. Analytical Tools

Affinity Diagram

Affinity diagrams are used to help a team generate a large number of ideas or issues and organize them into categories for further analysis, evaluation, decision, or action.

How to do it:

1. Agree on what the problem, issue, question, or desired outcome is.
2. Brainstorm as many ideas about the problem, issue, question, or desired outcome as you can.

3. Without discussion, sort the ideas into related groups.
4. If two people can't agree on which category it best fits, consider duplicating it and including it under both.
5. For each group, identify a name that summarizes the topics listed for them.

Tip: Use Post-it type notes to record the ideas on, which allows you to easily move the ideas from one category to another.

Benchmarking

Benchmarking is the process of measuring products, services, and practices against the toughest competitors or those known as leaders in their fields.

Why do it? Benchmarking can help you:

- Understand how you compare with similar organizations; and
- Identify areas for process improvement.

How to do it:

1. **Identify the process to be benchmarked.** Select a process (as opposed to a product) that is important to both your organization and your customers.

2. **Study other organizations.** Develop a list of organizations with comparable products and services. Determine which specific processes the organizations perform. Based on this information, rank the organizations from best to worst.

3. **Compare and evaluate.** Compare your process to the best and worst cases, and list the important differences. These differences can suggest potential improvements to your process.

Brainstorming

Brainstorming is designed to stimulate the free flow of ideas in a short amount of time without being analyzed or judged until the brainstorming is complete. There are three primary types of brainstorming: structured, unstructured, and silent.

- **Structured.** Participants take turns offering ideas; if someone doesn't have an idea when their turn comes, they can pass.
  - Advantage: Each person has an equal chance to participate.
  - Disadvantages: Lacks spontaneity; participants may get distracted by other ideas and forget theirs when their turn comes; atmosphere is more rigid.

- **Unstructured.** Participants offer ideas as they think of them.
  - Advantage: Participants can build on each others' ideas; atmosphere is more relaxed.
  - Disadvantage: Less assertive; lower-ranking participants may feel intimidated and not contribute.

- **Silent.** Participants write ideas individually on paper or Post-it notes. This is particularly useful when you have participants who just can't avoid discussing the ideas as they are offered.
  - Advantage: Prevents discussion of ideas during the ideas generation phase.
  - Disadvantages: May lose the opportunity to build on others' ideas unless a structured or unstructured session is held after the silent inputs are collected and displayed.

The brainstorming session ends when no more ideas are offered.

Ground rules for brainstorming may include:

- **Don't discuss ideas as they are offered.** In particular, don't analyze, evaluate, criticize, or judge. Discussion can be held after the brainstorming session ends.
- **There are no outrageous ideas.** There is plenty of time during the discussion after the brainstorming session to toss out ideas that won't work. Even if an idea is totally outrageous and obviously won't work, it may spark another idea that is usable.
- **Don't quit when the ideas first stop flowing.** Try to get participants to come up with at least two or three more ideas.
- **Strive for quantity, not quality.** The more ideas you generate, the better the opportunity to find the best possible solution.
- **Combine and rearrange ideas.** Additions, revisions, and combinations may create even better ideas.
- **Record ideas exactly as offered.** Don't edit or paraphrase.

Questions to stimulate thinking during brainstorming may include the following:

1. Can we use this idea somewhere else? As is? With changes?
2. If we change it, is there anything else like it? Any related issues?
3. Can we modify or rearrange the meaning, quantity, color, size, shape, form, layout, motion, sound, appearance, etc.?
4. Can we maximize or magnify it to make it stronger, larger, or newer?
5. Can we minimize or reduce it to make it smaller or lighter?
6. Can we substitute? Who? What? When? Where? How?
7. Can we reverse it? Opposite? Backwards? Upside down? Inside out?
8. What assumptions or constraints are we considering? Are they valid? What if we threw them out?
9. What if you could do anything you can imagine?

Cause-and-Effect Diagram ("Fishbone" or Ishikawa Diagram)

These diagrams help analyze a problem by increasing detail to identify all of its causes, leading to the discovery of its root cause(s). The Cause-and-Effect Diagram graphically depicts the relationship between a problem and its causes.

