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Introduction

This Exam Manual will help you prepare for the Project Management Professional (PMP®) exam administered by the Project Management Institute (PMI). The exam is based on PMI's A Guide to the Project Management Body of Knowledge (PMBOK®), Fourth Edition. The PMP is an internationally recognized project management credential that denotes familiarity with and application of generally accepted project management best practices. Its value is widely acknowledged by an increasing number of companies who now use the PMP as a selection criterion when hiring project managers. According to PMI, the PMP credential is today held by over 267,000 project managers worldwide.

This manual is not a substitute for reading the PMBOK and understanding the concepts, terminology and process relationships described in detail there. You should use this Exam Manual and the sample test questions as a means to help you master the PMBOK content and prepare you for the PMP exam.

What to Know

PMI has revised the examination in support of updates posted in Fourth Edition of the PMBOK. Prior to that time a proliferation of materials was widely available on how to successfully pass the examination. PMI has acknowledged that despite a lower passing score requirement, the percentage of people passing the PMP exam has dropped in recent years. This drop in the average examination score occurs despite more stringent eligibility requirements for taking the exam. With this in mind, PMP candidates should be aware that some commonly documented test-taking approaches may be less valid than they were in the past. Still, some general approaches to taking the test detailed in this manual are still helpful approaches, since a large portion of questions from the old PMP exam are still used on the new one.

Although there are formulas and other information that you will need to recall in the PMP exam to identify the correct answer, the exam is not simply a memory test. The exam tests the application of PMBOK concepts and processes to project management problems. To do this, you will need to become familiar with the PMBOK vocabulary (see the Glossary on pages 415-445 of PMBOK), understand how terminology is being used to describe specific project processes, and how those processes interact with and relate to other processes as described in the PMBOK.

Memorizing the PMBOK in itself will not guarantee success, unless you also understand how project management is practiced. The PMP designates that the holder is an active project management practitioner. For this reason, PMI mandates that PMP exam candidates must demonstrate as a prerequisite a minimum of five years/60 months unique, non-overlapping project management experience during which at least 7,500 hours are spent leading and directing project tasks. This requirement is reduced for candidates holding a Bachelor's degree (or equivalent) to a minimum of three years/36 months experience, of which 4,500 hours must have been spent leading and directing project tasks. In either case, when applying to take the PMP exam the candidate must demonstrate experience across all five of the project management performance domains defined in the PMBOK (although the experience need not be in all five domains within a single project).

PMI places significant value on structured project management training. Certified PMP project managers are required to fulfill a professional development hourly requirement in order to renew their certification. PMI establishes this emphasis for its certified PMPs by requiring test-taking candidates to provide proof of a minimum of 35 contact hours of specific instruction that covers project management learning objectives.

Difficulty in mastering the PMBOK often arises if your practical experience in project management (and the terminology you use in practicing project management) does not conform to the perspective presented in the PMBOK. The PMBOK is not a theoretical approach to project management. It is grounded in many thousands of hours of real-world project management experience. Nevertheless, in some instances you may need to put aside your personal experience ("That's not how it happens in the real world") when reading the PMBOK and preparing for the PMP exam. Additionally, specific knowledge areas covered in the PMBOK may not be practiced regularly by project managers in some project environments. For example, in some project environments procurement may be handled by a central function in the organization. PMP candidates should identify early in their test preparation any Knowledge Areas in which they either have limited practical experience or their practical experience deviates from what is outlined by the PMBOK.

Experienced project managers will note that the discipline of project management encourages the sharing of information and formal or informal mentoring between project managers of different experience levels. In part for this reason, a proliferation of knowledge on successful approaches to passing the PMP exam has emerged as part of the tribal lore of many project management offices or project management networking groups. PMP candidates should be aware of differences between the Third and Fourth Editions of the PMBOK. This manual will highlight some of the significant differences in content. PMP Candidates will get a more thorough explanation from Appendix A in the Fourth Edition, appropriately titled Fourth Edition Changes (see pages 349-357).

The PMP exam consists of 200 multiple-choice questions comprising four possible answers per question. Included within the question set are 25 pretest questions. These are questions that do not count towards the final score, but that PMI has included to evaluate their potential inclusion (as scored questions) in future exam question sets. Pretest questions are not explicitly identified, so you must ensure that you answer all questions in the exam.

To pass, you must answer 106 questions correctly, out of 175 scored questions (a pass rate of 61%). Questions can cover any of the nine major Knowledge Areas comprising the 44 constituent Project Management Processes defined and described in the PMBOK.

The PMP will test your knowledge of these under one of the six following project domains:

1. Initiating the Project [11% of scored questions]
- i. Conduct Project Selection Methods
- ii. Define Scope
- iii. Document Project Risks, Assumptions, and Constraints
- iv. Identify and Perform Stakeholder Analysis
- v. Develop Project Charter
- vi. Obtain Project Charter Approval

2. Planning the Project [23%]
- i. Define and Record Requirements, Assumptions, and Constraints
- ii. Identify Project Team and Define Roles and Responsibilities
- iii. Create the WBS
- iv. Develop Change Management Plan
- v. Identify Risks and Define Risk Strategies
- vi. Obtain Plan Approval
- vii. Conduct Kick-off Meeting

3. Executing the Project [27%]
- i. Execute Tasks Defined in Project Plan
- ii. Ensure Common Understanding and Set Expectations
- iii. Implement the Procurement of Project Resources
- iv. Manage Resource Allocation
- v. Implement Quality Management Plan
- vi. Implement Approved Changes
- vii. Implement Approved Actions and Workarounds
- viii. Improve Team Performance

4. Monitoring and Controlling the Project [21%]
- i. Measure Project Performance
- ii. Verify and Manage Changes to the Project
- iii. Ensure Project Deliverables Conform to Quality Standards
- iv. Monitor all Risks

5. Closing the Project [9%]
- i. Obtain Final Acceptance for the Project
- ii. Obtain Financial, Legal, and Administrative Closure
- iii. Release Project Resources
- iv. Identify, Document, and Communicate Lessons Learned
- v. Create and Distribute Final Project Report
- vi. Archive and Retain Project Records
- vii. Measure Customer Satisfaction

6. Professional and Social Responsibility [9%]
- i. Ensure Individual Integrity
- ii. Contribute to the Project Management Knowledge Base
- iii. Enhance Personal Professional Competence
- iv. Promote Interaction among Stakeholders

Note that the sixth domain (Professional and Social Responsibility) is not covered by the PMBOK, but is based on the PMI's PMP Code of Professional Conduct. You will need to understand the scope and content of the code in addition to the content contained in the PMBOK.

The exam is 4 hours in duration and there are no breaks. (You may take a break at any time during the exam, but the clock does not stop). All candidates are given a 15-minute tutorial prior to the start of the exam to familiarize themselves with the computer-based test system.

The PMP exam is a psychometric test that is based on the PMP Examination Specification. It is not necessary to read the specification in order to take the exam, though it does provide insight into the design of the exam. It has been designed so that even experts are unable to answer (correctly) all of the questions on the exam. Remember that the goal is to answer 106 questions correctly. The PMP is not a graded qualification. There is no PMP with Distinction or Grade II PMP; you either pass or fail. You can answer 69 scored questions incorrectly and still pass the exam; that's a 39% contingency against failure. There are no trick questions on the exam, but you will need to read each one **very carefully**. When taking the exam, if you are unsure of which answer to select, ask yourself the question: "What is the real point of this question? What are they really asking here?"

Questions will test your knowledge and understanding by asking you to identify what actions to take under various situations. For example, you may be presented with a scenario and asked, "What is the FIRST thing you should do…" or "What is the NEXT thing you should do…" or "What is the BEST thing for you to do…." Other questions will describe a scenario and then ask you to identify exceptions in a list (e.g. "All of the following are tools and techniques used during Scope Verification EXCEPT…").

When you submit your application for the PMP exam, you will have to pay an exam fee. You do not have to be a member of PMI to take the exam, but PMI members receive a discount and other member benefits. For non-PMI members, the exam fee is currently $555; for PMI members the exam fee is $405.

Tips

There are many courses available (classroom-led as well as online, or virtual) from a variety of vendors that can help you prepare for the exam. However, it is not necessary to take such classes to pass the exam. Additionally, there are text books that cover the PMBOK content more extensively and in greater depth than this Exam Manual. However, many credentialed PMP holders have passed the exam simply by reading the PMBOK in conjunction with practice exam questions. Preferred styles of learning and exam preparation vary from individual to individual. You need to determine what style suits your learning needs best and then identify the learning resources to meet those needs. If you need help, PMI provides guidance on a variety of learning resources, including a list of PMI Registered Education Providers (R.E.P's). Start with this Exam Manual and use it as the basis for creating your own learning program that best fits your own personal study needs. How long it takes to prepare for the exam will vary from individual to individual. Some candidates have prepared for the exam by cramming in 10 days (or less), while others have taken three months studying topics in greater detail than is actually required by the exam. This variance shows the differences in individual learning preferences and does not necessarily reflect the difficulty or ease with which the PMBOK content can be mastered. Candidates that can successfully pass the examination cramming over a 2 to 4 week period are rare exceptions. Candidates should expect to spend close to 100 to 200 hours studying for the exam on their own if they elect to prepare for it without using a structured learning class.

The objective of the PMP exam is to test your knowledge of the commonly accepted project management body of knowledge (as presented by the PMBOK). You will therefore need to read the PMBOK from cover to cover at least once before taking the exam. Specific portions of the PMBOK demand special attention for test takers. Critical sections of the PMBOK are noted within this manual, and briefly, these sections consist of Table 3-1 (Mapping of the Project Management Groups and the Knowledge Areas) and all critical project management formulas. Without variance, successful candidates will need to commit these facts to memory in order to successfully pass the exam. Though some commonly used approaches for comprehending and remembering these facts are detailed within this manual, learning preferences will vary according to the individual.

Most PMP candidates agree that the best form of preparation are practice exam questions. They will familiarize you with the format and style of PMP exam questions and are a good way to help you identify those exam topics requiring further study prior to taking the exam. You should use this Exam manual in conjunction with the practice test questions available from PrepLogic to prepare for the exam.

Resources

PMI Certification Program
Free Question of the Day
PrepLogic Practice Exams

PMBOK Overview

Information is presented in the PMBOK according to a logical scheme. The scheme presents the 42 Project Management Processes (or activities) within one of five Project Management Process Groups (which are sometimes referred to as project phases, though this is not strictly correct).
These five process groups are:

- **Initiating** – comprising 2 processes
- **Planning** – 20 processes
- **Executing** – 8 processes
- **Monitoring & Controlling** – 10 processes
- **Closing** – 2 processes

The scheme also presents the 42 processes as parts of one of the nine Knowledge Areas to which they belong. These are:

- **Project Integration Management** – comprising 6 processes
- **Project Scope Management** – 5 processes
- **Project Time Management** – 6 processes
- **Project Cost Management** – 3 processes
- **Project Quality Management** – 3 processes
- **Project HR Management** – 4 process groups
- **Project Communications Management** – 5 processes
- **Project Risk Management** – 6 processes
- **Project Procurement Management** – 4 processes

The matrix relationship between Project Management Processes, Project Management Process Groups and Knowledge Areas is summarized in Table 3-1 of the PMBOK (see page 43, Project Management Process Groups and Knowledge Areas Mapping). This is a map to the total project body of knowledge on which you will be tested by the PMP exam. Note that the majority of project processes are performed during Planning (20 processes) and that as many processes are focused on Controlling a project (9 processes) as in Executing a project (8 processes), but that both Project Time Management and Project Risk Management processes are weighted towards Planning processes over Controlling (5:1).