How to do it:

1. Use brainstorming to generate the potential or known causes for the problem (or effect) being studied.
2. Begin constructing the "fishbone" diagram by placing the problem statement on the right side of the chart (head of the "fishbone").
3. Draw an arrow from left to right, ending at the problem statement (the backbone of the "fishbone").
4. Place the major cause categories (if known) as the major "bones" of the fishbone, as shown in the example below (in the example: people, product, process, equipment).
5. If the major causes are not known, after brainstorming all the causes, sort them into similar groups using the Affinity Diagram. The titles of the groups become the major causes categories.
6. Add the brainstormed causes as the smaller bones in the diagram, as shown in the example below (e.g., inadequate training, poor teamwork, etc.) Causes can be added to the major categories after all the causes have been generated via brainstorming (recommended) or as they are generated.

Tip: To spark additional brainstorming of causes, ask for each of the "small bone" causes, "What causes this to happen?"

Figure 94: Example Cause-and-Effect Diagram

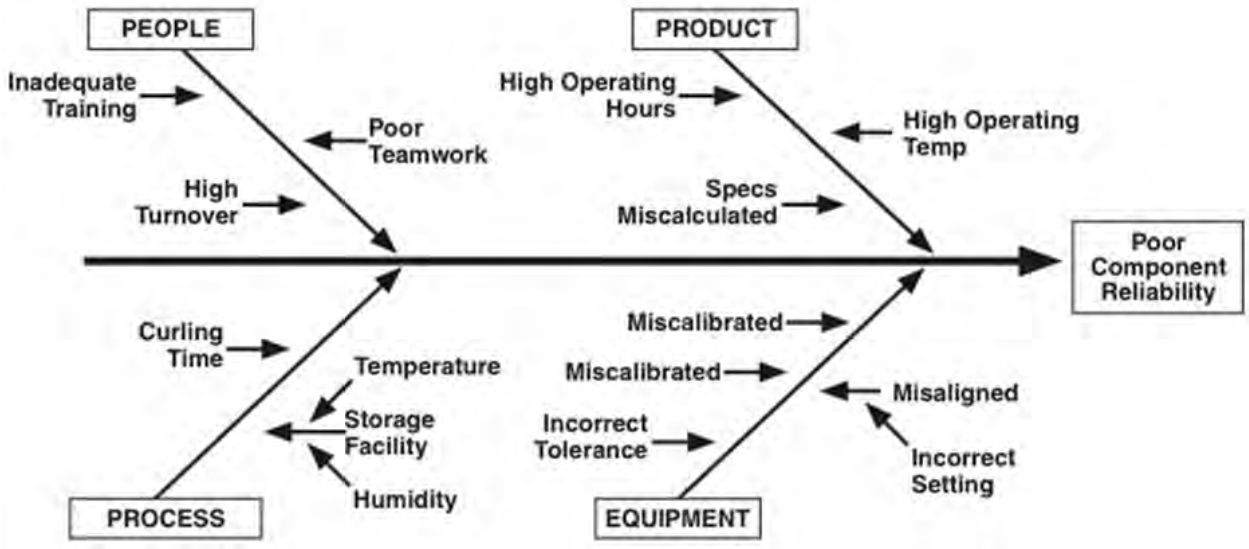
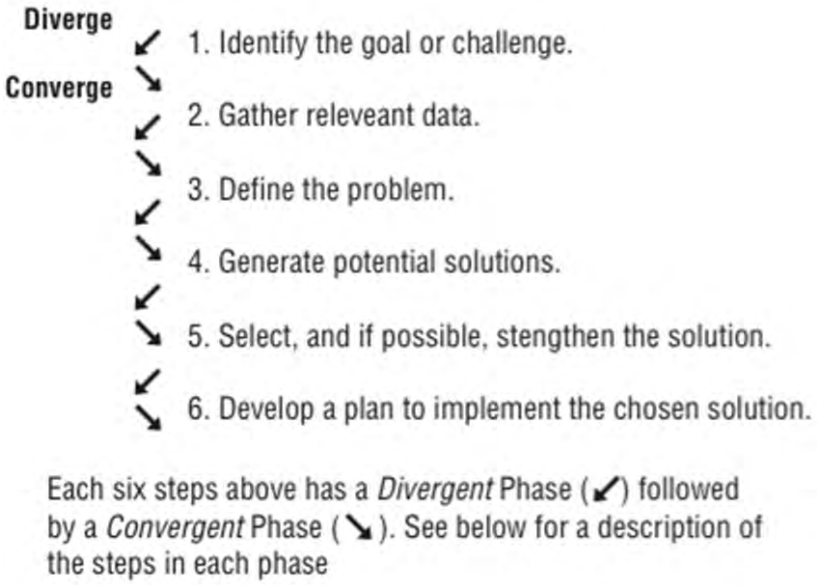


Figure 95: Six Steps of Creative Problem Solving



Each six steps above has a *Divergent* Phase (↙) followed by a *Convergent* Phase (↘). See below for a description of the steps in each phase

Divergent Phase

1. Avoid judging or evaluating ideas as they are offered.
2. Generate as many ideas as possible.
3. Accept all the ideas generated.
4. Stretch your thinking.
5. Allow time for ideas to "grow."
6. Combine or connect ideas or concepts.

Convergent Phase

1. Use a logical, methodical approach to make choices or decisions.
2. Clearly and specifically state the basis for evaluating ideas.
3. Avoid a rush to closure.
4. Don't ignore or avoid difficult issues.
5. Look for strengths or positive aspects of ideas.
6. Remain focused on the objectives.

Flowcharting

Flowcharts are used to identify the steps or tasks in a process. The current process can then be analyzed to discover duplicate or unnecessary actions, bottlenecks, or other problem areas. Ideas for improvement can then be identified.

How to do it:

1. Clearly define where the process begins and ends.

2. List all of the steps in the process, including decision points and inputs to and outputs from the process.
3. Arrange the steps of the process in the sequence in which they currently occur. If it is a new process, begin with the sequence in which you believe they will occur.
4. Draw the appropriate symbols for each of the items in the process.
5. Label the items in the process with text describing that item.
6. Add arrows showing the process flow.
7. Review for accuracy.
   - Correct symbols
   - Correct labels
   - Correct sequence
   - Correct direction of flow

Figure 96: Common Flowchart Symbols

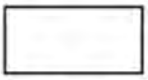
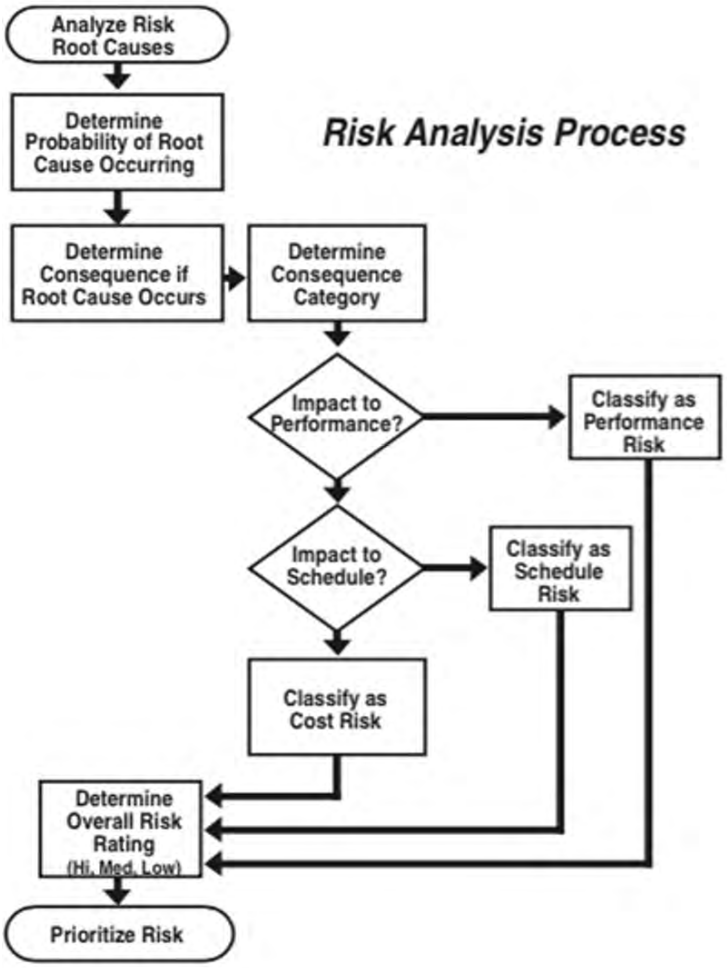
	**Terminator** - shows the begining and ending points of the process. Start points are usually some sort of trigger acrivity for the process.
	**Activity** - an action step or process (within the process).
	**Decision Point** - where a decision is required; usually with two options (e.g., yes/no).
	**Document** - a step or action that produces a document.
	**Connector** - shows a jump from one point in the process to another, or to another page. Usually labeled with letters (e.g., A<B<C< etc.).