Make a copy of this table. Use it as a guide to the content of each Process Group and Knowledge Area and the ways in which these interact. Familiarize yourself thoroughly with its content.

It is recommended that you read the PMBOK twice. The first time, you should read the PMBOK in strict chapter sequence as the book is written (i.e. in linear sequence from cover to cover). This will enable you to understand and familiarize yourself with the processes as they relate to the Knowledge Area to which they belong. This is represented by the vertical axis in Table 3-1. For example, under Project Quality Management, read sections 8.1, then 8.2, then 8.3. This is the sequence in which this Exam Manual covers the PMBOK content. Note that this Exam Manual also follows the same chapter and sub-section numbering as PMBOK for quick and easy reference. The second time (as a prep for the exam), you should read the PMBOK in Process Group sequence (i.e. in the order in which processes are performed within the Process Group, represented by the horizontal axis in Table 3-1). For example, under Monitoring & Controlling read and review sections 4.4 and 4.5, followed by 5.4 and 5.5, and then 6.6, 7.3, etc.

The project management processes described by the PMBOK are presented as discrete components with well-defined interfaces. Interactions within and between processes are also described. However, note that the PMBOK acknowledges the limitations in mapping these interactions and that in practice these processes may overlap and interact in ways that cannot be completely documented in the PMBOK.

There are some stylistic and structural features that you will become aware of as you read the PMBOK. These are deliberately designed to articulate the fact that the practice of project management is an iterative and integrative process. As the project progresses through initiation, planning, execution, etc., project information is progressively elaborated via the repetition of the processes described. As you read the PMBOK, note that each process occurs at least once in every project and may occur in one or more project phases if the project is sub-divided into phases.

The dynamic of each process is presented using a standard I-TT-O diagram: Inputs-Tools & Techniques-Outputs. You should review these carefully and note how the Output(s) from one process provide the Input(s) to another. This Exam Manual references the relevant I-TT-O diagram (as found in PMBOK) at the beginning of each Process description. Inputs are transformed into Outputs via the application of various Tools & Techniques relevant to the process described. Use the I-TT-O diagrams when revising topics to ensure that you understand how the process works and what the purpose (outcome) of the process is. When familiarizing yourself with PMBOK terminology, note how the Glossary classifies these components according to their primary characteristic as a Process, Technique, Tool, or Output/Input.

There are a small number of Formulas, Definitions or Important Facts that you will need to know in order to take the exam. Memorizing these will help you to identify the correct answer during the exam and are referenced in bold type within the body of this Exam Manual. For example, Formula: n(n-1)/2 where n = number of stakeholders. At a minimum, you should memorize these in addition to any other information that you feel you may need to recall during the exam.

Table of Contents

1. Introduction: The Project Management Framework

The PMP exam questions focus primarily on the knowledge covered by the nine Project Management Knowledge areas (Chapters 3 thru 12). However, there is an implicit assumption in the exam of general project management concepts that provides the foundation for understanding the purpose, application, and relationships between the processes described in the nine knowledge areas. These general concepts are covered in Chapter 1 of the PMBOK (pages 3-14). You should familiarize yourself with the following concepts:

- A project is "a temporary endeavor undertaken to create a unique product, service, or result," (page 5) in which *temporary* means a finite (fixed) duration and *unique* denotes a set of circumstances (the project) that, although resembling similar circumstances in many aspects, have not been previously encountered before.
- A project proceeds through the process of *progressive elaboration*. That is, progressive elaboration "involves continuously improving and detailing a [project] plan " (page 7) as more and more detail is added to the plan and occurs in many project management processes. Progressive elaboration enables better control and understanding of the project by the Project Management Team.
- A project is distinguished from the operational activities of a company by the fact that it is both temporary and unique. Operational activities are ongoing and repetitive (pages 22-23).
- A project is a vehicle that companies use to achieve their strategic goals (page 10-11).
- Project management is the "application of knowledge, skills, tools and techniques to project activities to meet project requirements." (page 6) It sounds obvious, but this is an important distinction: project management is applied to projects, not to operational activities. This means meeting project requirements, not operational requirements. Some operational activities can, however, be managed using project management approaches. This is known as *management by project*.
- To manage a project requires that a project manager balances the competing project constraints of scope, quality, schedule, budget, resources, and risk. Changes applied to one constraint may require changes or adjustments to one or more of the other project constraints.
- The effective practice of project management requires a combination of general management, project management (technical) and interpersonal (soft) skills (page 13).
- Projects co-exist with related projects through strategic intent. These inter-project relationships are created by companies using programs and portfolios (pages 7-10).
- A program is "a group of related projects that are managed in a coordinated way to obtain benefits and control not available from managing them individually." (page 9)
- A portfolio is "a collection of projects or programs and other work that are grouped together to facilitate effective management of that work to meet strategic business objectives." (page 8)
- A Project Management Office (PMO) provides organizational focus for the management of projects within a performing organization using program and/or portfolio structures to manage project relationships. A PMO provides project management governance through standards and procedures, and ensures alignment of projects with strategic business goals (page 11).

2. Project Life Cycle and Organization

Organizational factors influence how projects are performed and the outcomes of projects. Although projects are temporary and unique, they are defined by a common life cycle whose general characteristics can be discerned in all projects. These life cycle characteristics are described in Chapter 2 (pages 15-33). You should familiarize yourself with the following life cycle concepts:

- A *project* life cycle defines the phases through which the project progresses from beginning to end. Different application areas have different life cycle models. Many of the functional characteristics of these models are similar, such as the use of project gates to pass from one phase to the next (pages 15-17).
- A *product* life cycle describes the phases through which a product progresses from inception (idea) to end-of-life (obsolescence) (pages 18).
- *Stakeholders* are many and various. Their wants, needs, and desires shape project requirements and influence project performance. Their expectations must be actively managed throughout the project by the project manger (pages 23-27).
- The culture and structure of a performing organization influences (constrains) the ways in which work on a project can be performed (see Table 2-1 Organizational Influences on Projects, page 28). Organizations can be structured in various ways to meet both the ongoing operational and project needs of the performing organization (pages 28-32).

3. Project Management Processes

Project management comprises a set of processes that are commonly used to perform project activities. These processes can be grouped by the general function that they perform within the project life cycle. These groups are <u>not</u> the same as project phases, although their nomenclature can often mislead one into making that assumption. Make sure that you understand the distinction between project processes and project phases. The general characteristics of these processes and their representation within the PMBOK are described in Chapter 3 (pages 37-65). You should familiarize yourself with the following:

- The PMBOK Guide is a *standard* that describes the application of project management processes to project activities that are considered "good practice on most projects most of the time" (page 37). *Good practice*, in this context, helps to "enhance the chance of success" (page 38) of project work performed.
- The PMBOK Guide is not an exhaustive standard. It is a generally applicable standard. Processes may overlap and interact in ways not described in PMBOK (page 38). Therefore, it is the responsibility of the project manager and the project management team to identify and determine which specific processes to apply to their specific project.
- There are five process groups to which all project management processes can be mapped. These are: Initiating, Planning, Executing, Monitoring & Control, and Closing (page 44-65).

4. Project Integration Management

Chapter 4 of the PMBOK – Project Integration Management may well be the most significant chapter in the Fourth Edition of the PMBOK. Much of the core tasks and roles of what is commonly thought of as project management is covered in this process group. Key PM functions like (1) Develop Project Charter, (2) Develop Project Management Plan, (3) Direct and Manage Project Execution, (4) Monitor and Control Project Work, (4) Perform Integrated Change Control, and (5) Close Project or Phase.

The PMBOK describes Project Integration Management as the "processes required to ensure that the various elements of the project are properly coordinated. It involves making trade-offs among competing objectives and alternatives to meet or exceed stakeholder needs and expectations." More so than any other Process Group, Project Integration Management depends on sound judgment and experience. Successful PMP candidates will need an arsenal of experience to draw from in answering questions related to Project Integration Management, but equally as important is a solid understanding of PMI's view of critical processes, such as creating a project charter or managing change control on a project.
The definition of a project charter or the practices for change control for Company X or Company Y will not appear on the PMP exam, but PMI's interpretation of those processes will appear.

Project Integration Management (Chapter 4, pages 71-101) comprises five project management processes:

4.1 Develop Project Charter [*Planning*] – developing the project charter that formally authorizes a project or a project phase (pages 73-77);

4.2 Develop Project Management Plan [*Planning*] – documenting the actions necessary to create the project management plan and any subsidiary plans that form part of the overall project plan (pages 78-81);

4.3 Direct and Manage Project Execution [*Execution*] – executing work defined in the project management plan to achieve the project's requirements as defined in the project scope statement (pages 83-87);

4.4 Monitor and Control Project Work [*Controlling*] – monitoring and controlling the processes used to initiate, plan, execute, and close a project to meet the performance objectives defined in the project management plan (pages 89-92);

4.5 Perform Integrated Change Control [*Controlling*] – reviewing, approving and controlling all change requests to project deliverables and organizational process assets (pages 93-98);

4.6 Close Project [*Closing*] – completing and finalizing all activities across the project management process groups to ensure that the project or project phase is formally closed out (pages 99-101).

The primary characteristic of a project is that it is an integrative endeavor. All of the elements of a project must be successfully integrated for the project to succeed. Integration is necessary in order to combine, coordinate and control project elements as they interact with one another in order to deliver project results. But no project proceeds to completion without change. Integration management enables changes to be made to the project by actively managing the trade-off between competing objectives and alternative options without impairing achievement of the project goals. Integration is necessary to ensure that customer and other stakeholder requirements are met and satisfied so as to manage stakeholder expectations.

As you review the I-TT-O diagrams, note how many times the execution of project processes result in adjustments or changes (Corrective actions or Updates) to the resultant artifacts of those processes; note how many times those processes are repeated throughout the nine Knowledge Areas. This does not happen by accident. It demonstrates the extent to which the many project processes are inter-related and connected. Without conscious and controlled integration of these processes the project would fail. As if this were not enough for the project to succeed, integration also needs to take place at external interfaces to the project environment, such as when project deliverables are incorporated into the performing organization's or customer's ongoing business operations. Again, integration management is the Art of Project Management.

4.1 Develop Project Charter

[Page 73, Figure 4-3. *Develop Project Charter: Input, Tools & Techniques, and Output*]

The Project Charter is a key concept or process because it initiates the start of a project. Project managers should understand that the Project Charter is independent of deliverables, such as needs assessments or feasibility studies that might be required before a project is approved. PMP candidates should also be aware that PMI's definition of a project charter may differ from what many project managers consider to be or not to be a project charter.

Many projects run into trouble in later phases for want of a charter. Why is a charter so important? A charter ensures that the project will address needs and requirements in a way that is consistent with ongoing business operations and is aligned with the performing organization's strategic plans.

A charter is important because it:

- formally authorizes the existence of the project;
- signifies that the project has an active sponsor (or initiator) who is responsible for issuing the charter;
- formally identifies the project manager to the performing organization; and
- gives the project manager formal authority to apply organizational resources to project activities.