Figure 97: Example Flowchart



Deployment Flowcharts

Deployment Flowcharts depict a process and the individuals or teams responsible for the steps/actions in the process.

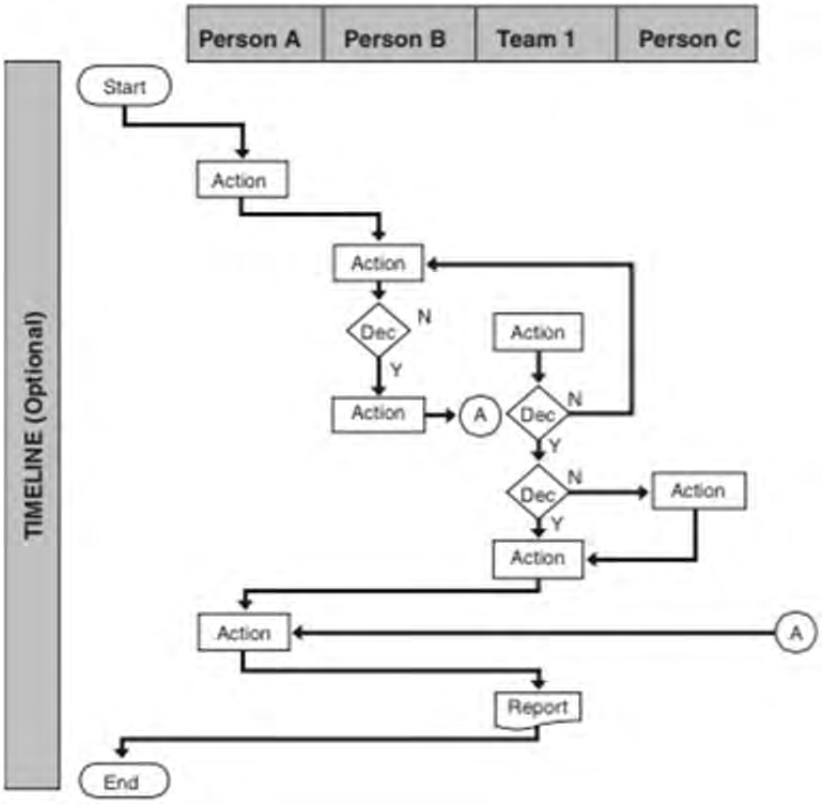
Why create one?
Use a Deployment Flowchart to clarify individual or team roles and responsibilities as well as to detect/prevent duplication of effort.

How to do it?

1. List the steps of the current process.
2. Identify the individuals/teams involved.
3. Draw the Deployment Flowchart showing the activities, decisions, inputs, outputs, documents, etc. (see example below).
4. List the individuals/teams across the top of the chart and the timeline (if applicable) down the side (see example below).

5. Evaluate the current process for possible changes, and update as necessary.

Figure 98: Example Deployment Flowchart



Force Field Analysis

Force field analysis is used to identify factors or forces that either support or work against a desired outcome.

How to do it:

1. Draw a "T" shape as shown below.
2. Brainstorm the forces that will assist you in achieving the desired outcome. List them on the left side of the vertical line.
3. Brainstorm the forces that may prevent or restrain you from reaching your outcome. List them on the right side of the line.
4. (Optional) Prioritize the driving forces (left side) and/or the restraining forces (right side).
5. Look for opportunities to take advantage of or strengthen driving forces.
6. Identify restraining forces that you might be able to eliminate (reducing their "force" or impact).
7. It is often more helpful to eliminate restraining forces than attempting to strengthen driving forces. In most cases, the driving forces will remain present and continue to

help you even if you do nothing to strengthen them, whereas eliminating restraining forces can have significant benefits in achieving your objective/outcome.
8. In a "pound-for-pound" or "best bang for the buck" fashion, the force field analysis is one of the most powerful tools in terms of the effort required to generate it and the potential benefits derived from it.
9. Restraining forces can also be identified as potential risks, and they can be entered into the risk management tracking system.

Figure 99: Example Force Field Analysis

Histogram

Histograms are used to graphically depict the frequency distribution of data items using a vertical bar chart (columns) format.

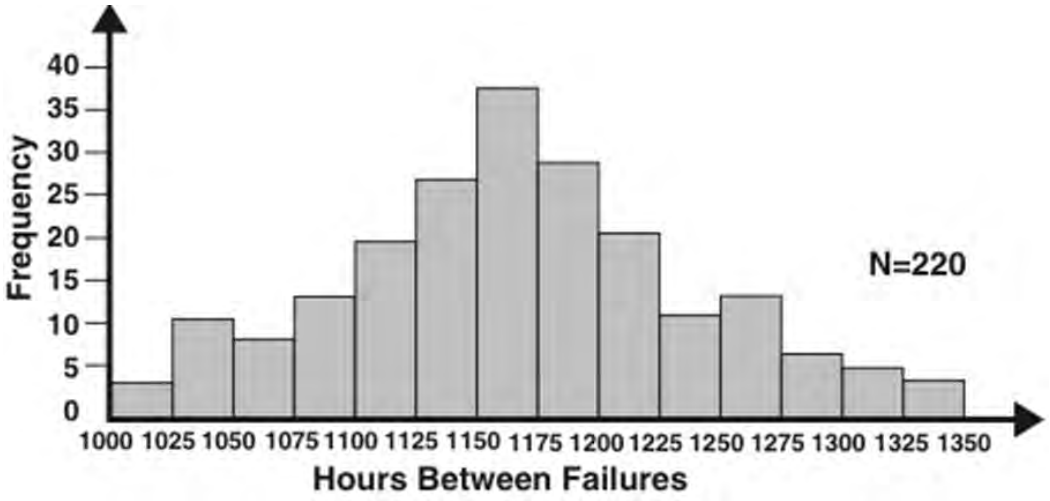
How to do it:

1. Collect data on a particular variable.
2. Generate a frequency table listing all the data points.
3. Count the number of data points.
4. Determine the range of values for the data (maximum value minus the minimum value).
5. Determine the number of bars to depict in the chart. One common method is to use the square root of the number of data points (e.g., 100 data points = 10 bars, 225 data points = 15 bars, etc.).
6. Calculate the intervals represented by each of the bars. The simplest method is to divide the range of values by the number of bars (from previous step).
7. Determine the frequency of data points within each interval of values.
8. Create a vertical bar chart with a vertical bar (column) for each of the variable values or range of values you measured on the horizontal axis. The height of the bar will equal the frequency (on the vertical axis) for each of the values/ranges.

Example:

- In the example below, the sample size is 220 data points (N=220).
- The square root of 220 is between 14 and 15, so either will work for the number of bars in the cart (14 bars are used in the example).
- The range of values is 350 hrs. (1350 hrs. minus 1000 hrs.). Dividing the range (350) by the number of bars (14) results in intervals of 25 hrs.

Figure 100: Example Histogram



KNOT Chart

Why create one?

KNOT Charts are useful for organizing/coordinating the next steps of the problem-solving process.

Figure 101: KNOT Chart

Know	Need to Know	Opinion	Think We Know

As you work your way through the problem, everything should move into the left column—"Know."

Nominal Group Technique

The nominal group technique (NGT) is used to rank or prioritize the importance of issues, alternatives, or processes. It helps a team reach consensus quicker by showing preliminary areas of agreement and allows individual team members to assign a rank or priority to items without influence or pressure from others.

How to use it?

1. Brainstorm a list of the issues, alternatives, or processes that you are analyzing.
2. Compile a list of brainstorming inputs by eliminating duplicate or similar inputs and clarifying the meanings of any inputs that are unclear.
3. Each team member votes by ranking the inputs in order of importance (see first example on next page).
4. The highest number is generally used to indicate the most important or highest priority item. For example, if team members are ranking 10 items, "10" would represent the most important item and "1" the least important item. Make sure you specify the values used in the ranking (i.e., which number represents the highest or most important rating and which represents the lowest to ensure there is no confusion).
5. Team members may rank all of the items or some pre-designated portion of the items (particularly when there is a long list), such as a third or a half.
6. Add all of the rankings, and analyze the results.
7. Unless the team is pressed for time, use the ranking information as a starting point for discussion instead of accepting it as a "final score."

8. An alternate method is to assign each team member a number of points (e.g., 100), which they allocate across the options (some or all). This variation is known as weighted multi-voting (see second example on next page).
9. When using weighted multi-voting, it is a good idea to assigned a maximum number of points that can be assigned to any one item (e.g., 40 out of 100) to prevent one team member from over-representing the relative importance of an item.