The sponsor is usually someone external to the project organization that has the authority to fund the project. The extent of the resources that the project manager can apply is usually limited by the initial requirements to define the scope of the project.

Projects are usually initiated in response to changes within the business environment of the performing organization. These changes manifest themselves as problems, opportunities, or business requirements.

Changes in the business environment may be triggered by:

- **Technology** – innovations in technology (e.g. the Internet) often provide a business *opportunity* for the performing organization by creating a new market or new delivery platform for its products and services. It may also present a *threat* by providing an opportunity for other organizations to compete in its existing markets. As part of the cycle of continuous technical enhancement, changes to mature technologies may also require the performing organization to update or renew existing hardware or software simply so that it can *continue to do business*.
- **Regulatory & Compliance** – the performing organization may need to change or update the ways in which it does business in order to comply with new regulatory or other statutory requirements affecting its business environment. For example, by amending existing or introducing new administrative and financial systems to comply with the requirements of the Sarbanes-Oxley Act. Compliance is usually represented by *legal* requirements but may also be driven by *technical* (for example, a system needs to be compliant with a specific technical standard to maintain quality of service) or *market* needs (for example, the conversion of financial systems from a national currency to the Euro currency).
- **Customer** – to *remain competitive* and to continue to service the needs and wants of its existing customer base, the performing organization must respond to customer requests, fix any service problems and introduce new features. If the right responses to these requests are made, then this may also provide an opportunity to *grow the business* by winning new customers.
- **Market** – changes in the market(s) in which the performing organization competes may present a combination of *threat*, *opportunity* and *compliance*. For example, increases in the price of gasoline may require a mature automobile manufacturer to develop more fuel-efficient or hybrid vehicles to comply with government–mandated fuel efficiency standards, to address potential threats from competitors developing similar vehicles and to create a new niche market to diversify and differentiate its existing product line.
- **Social** – both government agencies and not-for-profit organizations respond primarily to a variety of social needs in initiating projects. For example, providing infrastructure that meets *community needs* or responds to problems in the areas of health, education, housing, nutrition, the environment, etc.

Whatever its source, before chartering a project the management of the performing organization must evaluate the impact of the change on its business environment and then formulate a response appropriate to that change. If there is more than one possible response, the performing organization will need to screen the alternatives in order to select the best response (the project to be chartered). Screening criteria fall into one of two categories:

- **Benefits measurement** – which uses scoring models, comparative approaches, benefit contribution, and economic models to compare project alternatives; and
- **Mathematical** – which uses various mathematical formulae (linear, non-linear, dynamic, integer, multi-objective programming algorithms, etc.) to evaluate alternative projects.

Benefits measurements use scoring methods and economic analysis to focus on the cost and revenue aspects (and hence, profitability) of the proposed responses. They answer the question: *"What will this project return on our investment?"* The charter documents any business needs identified during this process as well as the needs, wants and expectations (requirements) of the proposed project's stakeholders. The results of benefits measurements also provide insight into how the project will be funded (see page 178), as one of the functions of the charter is to authorize initial funding of the project.

Tools typically used for assessing the relative financial performance of alternative responses include Internal Rate of Return (IRR), Net Present Value (NPV), Benefit Cost Ratio (BCR), etc., and are discussed in more detail under Project Cost Management.

In terms of the selection process, note the similarities (and differences) to the screening process that occurs under Plan Procurements (see page 316) using a list of Evaluation Criteria to identify the most appropriate contracting entity from a number of competing candidates. But don't confuse them!

Key inputs to develop the charter include the Project Statement of Work, Enterprise Environmental Factors and Organizational Process Assets.

Definition: Statement of Work (or SOW) – A narrative description of products, services, or results to be supplied by the project.

The SOW is important because it:

- identifies the business needs that will be met by the project;
- documents the *product requirements* and characteristics of the product or service that the project will deliver; and
- demonstrates how the product or service supports the performing organization's strategic plan.

The SOW is also an input to the Develop Project Charter process (page 74). Note that the SOW is focused on *product scope*, not on *project scope*. Do not confuse the two. You will encounter another kind of statement of work under Project Procurement Management. How does the SOW differ from the *Contract* statement of work (see page 324)? One way to distinguish between the two is the Project Statement of Work is the description of the work performed in the project, while the Contract Statement of Work is the description of the work being purchased. Test takers should be cognizant that this word confusion presents an opportunity for PMI to prepare a difficult question on the PMP exam. Project managers with a strong understanding of the subject matter should understand the distinction between the two.

Definition: Enterprise Environmental Factors – Any or all external environmental factors and internal organizational factors that surround or influence the project's success.

PMBOK lists a number of these factors, ranging from company culture to project management information systems (page 83). Note that Stakeholder risk tolerance is included in this list. Why is that? A project manager must be cognizant of each stakeholder's risk tolerance because stakeholder actions (or aversion to taking action) will strongly influence the ultimate outcome of the project.

Definition: Organizational Process Assets – Any or all process-related assets, from any or all of the organizations involved in the project that are or can be used to influence the project's success.

These assets include such artifacts as formal and informal plans, policies, procedures, guidelines, standards, templates, etc., covering all aspects of project planning, execution, control and closure. Also included in these are *Lessons learned* and *Historical information*, maintained in the performing organization's knowledge base.

When selecting a project, having the capability to succeed is a key criterion. In many respects, organizational process assets represent the performing organization's capability. This is why, for example, you must always review and approve all change requests affecting organizational process assets because they directly influence project performance. The extent to which organization process assets influence project outcomes can be judged by the number of times they occur as Inputs (25) and as Outputs (12).

As you review the I-TT-O diagrams, make a note of where they occur and how they affect the process in which they occur. Organizational process assets are not just paper-work or bureaucratic red tape: they can make or break a project.

One of the key tools used to create the charter is the Project Management Information System [page 80]. A PMIS is defined by PMBOK as a standardized set of *automated* tools and techniques that are used by the project team to gather, integrate and disseminate the outputs of project management processes. It is an important tool for integrating project management processes and is used in all of the major process areas to:

- Create the Project Management Plan (page 78);
- Direct and Manage Project Execution (page 83);
- Monitor and Control the project (page 89);
- Perform Integrated Change Control (page 93); and
- Close the project (page 101).

Your organization may not have such a system (formal or informal) or not one that you would readily recognize as a PMIS. This is yet another instance where PMP candidates should assume the existence of a PMIS even if your experience of such a system is limited.

Another important tool that is used to create the charter is Expert Judgment, where expertise in a specific knowledge domain, application area or specialist discipline is applied to a project process, problem or issue. This is provided by a group or an individual with the requisite knowledge, skills and experience to render an informed evaluation and assessment (judgment). Expert judgment represents applied capability. Note that a judgment is based on experience and can therefore only be rendered by a *human agent*, not by a machine-based system (no matter how sophisticated or adept its computational capability might be). Like the PMIS, Expert Judgment is used across many process areas to:

- Develop the Project Charter (page 73);
- Develop the Project Management Plan (page 78);
- Monitor and Control the project (page 89);
- Perform Integrated Change Control (page 93); and
- Close the project (page 101).

In fact, Expert Judgment is used as a tool in nine more processes. Can you identify what they are? What is the purpose of using Expert Judgment in these processes? Under Project Risk Management, you will encounter a related tool that has the function to mediate bias among differing expert views and achieve a consensus among those views.

4.2 Develop Project Management Plan

[Page 78, Figure 4-4. *Develop Project Management Plan: Inputs, Tools & Techniques, and Output*]

What is referred to as the "project plan" is another term that in the past caused some confusion. The term "project plan" had become commonly used to describe a GANTT chart, or what PMI refers to as a "project schedule." PMI responded by changing the title from the "Develop Project Plan" process to the "Develop Project Management Plan" process. As the name suggests, the resulting plan output (1) provides structure and a baseline; (2) facilitates communication amongst groups; and (3) serves as a master plan, or book of record, for all of the project's subsidiary plans. By keeping this in mind, PMP candidates will be on their way to a better comprehension of this key process area and, ultimately, success on the exam.

Project plans vary in their content depending on the needs of the project. Each subsidiary plan, covering such aspects as Risk, Cost, Schedule, Quality, etc., is detailed to the extent that it is required by the project. Successful PMP candidates will need to know all possible subsidiary plans and how they are related to other process areas. By understanding this concept, the relationship of the Integration Management Process Group may become a little clearer.

The Project Management Plan defines how the project will be executed, monitored and controlled, and closed. Whatever the scope and complexity of the project, the process used to create the plan will include any of the actions necessary to define, integrate and coordinate all subsidiary plans into an overall Project Management Plan. All subsequent changes and updates to this plan are managed through the Integrated Change Control Process (see page 93).

The project plan is maintained using the Configuration Management System, a sub-system within the PMIS. This sub-system facilitates the:

- Submission of proposed changes;
- Tracking, review and approval of proposed changes;
- Definition of relevant approval levels authorizing the proposed changes; and
- Validation of approved changes.

Using formal documented procedures, the Configuration Management System provides for technical and administrative direction and surveillance. This is used to identify and record the functional and physical characteristics of the product of the project, and thus enable and support the audit of the product to verify *conformance to requirements* (a key Quality parameter, see page 95).

The Change Control System is a sub-system of the Configuration Management System. It is a collection of formal documented procedures that define how deliverables and other project artifacts, such as documentation, are controlled, changed and approved.

Note the ways in which the PMIS, the Configuration Management System and the Change Control System are used to integrate project elements.

Some project organizations may not have a formal PMIS or a Change Control System. They may have variations of the version outlined by PMI. For a project manager working in one of these environments it is important to remember that it will always be PMI's interpretation that the BEST possible solution to this absence will be to create or procure the PMIS, Configuration Management System or Change Control System.

4.3 Direct and Manage Project Execution

[Page 84, Figure 4-6. *Direct and Manage Project Execution: Inputs, Tools & Techniques, and Output*]

Project execution is primarily concerned with ensuring that the work defined in the project scope statement is accomplished as described in the plan. The project manager and the project team are responsible for directing the performance of the planned project activities. As part of the execution process, Work Performance Information about how activities are being performed and the status of work accomplished (in the form of outputs and deliverables) is collected, evaluated and reported. This includes both tangible and intangible project deliverables (for example, delivering a training course is an intangible deliverable of the project). What kinds of information and data are collected when creating Work Performance Information outputs? (See page 95.)

The project team (including the project manager) must first plan the work, and then they must work the plan. All project work must be performed in conformance with the approved plan.

The evaluation and analysis of actual work performed versus the planned work may indicate the need for any of the following:

Approved corrective actions – required to bring anticipated project performance back into conformance with the project plan (affecting Scope, Schedule, Cost, Quality and Risk);

Approved preventive actions – required to reduce the probability of potential negative consequence (affecting Quality, Risk and Human Resource Management); or

Approved defect repair requests – required to correct product defects found by the quality process (affecting Quality).

Corrective actions mainly occur as Outputs (13 times) though sometimes they appear as Inputs (2 times). Preventive actions occur six times as Outputs and three times as Inputs. In which processes do these occur?

All approved change requests must be scheduled for implementation by the project management team.

4.4 Monitor and Control Project Work

[Page 89, Figure 4-8. *Monitor and Control Project Work: Inputs, Tools & Techniques, and Output*]

Monitoring is performed proactively and continuously throughout the project. It involves the collection, evaluation and dissemination of performance information. This includes measurement and examination of performance trends over time to determine if project performance is improving or deteriorating (see page 179). If the trend is deteriorating, the analysis should identify those areas of project execution that require attention by the project management team to bring the project back into conformance with the plan.

Root cause analysis is often performed to identify the causes of variance and the appropriate corrective actions required to put the project back on track. Root cause analysis is used in both the Schedule Control and Quality Assurance processes.

Timely and accurate communication of performance information to stakeholders is an important aspect of successful project monitoring and control. Project status reporting should cover both current actual performance (versus planned future performance) and updated forecast performance, particularly cost and schedule information resulting from evaluation of the performance data. This earned value management methodology (referred to as Earned Value Technique in PMBOK) is discussed in more detail under the Performance Measurement Analysis (pages 172-174).

Control of the project is primarily accomplished through the use of corrective or preventive actions (see above) and is performed in conjunction with monitoring.

4.6 Integrated Change Control

[Page 95, Figure 4-10. *Monitor and Control Project Work: Inputs, Tools & Techniques, and Output*]

Changes occur in all projects, and Integrated Change Control occurs throughout the project (from inception to completion). Because projects must be managed to plan (including any and all subsidiary plans), and projects rarely run to plan, all change requests must be reviewed, approved (or rejected) and then implemented.

Once changes are approved, plans must be updated to reflect all approved changes. The update to the baseline plan results in a *revised baseline*, which is a critical concept for this section and for PMI in general. Think for a moment about the advantages of base-lining projects. The value of cost variances, performance reporting and future duration estimates would all be diminished without base-lining projects. Keep this concept in mind as you review the Integrated Change Control process group. Other than maintaining the integrity of project baselines, Integrated Change Control is necessary in order to:

- identify that a change has occurred or needs to occur;
- ensure that only approved changes are implemented by influencing those elements that may circumvent integrated change control; and
- coordinate all approved changes across the project as they affect interdependent, interconnected or related components of the project.

According to PMBOK (page 94), the Configuration Management System provides the performing organization with:

- an evolutionary method to consistently identify and request changes, and to assess the value and effectiveness of the requested changes;
- opportunities to continuously validate and improve project performance by evaluating the impact of each change requested; and
- a mechanism for the project management team to consistently communicate all approved changes to stakeholders.

Configuration management is comprised of:

- **Configuration Identification** – provides the basis by which product configuration is defined and verified, products and documents are labeled (i.e. version, series, etc.), changes are managed and accountability is identified and maintained;
- **Configuration Status Accounting** – assures the capture, storage and retrieval of configuration management information required to effectively manage both the product and information about the product; and
- **Configuration Verification and Auditing** – establishes that the performance and functional requirements defined in the configuration documentation have actually been met as specified.

All changes must be formally approved (or rejected). This determination is usually performed within the project management team or by an external representative of the project's initiator, sponsor or customer who has the authority to make such a decision. Many projects have a formal Change Control Board that is mandated for this purpose with the authority to review and approve the project's change requests. In some organizations, if coordination of the requested changes with ongoing business functions or other projects is required, then changes may also need to be reviewed and approved hierarchically. For example, a Project Board may need to authorize changes that the Change Control Board recommends.

Note that in cases where project work is performed under contract, all changes must be approved by the customer (see pages 338 and 431).

4.6 Close Project

[Page 100, Figure 4-12. *Close Project: Inputs, Tools & Techniques, and Output*]

The Close Project process is the final process added to the Integration Management Process Group. Since PMI has added it to the group, there clearly is value in knowing and understanding the process. For PMI, important concepts can lurk in the mundane topic of project closure. Keeping in mind the value that PMI places on creating and maintaining a historical record of project information that can be used for future projects, it should be clear why the process can be so valuable for good management of projects.

The Close Project process ensures that those parts of the project scope and associated activities applicable to a given project phase are closed out in good order. The process is also used to close out the overall project when it is finally completed. The procedures required to establish the necessary interactions needed to achieve closure are developed to meet the needs of the project.

The Close Project process establishes procedures to:

- coordinate activities needed to verify and document the project deliverables;
- coordinate and interact to formalize acceptance of those deliverables by the customer or sponsor; and
- investigate and document the reasons for actions taken if a project is terminated before completion.

Activities performed during the *Administrative closure procedure* include the collection and archiving of project records, analysis of project success or failure, gathering lessons learned and the archiving of project information for future use by the performing organization. Note that the Configuration Management System is used during closure to develop the index and establish the location of project documents. Organizational process assets are updated as a result of closure. This includes documenting the project's lessons learned, as well as formal acceptance of the product(s) of the project by the sponsor or customer.

The *Contract closure procedure* ensures that activities required to settle and close any of the project's contracts are developed and executed during contract closure. This involves both product verification (that all the work specified under contract was completed correctly and satisfactorily) and administrative closure (ensuring that contract records are updated to reflect the final results of the work performed, and the archiving of that information for future use).

Early termination of a contract is a special case of contract closure. Note that the agreed contract closure procedure should always be followed. Early termination may occur due to:

- inability to deliver the project's product;
- a budget overrun; or
- lack of required resources.

Note that early termination is an input to the Close Contract process.

A project is a temporary and unique endeavor. It has many moving parts and is comprised of disparate processes that overlap and interact in ways that are beyond the scope of PMBOK to fully describe. The primary purpose of Project Integration Management is to ensure that, as far as possible, project processes combine and interact in predictable and controlled ways to keep project activities focused on delivering expected results. This is a very important topic to understand from the perspective of both actual project management practice and PMP exam preparation. Spend time studying it.

5. Project Scope Management

PMI modified Chapter 5, Project Scope Management, in its Fourth Edition. PMI opens this updated version with a Collect Requirements process which had formerly been reserved for the Scope Planning process. Much of what had been reserved for an independent Scope Planning process is now represented in 4.2 Develop Project Management Plan, 5.1 Collect Requirements, and 5.2 Scope Definition. PMI's decision to stress the requirements collection process reflects general trends in many industries towards more formal standards for the collection and eventual testing of project or product requirements. Standards and organizations similar to PMI now exist for professional business analysts, working typically in software development/delivery functions.

As in the Third Edition PMBOK, the role of the Work Breakdown Structure (WBS) is given heavy emphasis. In past PMP exams, both the Scope Management Plan and the WBS were critical areas to understand to be successful. While confusion has always existed around the relationship between processes and outputs in this chapter, removing the Scope Management Plan process gives the entire chapter a clearer message – requirements are used to develop a well-defined project scope and ultimately a Work Breakdown Structure. This Work Breakdown Structure will serve as a critical input to future project management activities. Since the scope is the primary input for the WBS, it should be baselined and subject to agreed upon change control procedures.

Project Scope Management (Chapter 5, pages 103-128) comprises five project management processes:

5.1 Collect Requirements [*Planning*] – documenting and defining stakeholders needs to meet the project objectives (pages 107-10);

5.2 Define Scope [*Planning*] – developing a detailed Project Scope Statement as the basis for future project decisions (pages 112 - 115);

5.3 Create WBS [*Planning*] – sub-dividing the major project deliverables and project work into smaller, more manageable components (pages 116-121);

5.4 Verify Scope [*Controlling*] – formalizing acceptance of the completed project deliverables (pages 123-125); and

5.5 Control Scope [*Controlling*] – controlling changes to the project scope (pages 125-128)

The wants, needs and expectations of stakeholders exert tremendous influence over the scope and outcome of the project. Project Scope Management is primarily concerned with managing those influences by defining and controlling what is and is not included in the project. Note that three of the five project management scope processes are Planning processes. Careful and comprehensive planning is required to successfully manage the project's scope. The boundaries of the project must be clearly understood, communicated and managed to ensure that the project does not undertake any extraneous or unauthorized work that does not contribute to and result in agreed project outcomes.

Definition: Project Scope Management – includes the processes required to ensure that the project includes *all* the work required, and *only* the work required, to complete the project successfully.

Each of the Product Scope Management processes occurs at least once in every project and occurs in one or more phases in multi-phase projects. The Project Management Plan documents the processes used by the project to manage project scope. *Project scope* describes the work that needs to be accomplished in order to deliver the product, service or other outcome, with the features and functions described in the product scope. The features and functions of the product or service to be delivered are documented in the SOW. Completion of the project scope is measured against the project management plan, Project Scope Statement and associated WBS and WBS dictionary. Completion of the product scope is measured against the product requirements. PMP candidates need to be clear on the difference between product and project scope. Questions on the PMP exam will focus primarily on project scope, but test takers should be cautious not to confuse the two.

5.1 Collect Requirements

[Page 105, Figure 5-2. *Scope Planning: Inputs, Tools & Techniques, and Output*]

One of the greatest, and often forgotten, reflections of project success is whether or not the requirements and expectations of project stakeholders were met. With astonishing regularity projects are delivered under clouds of controversy related to whether all expected functions and features have been delivered. For internal delivery organizations or lines of business, this failure can lead to new, expedited projects to cover gaps in expectations. For vendors, the failure to meet expectations can lead to lawsuits or a delay in the receipt of payment for services rendered. More often than not, the core of the problem can be attributed to poor practices during the collection of requirements.

Limiting the risk of rework, missed expectations, product defects and 'second phase' projects begins with the collection of requirements. PMI offers that "the project's success is directly influenced by the care taken in capturing and managing the project and product requirements … collecting requirements is defining and managing customer expectations." Opening a successful Requirements Collection process will require a careful review of the project's charter and a detailed list of all stakeholders since ultimately the most critical step in successful requirements gathering is finding the right individuals to gather requirements from.

Using the inputs noted above, the project team can employ a variety of Tools and Techniques to collect requirements from stakeholders. These tools include one-on-one interviews, focus groups, facilitated workshops, group creativity techniques, group decision making techniques, questionnaires/surveys, observations and prototypes. All of these tools and techniques should be reviewed carefully. Exam candidates that are not already familiar with facilitated workshops types, like Joint Application Development sessions or Quality Function Deployment should perform some additional research on how these are performed. Additionally, group creativity techniques, like the Delphi Technique have traditionally been commonly used in past PMP exam versions. Prototyping should also be noted since it is progressively becoming more and more common in the solicitation and gathering of requirements in certain industries, like software.

Output from the Collect Requirements process include requirements documentation, a requirements management plan, and a requirements traceability matrix. Key foundational components for all of these outputs include but are not limited to:

1. Functional requirements for the product
2. Non-functional requirements (level of service, security standards, etc)
3. Business rules
4. Acceptance criteria for the delivered requirement

The notion of 'traceability' is a key concept to remember. Ultimately, requirements will need to be traced ***back to*** the original, stated business needs for the project and ***forward to*** the successful testing and demonstration of their delivery. While onerous at times to complete, a deliverable like a Requirements Traceability Matrix can be very effective in tracking requirements and the expectations of stakeholders.

5.2 Define Scope

[Page 112, Figure 5-4. *Scope Definition: Inputs, Tools & Techniques, and Output*]

The detailed Project Scope Statement is created through progressive elaboration as information is collected from stakeholders and analyzed by the project team. As we already know, progressive elaboration means that there will be a succession of iterations to the scope definition. This, by definition, implies that the original scope statement will change as the project progresses. As always, the project team will need to reference the Project Management Plan when determining how to manage updates to the Project Scope Statement as they occur.