Figure 102: Example Nominal Group Technique (NGT)

Problems with Team Performance (Ranking for Example)

Causes (7)	Peter	Paul	Mary	Total
Inadequate team training	6	3	5	14
Unclear objectives	4	7	3	14
Insufficient resource	3	5	2	10
High team member turnover	2	2	4	8
Inefficient team process	5	6	7	18
Team member hidden agendas	7	4	6	17
Poor functional representaion	1	1	1	3

Weighted Multivoting Example

Issues (12)	John	Paul	Ringo	George	Total
Item A	40	30	10	20	100
Item B		5			5
Item C	10	10		20	40
Item D	10			20	30
Item E		20		10	30
Item F	5		5		10
Item G	15	20	20	20	75
Item H			50		50
Item I	10	5		5	20
Item J		5	10		15
Item K	10				10
Item L		5	5	5	15

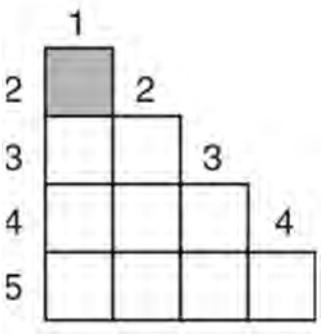
Pairwise Ranking

This tool provides a structured method for ranking small lists or items in priority order.

How to do it?

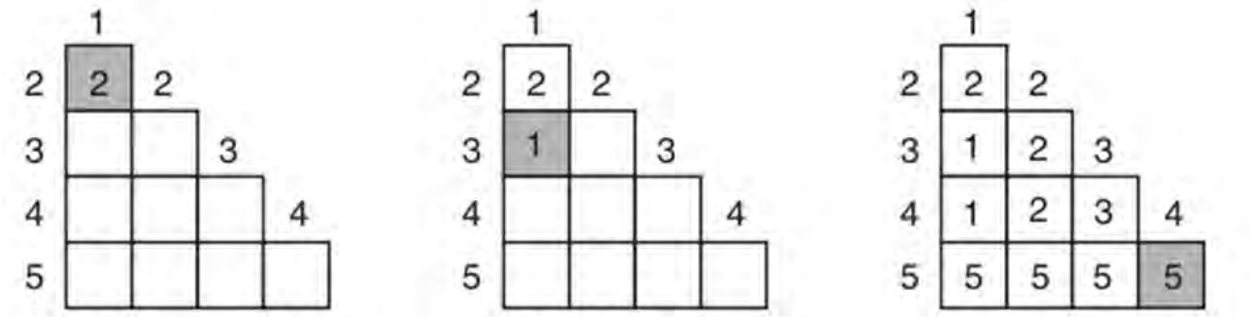
- Construct a pairwise matrix.
  - Each of the squares in the matrix at right represents the pairing of two items (where the numbers intersect).
  - In this example, the list includes five items; the top square (shaded) represents the pairing of item 1 with item 2.

Figure 103: Pairwise Matrix



- Rank each pair of items.
  - For each pair of items, the team should reach consensus on which of the two items is preferred over the other.
  - As the team completes each of the comparisons, the number of the preferred item is recorded in that square until the matrix is completely filled in.

Figure 104: Example Pairwise Matrices



- Count the number of times each item appears in the matrix.
  - Using the filled-in matrix (on the far right above), count how many times each item is listed in the matrix and record the totals in the ranking matrix (at right).

Figure 105: Example Pairwise Matrix Count and Rank

Alternative	1	2	3	4	5
Count	2	3	1	0	4
Rank					

- Rank all of the items.
  - Rank the items based on how many times they appear in the matrix.
  - To break a tie between two items appearing the same number of times, look at the square in the matrix where the two were compared; the item appearing in that box receives the higher ranking.

Figure 106: Example Pairwise Matrix Process

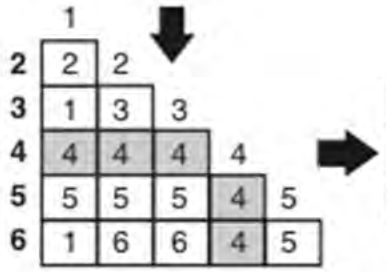
Items 5 appear four times in the matrix, so it ranks 1st (see shaded squares in the matrix at right); Item 2 appears three times, which ranks 2nd, etc.