Using the inputs like the Project Charter and Requirements Documentation, the project team can employ a variety of Tools and Techniques to define the project's scope. The identification and documentation of the proposed product's requirements is accomplished using a variety of *product analysis techniques*, such as value engineering, value analysis, systems analysis, systems engineering, etc. (page 114). In conjunction with this, the project team will also explore alternative ways in which the work to deliver the product (or service) might be performed. Facilitated Workshop techniques such as *brainstorming* or *lateral thinking* can be used to generate alternative scenarios. The savvy PMP candidate might notice that Facilitated Workshops techniques can be used during the Collect Requirements process as well. Why would a second set of facilitated workshops be needed after requirements have been collected? The answer reflects the subtle difference between the collection of requirements and the definition of a project's scope. Requirements collection may gather requirements that are ultimately not included in the delivery of the project. The Project Scope Statement will begin to introduce constraints associated with the project, like a predetermined budget. As discussion ensues around constraints, requirements may be omitted. Settling on a project scope statement will, therefore, require significant discussion and negotiation. Techniques, like a facilitated workshop with stakeholders, can help expedite decisions on the scope of the project.

The project manager and project team must document the wants, needs and expectations of the project's stakeholders and then select, prioritize and quantify these in order to arrive at a comprehensive and informed understanding of their requirements. This takes time and should not be hurried. Tacit or assumed stakeholder expectations can create serious problems later in the project if these are not explicitly identified and discussed during scope definition. Be very clear with stakeholders about what the project will and <u>will not</u> accomplish in meeting their expectations.

The Project Scope Statement is an important communications tool that provides all project participants with a shared and common understanding of the project's deliverables and the work that will be performed to create those deliverables. It is a key project management document that provides the project team with guidance on the work to be performed during project execution. When change requests are raised, it also helps the team answer the question, *"Will this change result in work that is within scope of the project?"* That is, will the new work contribute to the agreed scope of the project? There is a direct correlation between the level of detail to which the scope of the project is specified by the Project Scope Statement and how well the project management team is able to control the scope. More *clarity* makes for better decision making.

PMBOK (page 115) identifies six components of a Project Scope Statement. Note how each component is necessary to map out and manage the total scope of the project. These components comprise:

- **Product scope description** – detailing the project's product or service characteristics. These are *progressively elaborated* as more information is collected and analyzed;
- **Product acceptance criteria** –defining the process and criteria for formally accepting the product(s) of the project;
- **Project deliverables** – in the form of project outputs (product or service). Note that project artifacts, such as project plans, reports and other documentation, are also included under deliverables (the outputs from performing project work);
- **Project exclutions** – describing the elements that may restrict and restrain how the project is executed, such as a limited budget (*must be delivered for less than $10 million*) or imposed deadline (*must be completed by no later than December 31st, 1999*);
- **Project constraints** – identifying any project funding limits (e.g. total project spend not to exceed $10 million), imposed dates, schedule milestones and so forth that might influence what can and cannot be delivered with the project;
- **Project assumptions** – listing all of the assumptions underpinning the performance of the project. This also includes identifying their associated impact to project performance in the event that any of the assumptions is proved false or invalid (see Definition below);

Definition: Assumptions – Factors that, for planning purposes, are considered to be true, real or certain without the need for proof or demonstration. In the absence of validation or verification, assumptions always imply a degree of risk.

Assumptions are used widely in Scope Definition, Activity Definition (page 127), Sequencing (page133), Resource Estimating (page 141) and Duration Estimating (page 146), Schedule development (page 152), Cost estimating (page 168) and Risk Identification (page 282). Why are assumptions so important to the execution of project work? No matter where they are applied, all project assumptions must be examined by the project team for accuracy, consistency and completeness. Like risks, not all assumptions are equal in the magnitude or extent of their impact on project performance should they prove to be false. The project management team must therefore identify very carefully what these impacts are likely to be if any assumption is subsequently proved to be invalid.

Outputs from the Scope Definition process also include any updates to project documents, like the Requirements Traceability Matrix. While some of this may seem intuitive, questions regarding this output can be a little tricky, especially during test-taking conditions. What is important to remember is that during the Scope Definition process a large amount of new information will be uncovered which may require changes to subsidiary plans or documents. These changes should be expected, since all parts of the project will be progressively elaborated as the project progresses and more information is available.

5.3 Create WBS

[Page 116, Figure 5-6. *Create WBS: Inputs, Tools & Techniques, and Output*]

Definition: Work Breakdown Structure (WBS) – A deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables. It organizes and defines the total scope of the project.

As mentioned in this chapter's opening, the Work Breakdown Structure (WBS) is a new edition to Project Scope Management process area. While this may seem like a subtle change, it is very significant. Through questions on prior exams, PMI heavily stressed the relevance and importance of the WBS, despite its status as a process input or output. In the latest version of the PMBOK, the emphasis and coverage of the WBS is more consistent with the importance PMI places on it when the time comes to take the PMP exam. To be clear, the WBS is considered by PMI to be one of the most important processes in project management because it represents the work that will need to be completed. The importance of the WBS makes perfect sense in these terms. Project managers can get confused when they depend too much on their own experience to answer questions on the PMP exam related to changes to tasks or schedules. All project managers prepare Work Breakdown Structures; however, many do not prepare, change or update them the way that PMI advocates. Remembering that the WBS is the most important input for most project management processes, and that changes must be made to the WBS before changes are made to these subsequent processes, will keep PMP candidates on the road to a passing exam score.

Again, the WBS provides the project team with a means of identifying and depicting all of the work that needs to be performed to create the project deliverables, enabling them to organize work for each deliverable at a level commensurate with the detail of the work required to create that deliverable. A WBS typically presents planned work in a descending order of granularity. This means that very specific activities or *work packages* are represented at the lowest levels of the WBS hierarchy (where the work is performed) and summary or rolled up activities are at higher levels of the WBS. For example, if a project deliverable (e.g. *Take delivery of jet engine*) is to be created under contract by an entity external to the performing organization, then this may appear as a rolled-up or summary activity within the performing organization's WBS. This would also appear in the contracting entity's own WBS, though it will show a greater degree of task granularity in the lower level work packages required to meet this deliverable (e.g. *Develop, test and manufacture the production-ready engine*). In turn, each of these tasks might be composed of other, more granular tasks (e.g. *those required to develop the engine, those required to test the engine, etc.*) that are represented at a lower level within the WBS.

Why is it so important for the WBS to capture all work packages at the lowest level? Because it is the level at which the work to be performed can be represented with a sufficient degree of *specificity* to enable the task, activity or other output to be:

- scheduled in relation to other project tasks;
- assigned to an owner responsible for completing the deliverable;
- cost estimated so that the budget can be allocated to the performance of the work package;
- tracked and monitored as the work is performed; and
- controlled so that the completed deliverable meets the project needs for which it was undertaken.

In many performing organizations, the creation of the WBS is facilitated by using a *WBS template*. Such templates are usually designed to meet the industry or business sector-specific project needs of the performing organization and provide ready-made structures for organizing standard tasks that may be repeated from project to project (e.g. *product or service testing activities*).

As if there was not enough evidence already, you can gauge the importance that PMI places on the WBS by the fact that it has published a Practice Standard for Work Breakdown Structures that provides guidance on creating Work Breakdown Structures and examples of industry-specific WBS templates.

The process for identifying and organizing work packages in the WBS is called *decomposition*. Decomposition is achieved by subdividing project deliverables into smaller, more manageable components until the work and deliverables are defined to the requisite work package level. A work package represents a *manageable* work effort. The management and control of work packages is facilitated by the assignment of an *identification code* to each work package.

The process of decomposition is considered complete when the work package has been defined to the right level of specificity with respect to the manageability of the work to be performed. To carry on decomposition beyond this point adds little value by way of planning, managing and controlling the work to be performed.

Decomposition proceeds via analysis of the Project Scope Statement, often involving the domain knowledge of subject matter experts (SMEs) who apply their expert judgment to identify the total scope of work. In which other process might SMEs be used to enhance the quality of the analysis performed? The results of this analysis are captured in the WBS. The project team selects a form of WBS representation appropriate to the scope and organization of the project. For example, some WBS charts organize tasks by project phase (*concept, design, development, testing, product manufacture*), while others organize tasks around functional deliverables (*marketing, product support, customer training, etc.*). The project team needs to determine the best WBS form to represent the scope of their project.

Whatever form the WBS takes, it is important that all work packages are completely defined and assigned to an *accountable* owner who accepts responsibility for completion of the task(s) assigned. Work packages must therefore be defined in terms of how the work will *actually* be performed and controlled.

The project team must verify that decomposition was performed correctly in the creation of the WBS. Verification is performed by determining that all lower-level WBS components (work packages) are both *necessary* and *sufficient* for completion of the higher-level deliverables to which they are linked. This *bottom-up* technique is also used in Resource Estimating (page 141) and Cost Estimating (page 168). Why is that? Because if verification of the completeness of the WBS is omitted or incomplete, there will be serious impact on the assumed resources and budget required to deliver the project successfully. Note that the assignment of identifiers to each work package facilitates the summing of project cost, schedule and resource information as one moves up the WBS hierarchy.

The WBS occurs as an input in five other processes (four Planning and one Control). Can you identify what they are?

Other breakdown structures are used elsewhere in the project to perform similar *analytical* functions to the WBS. Do not confuse them. Each has its own distinct purpose. PMBOK identifies the following breakdown structures:

- **Organizational Breakdown Structure (OBS)** – identifies the functional unit within the performing organization responsible for delivering project work packages. The units are organized hierarchically within the OBS (page 220);
- **Bill of Materials (BOM)** – documents the formal hierarchical tabulation of the physical assemblies, subassemblies and other components that are needed to fabricate the product of the project;
- **Risk Breakdown Structure (RBS)** – represents the identified project risks arranged by risk category within a hierarchical structure (page 280); and
- **Resource Breakdown Structure (RBS)** – represents the resources arranged by resource type that are to be applied to project work within a hierarchical structure (page 145).

It is necessary that each WBS component or work package is described fully and that the project team has a means of identifying and accessing such information. This is facilitated by an index system known as the WBS Dictionary.

Each entry in the dictionary contains attribute information about the specific task, activity or deliverable that has a corresponding entry in the WBS chart. This dictionary cross-references each entry as it relates to other associated project components. Each dictionary entry may cover any of the following information, as required by the project:

- a code of account identifier;
- a statement of work;
- accountable organization or business unit responsible for the activity;
- a list of scheduled milestones;
- contact information;
- quality requirements;
- technical information relevant to the performance of the task;
- a charge number (for control accounts – page 129);
- a list of related schedule activities;
- resource requirements; and
- cost estimate.

The approved Project Scope Statement, together with the WBS and WBS Dictionary, provide the *scope baseline*. It is to this baseline that the project team will manage the project's scope. It is referenced whenever change requests are raised or when work performed needs to be verified as within scope of the project.

5.4 Verify Scope

[Page 123, Figure 5-9. *Scope Verification: Inputs, Tools & Techniques, and Output*]

Verification of project scope is the process whereby stakeholders formally accept the completed project scope and associated deliverables. Deliverables are reviewed to ensure that they have been completed satisfactorily, meet the project's requirements and that they are *acceptable* to stakeholders.

Do not confuse scope verification with *quality control* (page 206), which is concerned with meeting the quality requirements specified for each deliverable. Note that quality control is usually performed before verification, as the quality attributes of a deliverable will obviously affect its acceptance. The deliverables review process facilitating verification is called *inspection*. Inspections include a variety of verification techniques, including measuring, examining, comparison with the specified product requirements and applying acceptance criteria. Inspections may also be referred to as:

- reviews;
- product reviews;
- audits; and
- walkthroughs.

Project scope verification is always performed on every project, even if the project is terminated early. If early termination occurs (for whatever reason), the project team must establish and document the extent of completion before they can close out the project, especially when the work is performed under contract (page 313).

5.5 Control Scope

[Page 125, Figure 5-13. *Scope Control: Inputs, Tools & Techniques, and Output*]

The primary purpose of project scope control is to *influence* factors that create changes to project scope and to *control the impact* of those changes if and when they occur. Control of scope changes is managed through the project Integrated Change Control process (page 93). To facilitate this, a project scope Change Control System provides the procedures by which the project scope and product scope may be changed. These procedures are documented in the Project Management Plan. Note that if a project is managed under contract, then the change control system must also comply with any relevant contractual provisions (page 335).

As project work is performed, variations from the project scope must be identified and responded to as appropriate to the impact of the variation. This is performed using *Variance Analysis*, whereby any variance relative to the scope baseline is measured and assessed. Assessment includes both identifying the causes of variation and determining if any corrective actions are required to bring the project back into conformance with the scope baseline as a result of the variance observed. Variance analysis is also performed during Schedule Control (page 160) and is a technique used in Cost Control (page 179). Do not confuse variance analysis with *earned value analysis* (page 182). Approved changes usually results in *re-planning* activities, such as amendments to the project scope statement, the project Scope Management Plan, the WBS (including WBS Dictionary) and updates to the project management plan.

6. Project Time Management

Project Time Management (Chapter 6, pages 123-163) comprises six project management processes:

6.1 Define Activities [*Planning*] – identifying all schedule activities that must be performed to deliver the project (pages 133-135);

6.2 Sequence Activities [*Planning*] – identifying and documenting dependencies and inter-relationships between the schedule activities identified in the activity definition process (pages 136-141);

6.3 Estimate Activity Resources [*Planning*] – estimating the type and quantity of resources required to perform each schedule activity identified in the activity definition process (pages 141-145);

6.4 Estimate Activity Durations [*Planning*] – estimating the duration and number of time periods that will be required to complete each schedule activity (pages 146-151);

6.5 Develop Schedule [*Planning*] – creating the project schedule by analyzing the sequence and duration of schedule activities, their constraints and the resources required to complete each schedule activity (pages 152-157); and

6.6 Control Schedule [*Control*] – controlling changes to the project schedule (pages 160-163).

"*So how long is this going to take*?" This is usually the question that management asks immediately after hearing the answer to "*How much is this going to cost?*" In reality, however, one cannot answer the "*how much*" question without first answering the "*how long*" question. As we know from our own experience, if you don't have an answer to that question, then management (or your sponsor, or your customer) will have an answer for you. All joking aside, this is an important principle of Project Time Management: it is the responsibility of the project management team to determine as accurately as possible the optimal duration of all activities that must be accomplished in order to meet project requirements.

As project requirements are derived from stakeholder wants and expectations, stakeholders often express desired dates for when they would like project activities to be completed. However, the project management team should never accept such dates without first analyzing their basis and then assessing whether (and how) they can be accommodated within the project schedule. If accepted, these dates are then treated as constraints in the development of the project schedule and any expectations that are subsequently held by stakeholders around such dates must be actively managed by the project manager throughout the duration of the project.

As with other process groups, the processes in the Project Time Management group are presented as discrete processes with interactions between the processes acknowledged in the various inputs and outputs described. However, in many projects the activities involved in activity sequencing (6.2), activity resource estimating (6.3), activity duration estimating (6.4) and schedule development (6.5) may be performed together as a single, integrated process. For example, changing the sequence of project activities may provide an opportunity for more efficient use of resources which, in turn, may shorten the overall duration of the project. Project planners should consider alternative sequences (or scenarios) and assess the resource estimates and activity durations associated with each sequence before arriving at the final baseline project schedule.

The PMBOK references many processes outside the Time Management Process Group as significant inputs. One of the most notable of these inputs is the process of creating a Schedule Management Plan. This particular process is addressed as part of the Develop Project Management Plan process and is considered a subsidiary or component part of the overall project management plan. It describes the format and identifies the criteria that will be used by the project management team developing and controlling the project schedule. Do <u>not</u> confuse this plan with the *schedule baseline*.

6.1 Define Activities

[Page 133, Figure 6-3. *Define Activities: Inputs, Tools & Techniques, and Outputs*]

Defining Activities involves identifying and documenting the work that is planned to be performed by the project. Work is performed at the lowest level of the Work Breakdown Structure (WBS). That is, at the *work package* level. This level is defined as the level at which the project's *deliverables* are created. Work packages are analyzed (or decomposed) to identify the activities that will themselves create the project's deliverables. These are known as *schedule activities*. These schedule activities are the building blocks that are used to develop the project's schedule. They represent all of the activities that are required to meet the project's objectives. To summarize, these elements are generally represented within the hierarchy of the WBS as follows (top-down view):

- *Level 1* – represents the *total scope* of the project;
- *Level 2* – represents the project's high level (or *rolled-up*) deliverables;
- *Level 3* – represents the project's *work packages* (or deliverables); and
- *Level 4* – represents the project's *schedule activities*.

Together with the WBS Dictionary, the WBS is one of the primary inputs to the activity definition process. Additionally, information about the project's deliverables, constraints and assumptions contained in the Project Scope Statement are also taken into account in the activity definition process.

The development of schedule activities from the analysis of this information is achieved by subdividing work packages into their smallest constituent elements, otherwise known as *decomposition*. Subdividing continues until the point at which no further subdivision of the activity is possible. This point defines the schedule activity by the following characteristics:

- the *duration* of the activity can be discretely estimated;
- the *cost* of the activity can be discretely estimated;
- the *resource requirements* of the activity can be discretely estimated; and
- the activity can be connected to other schedule activities via a *logical relationship*.

In other words, each schedule activity must be a discrete and *manageable* entity in its own right. Why is this so important? During schedule development, the flexibility to construct and evaluate alternative sequences of activities provides the project management team with opportunities to consider alternative schedules (for example, best case, worst case, etc.). During project execution, the exercise provides the project management team with the ability to change and update the project plan in response to risks and change requests.

Remember that the schedule activity is decomposed *from* the work package in the WBS. The work package *includes* the schedule activity (and the schedule milestones). Do not confuse schedule activity and work package (sometimes called the *project work component*). Just like cost estimation, activity definition should be performed by the project team member(s) responsible for the activity.

Progressive elaboration underpins many of the iterative processes described in the PMBOK. It is an incremental process whereby increasingly detailed and specific information is added to the project plans (*elaborated*) as it becomes available to the project team, and as the project progresses through the project life-cycle. But it is only explicitly referenced under the activity definition process as a part of Rolling Wave Planning, in which work that is to be performed in the near term is planned to a greater level of detail (that is, at lower levels of the WBS) than work that is further out, or is to be performed in later phases of the project (and is planned at higher levels within the WBS). Using this approach, schedule activities can be defined to a lesser or greater level of detail according to the specificity of the information available throughout the project's life cycle. A higher level WBS component can be used to perform decomposition if insufficient detail is available to create the required schedule activities using a lower level WBS component. The two most commonly used Planning Components are the Control Account, in which management control points are defined to aid the project management team in the planning process, and the Planning Package, which uses placeholders that are defined above the work package level but below the control account level.

The output from the activity definition process is the Activity List. This is a list of all of the schedule activities that must be performed in order to create the project's deliverables. These schedule activities are the component elements of the project schedule. The attributes associated with each schedule activity in the activity list are also described as part of the activity definition process. These include such attributes as:

- activity description;
- predecessor activities;
- successor activities;
- logical relationships;
- resource requirements;
- constraints;
- assumptions;

Why is this kind of information so important? Because it provides sufficient detail to enable the project team to select and order activities in alternative sequences during the schedule development process. From this, the project team can identify the best way for the project work to be performed.

6.2 Sequence Activities

[Page 136, Figure 6-5. *Sequence Activities: Inputs, Tools & Techniques, and Outputs*]

The objective of Sequencing Activities is to identify and document the logical relationships between schedule activities. Analysis of these logical relationships enables the project management team to assess alternative sequences of performing the project work and to develop a project schedule that is realistic and achievable within the scope of the project.

The sequencing of project activities in their logical relationships is modeled in the structure of the *project schedule network diagram*. A network diagram depicts the chronology of project activities from left (start of project) to right (end of project). In the past, PMI promoted the use of two diagramming techniques - **Precedence Diagramming Method** and the **Arrow Diagramming Method**. - to construct the network diagram. A major modification to the Fourth Edition, though, was the removal of references to the **Arrow Diagramming Method**. Members of the 4th edition revision team, noted that one reason for de-emphasizing the Arrow Diagramming Method was the widespread use of project management software which commonly performs all arrow diagramming for the project team once project tasks have been sequenced. By the release of the Third Edition PMBOK, Precedence Diagramming had already become the more common approach of the two. PMI's decision to only present the Precedence Diagramming Method essentially establishes that method as the single standard for network diagramming. That being said, PMP candidates will need to understand the critical concepts behind Precedence Diagramming to be successful covering the topic of Project Time Management during the final exam.

The **Precedence Diagramming Method** (PDM), also known as *activity-on-node* (AON), uses a node and arrow convention to model the relationships between schedule activities. The *nodes* are depicted using boxes or rectangles that represent activities. Activities are connected with *arrows* that represent dependencies between the activities (see *Figure 6-7* on page 139). The PDM can be used to model four different types of dependency relationships in which one activity cannot commence or finish until the preceding activity has either started or ended. These relationships are defined as:

- **Finish-to-Start** – The predecessor activity must finish before the successor activity can commence;
- **Finish-to- Finish** – The predecessor activity must finish before the successor activity can finish;
- **Start-to-Start** – The predecessor activity must start before the successor activity can start; and
- **Start-to-Finish** - The predecessor activity must start before the successor activity can finish.

Finish-to-start is the most commonly used precedence relationship (start-to-finish is rarely used). Most project management software tools use the PDM method to construct the project schedule. This is because PDM enables lags and leads to be modeled in the precedence relationships between activities. The use of lags and leads enables alternative paths to be constructed through the network.

A *lag* applies a delay to the successor activity. For example, in a finish-to-start relationship with a five day lag, a successor activity cannot start until five days after the finish of the predecessor activity. If the predecessor activity starts on day 1 and finishes on day 3, when does the successor activity start? On day 8 (3 + 5 = 8).

A *lead* accelerates the successor activity. For example, in a finish-to-start relationship with a five day lead, a successor activity can start five days before the finish of the predecessor activity. If the predecessor activity starts on day 1 and finishes on day 8, when can the successor activity start? On day 3 (8 – 5 = 3). Note that a negative lead is the same as a positive lag.

Project Schedule Network Templates based on previous projects may be used by the project team to create the schedule network diagram. These can be used to construct the network diagram for the entire project or a contributing part of the project (or *subnet*).