Alternative	1	2	3	4	5
Count	2	3	1	0	4
Rank	3rd	2nd	4th	5th	1st

EXAMPLE:

A program team was asked to recommend a site for testing a unique portion of a system. A feasibility study produced a list of six possible locations. The team then used Pairwise Ranking to determine that Nellis AFB was best suited for this particular test.

1. Fort Huachuca
2. Edwards AFB
3. Kirtland AFB
4. Nellis AFB
5. Eglin AFB
6. Hanscom AFB



Site	1	2	3	4	5	6
Count	2	1	1	5	4	2
Rank	3rd	6th	5th	1st	2nd	4th

Pareto Chart

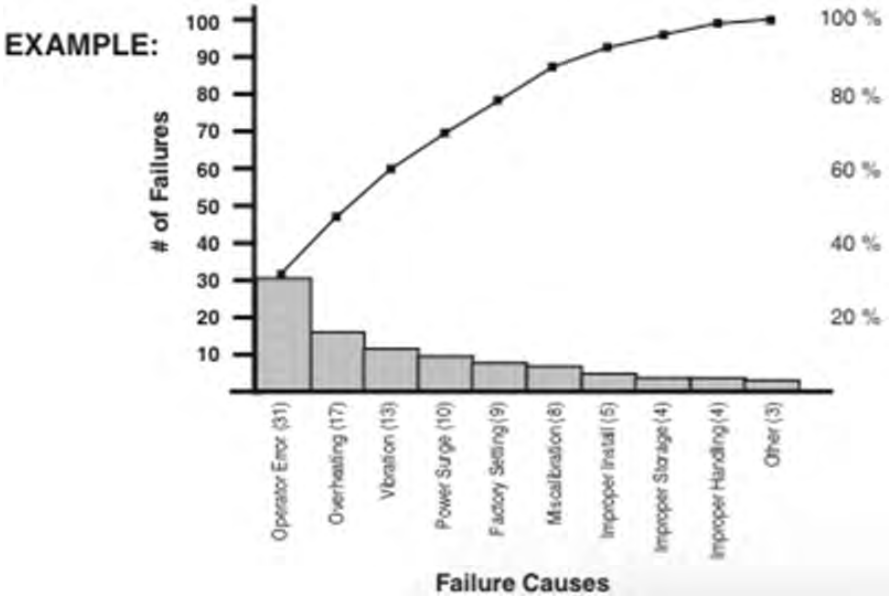
Pareto Charts are designed to help identify and prioritize issues or problems, identify root causes, or evaluate results of improvement areas. The Pareto Chart graphically displays the

frequency of occurrence of data items.

How to do it?

1. Decide on the categories of the items (e.g., issues or causes) on which to focus.
2. Choose the measurement units, which provide the most meaningful comparison between the categories of items.
3. Determine the time-period-to-collect date.
4. Collect data on the chosen categories of items.
5. Create a vertical bar chart with a vertical bar (column) for each of the categories with the highest frequency of occurrence on the far left side that continues in descending order to the right, to the category with the lowest frequency of occurrence on the far right side. The height of the bar will equal the frequency (on the left vertical axis) for each of the categories.
6. (Optional) Draw a line showing the cumulative percentages of the categories from left to right (0–100%). Draw a vertical axis on the right side showing the percentage scale.

Figure 107: Example Pareto Chart



Surveys

Surveys are used to collect data from a variable number of items or people for a comparative study. They are used when a new project is planned to prove the need and the demand of the customer.

Surveys can be used anywhere in the organization to find out specific information that is necessary to make improvements in a process.

Why create one? Surveys:

- Are an inexpensive way to test a system or product;
- Can be used with a large number of people or a small group;
- Can give you an overall view, determined by the questions you ask;
- Show if an organization is meeting its quality goal; and
- Help identify satisfied and dissatisfied customers or employees.

How to do it:

1. Determine the group to be studied.
2. Determine what questions will be asked.
3. Compile your results in chart form using a Pareto Chart (see above), histogram, or other tool that will give you clarification.
4. Use the compounded data to form a base for improvement.
5. Continue to take data to monitor improvements, and make sure the improvements you have made are working.

Tip: Train your data collectors thoroughly. Everyone must know how to ask the questions, whom to approach, and how to approach them.

Caution!

- Data must be collected honestly and consistently.
- An untrained collector can skew the data to reflect personal biases.
- A poor, inconsistent survey will give you invalid data.
- Make sure there is enough time allowed for the collecting process.