Templates are used throughout the project in a number of process areas. They provide project teams with readymade artifacts, usually applicable to the needs of specific application areas or are based on projects of similar scope and magnitude. They help to reduce the amount of effort required to perform work and improve the quality of the outputs from the process area in which they are used. Templates are an important *organizational process asset*. An indicator of a performing organization's *project capability* might be represented by the extent to which the organization has and uses templates to perform project work. Examples of templates commonly used include:

- Work Breakdown Structure (WBS) (page 121);
- Activity Definition (page 135);
- Activity Sequencing (page 141);
- Cost Estimating (page 174);
- Human Resource Planning (page 222); and
- Risk Management Planning (page 279).

A logical relationship is defined in the PMBOK as a dependency between two project schedule activities (page 437). It is important to identify these formal linkages between tasks because such relationships constrain the possible sequence of schedule activities to a limited set of alternatives. There are three types of logical relationships or *dependencies*:

- **Mandatory** (*hard logic*) –dependencies that are defined by the inherent or physical characteristics of the work to be performed. They mandate that a fundamental set of the project's schedule activities must be performed according to a hard sequence that generally cannot be changed. An obvious example is that the foundations of a building must be laid first before the superstructure can be erected;
- **Discretionary** (*soft logic*) – also referred to as *preferred* or *preferential logic*, are dependencies established by best practices generally followed in a specific application area or may be preferred according to the circumstances of the project. For example, the same sequence of schedule activities may have been used on a previously successful project;
- **External** –dependencies that arise from the relationship between project schedule activities and non- or external project activities. For example, the redenomination of a national currency to the euro by a government might require a project to link certain of its own internal change processes to that event.

The output from the activity sequencing process is the Project Schedule Network Diagram, which is a schematic display of the logical relationships among the project schedule activities.

6.3 Estimate Activity Resources

[Page 142, Figure 6-8. *Estimate Activity Resources: Inputs, Tools & Techniques, and Outputs*]

The Activity Resource Estimating process is closely linked with the Estimate Costs process (see pages 168-174), with which it is closely coordinated. It is concerned with estimating what *kind* and *quantity* of resource will be required, and *when* it will be required for each schedule activity. Activity resource estimating uses the bottom-up estimating technique (see page 427 and section *7.1 Estimate Costs* below). Decomposition of the schedule activity helps to improve the accuracy of the estimate and enables estimates to be aggregated (or rolled-up) to derive a total quantity for the resources required for each schedule activity. The estimate should also take account of any logical relationships or dependencies between schedule activities where such relationships might influence resource utilization.

6.4 Estimate Activity Durations

[Page 139, Figure 6-10. *Estimate Activity Durations: Inputs, Tools & Techniques, and Outputs*]

Estimating Activity Durations is performed by the project staff responsible for the work required to complete the schedule activity whose duration is being estimated. The estimate is developed and refined through progressive elaboration as more detailed information about the activity is gathered and analyzed. The process focuses on estimating:

- the amount of *work effort* required to perform the schedule activity;
- the amount of *resources* needed to complete the schedule activity; and
- the number of *work periods* that are required to complete the schedule activity.

Estimating the number of work periods often needs to take account of *elapsed time* affecting the schedule activity in a specific application area. Most project scheduling software tools are designed to handle elapsed time through the use of a Project Calendar. The Project Calendar defines the work periods that are used to manage and schedule project activities with respect to work periods (during which schedule activities are worked) and non-work periods (during which schedule activities are idle or dormant). Note that overall project duration is an output from the Schedule Development process, not from the Activity Duration Estimating process. The latter focuses on individual components of the project, or schedule activities.

Activity resource requirements are an important determinant of duration because the more efficiently a task can be performed the more its duration can be optimized. Both the quantity and quality of resource that can be applied to an activity will therefore directly influence its duration. Note, however, that adding resources to a task will not always result in schedule compression (a reduction in the time taken to complete a task). This is because every task has an optimal resource level: add too many resources and you incur inefficiencies with respect to coordination and learning curve associated with the increased resource level. A Resource Calendar is used to identify the capabilities, skills, quantity and availability of resources required of each schedule activity, in order to help manage task scheduling. Take note that like cost estimating, activity duration estimates require the techniques of analogous and parametric estimating in order to derive schedule activity estimates (see pages 149-150).

Duration estimates must also take into account the impact of risks to the project schedule activities. The Risk Register is used by the project team to identify and factor in risks relevant to each schedule activity. The potential impact of the risk on the schedule activity can be factored into the duration estimate by using a *three-point estimate* method. This method is used to derive a range of durations that can then be used to determine the baseline estimate for the activity. The three types of estimates used in this method are:

- **Most likely** – representing the duration of the schedule activity on the basis of *most likely* resource availability and assignment, *known* dependencies and *realistic* expectations about the performance of the required task(s);
- **Optimistic** (or *best case*) – representing the duration of the schedule activity on the basis of *uninterrupted* and *optimal* performance of the required task(s) (the perfect realization of circumstances in the most likely scenario); and
- **Pessimistic** (or *worst case*) – which represents the duration of the schedule activity on the basis of *disrupted* and *imperfect* performance of the required task(s). In other words, anything that can go wrong in the most likely scenario will go wrong.

In a rare reversal of direction, PMI's Third Edition PMBOK removed explicit reference to the PERT (Program Evaluation and Review Technique) estimation technique, which uses a four-point estimating method. At the time of publication, this omission was attributed primarily to the fact that PERT was based on a *weighted average* value instead of a straight average estimate. Several years later, though, the Fourth Edition PMBOK team has returned PERT estimation back to its rightful place in the PM's Body of Knowledge. What's worth remembering is that a PERT review analysis uses the following formula to gather a final estimate based on submitted three point estimates: O plus 4, times M, plus P and divided by 6 equals E, where O = the Optimistic value, M = the Most Likely value, P = the Pessimistic value and E = the Expected Value.

The outputs from this process are activity duration estimates that represent quantitative assessments of the likely number of work periods that will be required to complete each schedule activity. Estimates are usually given as a range (for example, 1 month +/- 5 days) to account for likely variance in the performance of the schedule activity. More precision is applied to the duration estimates as the plan is progressively elaborated.

6.5 Develop Schedule

[Page 152, Figure 6-12.*Develop Schedule: Inputs, Tools & Techniques, and Outputs*]

The objective of the Schedule Development process is to identify start and finish dates for all schedule activities such that a start-to-finish baseline schedule can be created against which project progress can then be tracked and monitored.

The development of the project schedule by the project team is limited by the constraints documented in the project scope statement. Constraints that most affect schedule development are:

- project start and finish dates that are imposed by the *circumstances* of the project and arise from the logical precedence of tasks in an application area or external factors that dictate when activities can be performed; and
- stakeholder dates that typically represent preferred dates or key milestones that are *desired* (or required) by the customer, sponsor or other project stakeholders.

Schedule Network Analysis techniques are applied to the sequence of schedule activities to create a project schedule, of which the most widely used technique is the **Critical Path Method** (*CPM*).

The CPM is a schedule network analysis technique that allows for the calculation of both theoretical early start and finish dates, and late start and finish dates for project activities. Calculating these dates enables *scheduling flexibility* to be identified across alternative network paths running through the project schedule network diagram. The objective of this is to identify the project path with the minimum total duration. The dates calculated provide a framework of time periods from which the project schedule is then constructed on the basis of the logical relationships, durations, leads, lags and other constraints on the tasks. Two methods are used to calculate the earliest and latest dates possible for the start and finish of activities:

- **Forward pass** – involves calculating the early start (ES) and early finish (EF) dates by moving *forward*, from left (start) to right (finish), through the network diagram.
  Formula: *EF = ES + duration*
  The early finish date is calculated by adding the duration of the activity to the early start date.
- **Backward pass** – involves calculating the late start (LS) and late finish (LF) dates by moving *backward*, from right (finish) to left (start) through the network diagram.
  Formula: *LS = LF – duration*
  The late start date is calculated by subtracting the duration of the activity from the late finish date.

Flexibility in the project schedule is represented by *float* (or slack) in the network paths. Float is defined by the amount of time that a schedule activity can be delayed without delaying the project. Float can be calculated using either late start and early start dates or late finish and early finish dates. Remember these for the exam:

- **Formula:** *Float = LS – ES* or
- **Formula:** *Float = LF – EF*

There are two kinds of float. Memorize these. Do not confuse the two:

- **Free float** – represents the amount of time that a predecessor schedule activity can be delayed *without delaying the early start of the successor schedule activity*;
- **Total float** – represents the amount of time that a schedule activity can be delayed from its early start date *without delaying the project completion date*.

Many project schedule software tools will automatically calculate critical path and float from schedule activity date values entered by you. If you are unfamiliar with CPM analysis, or do not perform it regularly on your projects, you will need to practice forward and backward passes through the network diagram. In addition, you must be able to calculate free and total float values in order to adequately prepare for the PMP exam. Most project managers use the phrase "critical path" loosely to describe the key (or critical) activities upon which the success of their project depends. But if you have manually calculated the critical path for yourself you will know that the *critical path*:

- is the path with the longest duration through the network diagram;
- is the shortest time in which a project can be completed; and
- has zero float along the path; in other words, delay to any activity on the path will delay the project.

If the path you have calculated through the network diagram has negative (-) float, then what does that tell you about the project based on that path? Although it may be the result of date constraints, such as a customer imposed milestones, your project is already late.

There should be one and only one critical path through the network. This does not mean that there cannot be more than one critical path throughout the lifecycle of the project. Applying leads and lags to activities can change the critical path through the network diagram However, more than one critical path through the network increases the risk profile of the project. Therefore, the critical path needs to be managed to a single thread or path.

Remember, if and when a lead or lag is applied to a schedule activity, or if the duration of a schedule activity changes, always check the alternative paths through the network diagram to see if one of these alternative paths has now become the project's critical path.

Where a project needs to meet imposed dates or other schedule constraints, *schedule compression* techniques can be used to shorten the project schedule while maintaining the scope of the project. Two compression methods are commonly used:

- **Crashing** – in which additional resources are applied to shorten the duration of critical path tasks. This usually implies an increase in cost to pay for additional staff, buy additional work hours (overtime) or purchase technology. If this increases the complexity of the activity, then it may also introduce added risk. In crashing, cost and schedule tradeoffs are analyzed by the project management team to achieve the most compression for the least cost;
- **Fast Tracking** – in which tasks that are normally performed serially are performed in parallel. This can result in tasks being removed from the critical path. Fast tracking can also result in decreased quality and increased rework. Risk also increases with fast tracking.

Alternatively, *resource leveling* can also be applied to the schedule in order to meet specified delivery dates by moving resources from one task to another, as a result of availability and utilization rates across the resource pool. This is usually performed *after* the critical path has been identified and may, therefore, cause the critical path to change (just as adding leads and lags might do).

Critical Chain Method is another schedule network analysis technique that is used to modify the project schedule to account for limited resources and can also result in a modified critical path. It uses duration buffers (non-work schedule activities) to schedule planned activities to their latest possible start and finish dates. The focus of this method is on managing the resources applied to the schedule activities.

Monte Carlo Analysis is a simulation technique that is used to calculate multiple durations for each schedule activity based on different variables that influence the performance of the activity (and hence, its duration). The output is a distribution of possible durations for each schedule activity which, when combined with the output for other schedule activities, provides multiple project outcomes. These are used as part of *"What if" scenario analysis* by the project management team to evaluate the feasibility of the project schedule under adverse or unexpected conditions.

The output from the schedule development process is the Project Schedule, which can be presented in one or more of the following formats:

- **Milestone chart** – presents the start and end dates for the project's major deliverables (milestones) in a bar chart format;
- **Bar** (or *GANTT*) **chart** – presents both the start and end dates for project schedule activities and their durations in a bar chart format. For management reporting purposes, summary bar charts are often used to display summarized, or *hammock*, activities;
- **Project schedule network diagram** – presents both the critical path and the network logic relationships using an AON diagram format. Alternatively, a logic bar chart format can be used to display a time-scaled schedule diagram.

Note that for tracking and monitoring schedule performance, a *schedule baseline* is created as one of the outputs from this process.

6.6 Control Schedule

[Page 152, Figure 6-11. *Control Schedule: Inputs, Tools & Techniques, and Outputs*]

Like project cost control, the Control Schedule process is a critical part of Integrated Change Control (see pages 93-98). Time intersects with both Cost (=budget) and Scope (=requirements, including quality), and involves tradeoffs between these elements when controlling the project schedule.

Controlling the project schedule means knowing what the status of the schedule is. In other words, it means knowing whether project activities are on, behind or ahead of the planned schedule. It also means identifying and influencing the factors that create changes to the schedule, as well as managing changes to the schedule when they occur.

The Schedule Baseline is an approved schedule for the project work to be performed, against which actual schedule performance is compared and deviations from the schedule are measured and assessed. It helps to answer the question "*Is the project schedule in control*?"

The Schedule Baseline is defined by the following characteristics:

- it is agreed and formally approved by the project team;
- it is maintained under formal change control;
- it is updated in response to approved change requests; and
- it is archived as and when approved changes are applied, and an updated baseline is issued.

Schedule performance and progress are monitored and reported by the project management team, including the completion percent of all current in-flight activities. Different conventions can be used to report progress on project activities. For example, an absolute measure only counts an activity as complete when it is 100% finished, whereas an 80:20 measure counts a task as 20% complete when it has started and the remaining 80% of the task is credited as complete when it is finished. Project schedule software tools support these kinds of conventions to enable "percent complete" tracking of project activities.

Variances from the planned schedule are measured using the *Schedule Variance* (SV) and *Schedule Performance Index* (SPI) earned value techniques (see *7.3 Cost Control* below). A series of SPI measures over time can be used to monitor whether the schedule is exhibiting an improving or a deteriorating *trend* in performance. Variances are assessed as to whether they are within defined and acceptable tolerances, or whether corrective actions may be required to bring future schedule performance back into conformance with the baseline. Variances observed on critical path activities should always be analyzed as to their cause and their impact on the project end date. Any necessary corrective actions should be taken, and the baseline should be adjusted and updated accordingly. *Total float variance* should also be monitored, and any increase or decrease should be assessed as to its causes and impact on project schedule performance. Changes to the project schedule and baseline should always be communicated to stakeholders. Note that the formats for presenting project schedule information described above are selected and used according to the communication needs of the recipients to which they are addressed.

7. Project Cost Management

Project Cost Management (Chapter 7, pages 157-178) comprises three project management processes:

7.1 Estimate Costs [*Planning*] – developing an approximation of the costs of any resources required to complete project activities (pages 168-174);

7.2 Determine Budget [*Planning*] – aggregating the estimated costs of individual activities or work packages to establish a cost baseline (pages 175-178); and

7.3 Control Costs [*Controlling*] – influencing the factors that create cost variances and controlling changes to the project budget (pages 179-187).

"*How much is this going to cost*?" is the question that management usually asks immediately after hearing the answer to: "*Do we have the capability to do this successfully?*" The primary objective of Project Cost Management is to determine the cost of the resources required to deliver the project according *to schedule*, and then to manage those costs according to the approved budget (the *baseline*). Funding for the project is limited to the amount required to do that, and only that. The funds allocated must therefore map as accurately as possible to the activities required to deliver the project. By extension, how well the project scope is defined will determine the limits of the project funding.

The cost of the project is therefore determined with respect to:

- **Resources** – What resources are required (technical, human), and are they available (technology, skills, expertise, quantity)?
- **Time** – How long will it take for those resources to complete activities and tasks to deliver the project?
- **Scope** – What are the project's boundaries and limits? What is not included (and therefore will not be funded)?
- **Quality** – What are the quality requirements of the project's products or services?

Think about how each of these cost components interrelates with one another and how they can influence the ultimate cost of the project. For example, decisions about product quality will impact the kind of resources required to create the product. The skills and expertise of those resources will affect project performance and therefore the duration of project activities. A change to the project's scope can impact both quality and time. Each of these components work together to create the project's cost. To effectively manage this cost, the project management team must focus on influencing those factors that create variances in cost.

In making decisions that affect project costs, the team must also consider any consequent effect on whole *product life-cycle* costs. Costs included in this category include operating costs, maintenance costs, support, delivery, etc. For example, if a project's product or service requires frequent and multiple updates or continuous upgrades in order to meet its operational requirements because it was rushed to market to reduce project delivery costs, it may render the product economically unviable (which equates to not meeting customer requirements).

In general, the completed product's performance and other operational costs are forecast and budgeted outside of the project. In some application areas, however, whole product life-cycle costs may be included within Project Cost Management, especially during the project selection process, when management wants to know, "*What will this project return on our investment?*"

You should familiarize yourself with the following techniques. These are used to evaluate the financial benefits of selecting one project over another to the performing organization. It is not necessary to know how to perform calculations using these techniques (although it helps if you do). The project manager is expected to know why the project was selected, and therefore you need to know what the result of each calculation means and how to compare the result of one technique to another.

- **Present value** – the discounted value (i.e. the *current* value) of a future sum or stream of cash flows. This value is expressed by the formula $PV = FV$ divided by $1 + r$ multiplied by n, where PV = Present Value, FV = Future Value, r = the interest rate and n = the number of time periods;
- **Net Present Value (NPV)** – equal to the *present value* of the total benefits (which can be expressed as either revenue or income) of the project, minus the costs. If the NPV value is greater than or equal to zero then the project is acceptable; but if that NPV is less than zero, the project should be rejected. Where there is a choice between projects with different NPV values, always select the project with the *highest* value (greater than zero);
- **Internal Rate of Return (IRR)** – the rate (expressed as an *interest* or *discount rate*) at which the value of the project inflows (revenues) and the project outflows (costs) are exactly equal, or the rate at which the *net present value* = 0. Where there is a choice, select the project with the *highest* IRR rate;
- **Payback Period** – the length of time (usually expressed as time periods or number of years/ months) required of a company to recover its initial investment in the project before it starts generating a profit, i.e. the time it takes to *pay back* the cost of the project. Unlike NPV, the payback period does not take into account the time value of money. Select the project with the *shortest* payback period;
- **Benefit Cost Ratio (BCR)** – compares benefits to costs. Benefits can be expressed as either revenue or payback (not profit). If the BCR value is greater than 1, then the benefits of the project outweigh the costs; if the BCR value is less than 1, then the costs outweigh the benefits. Always select the project with a BCR greater than 1, or the highest BCR value (greater than 1).

The time value of money is an important consideration when deciding, not only which project to select, but how to perform the project selected. When deciding amongst different approaches (or different projects), value analysis (or *value engineering*) is often used to identify less costly ways of performing the same scope of work. Why is this so important? Because the ability to influence project costs is greatest during the earliest phases of a project, when the scope of the project (what will and will not be funded) is being defined and agreed upon. If you omit, overlook or underestimate a stakeholder requirement at this stage in the project, it can become very costly to meet that requirement later on during the execution phase (which is why influencing stakeholders is so important to the success of a project).

You will recall that the criteria that will be used by the project management team for planning, estimating, budgeting and controlling project costs, was identified in the creation of the Cost Management Plan. As a subsidiary or component part of the overall Project Management Plan, the Cost Management Plan will be an important input into the processes of cost estimating, budgeting and cost control. Do not confuse this plan with the *cost baseline*. The Cost Management Plan defines how the following criteria will be applied to the project:

- **Units of measurement** – identifies the base units that will be used for measuring resource utilization; for example, hours, days, weeks, etc. for staff; dollars, euros, etc. for costs;
- **Level of precision** – prescribes the precision to which schedule activity cost estimates will be recorded; for example, to within the nearest $100, $1,000, etc. The level of precision establishes a consistent standard for the basis of the project estimates. Think of this as the *rounding convention*. (Note that precision and accuracy are not equivalent - see the introduction to *Chapter 8, Project Quality Management* below for more on this.)
- **Control thresholds** – prescribes the agreed variances in costs or time (schedule) that are tolerated when measurements are taken;
- **Earned value rules** – describes the basis on which earned value techniques (EVT) will be applied to monitor project performance;
- **Control account (CA)** – prescribes how work packages in the WBS will be linked to and tracked through the performing organization's accounting system. The control account identifies in the WBS a level at which performance is measured and maps to organizational components in the Organizational Breakdown Structure (see page 117). It thus enables the performing organization to identify the costs of each WBS component within the department, unit or group responsible for that component (and is why control accounts are sometimes referred to as *cost accounts* in some performing organizations);
- **Report format** – defines the formats for the project's cost reports;
- **Estimation, Budget & Control processes** – describes how the cost estimation, budget and control processes will be applied to the project.

The cost management plan is the foundation for performing cost estimating, budgeting and control. It is the plan that describes *how* these processes will be *managed*.

7.1 Estimate Costs

[Page 169, Figure 7-2. *Estimate Costs: Inputs, Tools & Techniques, and Outputs*]

The objective of the Cost Estimating process is to develop Activity Cost Estimates, which are quantitative approximations of the likely costs of the resources required to successfully complete scheduled project activities.

Two important factors determine the accuracy of those estimates:

- estimating must be carried out by the person(s) responsible for performing the tasks that are being cost estimated; and
- estimating should take into account the possible causes of variance in those costs, including risks.

Alternative ways of accomplishing project tasks should also be considered when developing the estimates, especially where there are opportunities for *trade-off* costs between activities (by increasing costs in one area and decreasing in another) to reduce the overall cost of the project. Note that such trade-offs may need to be analyzed from a whole product life-cycle perspective if they add significant on-going cost to the operational use and support of the product or service.

As the project progresses, and as more detail and better quality information about the project tasks becomes available, the accuracy of project estimates improves. This is reflected in the range of accuracy of the estimates produced. The following are the most commonly quoted ranges used when preparing project cost estimates. You should remember these ranges for the exam:

- **Rough Order of Magnitude** (**ROM**) – is in a range of -50% to +100% from the expected or actual value;
- **Order of Magnitude** – is in a range of -25% to +75% from the expected or actual value;
- **Budget estimate** – is in a range of -10% to +25% from the expected or actual value; and
- **Definitive estimate** – is in a range of -5% to +10% from the expected or actual value.

At what point in the project life cycle would you expect a definitive estimate to be given? Definitive estimates are provided at the end of the planning phase, or early in the execution phase, when the level of detail in the plan allows for greater accuracy in estimating costs than at project inception (where a ROM estimate might be used).

In addition to accounting for all resources (human, materials) that are to be used to perform scheduled project activities, estimates should also take into account factors that may cause variance in the actual cost of the work performed. For example, on global projects, where work is being performed in different countries and paid for in different currencies, it is important to allow for *exchange rate fluctuation* when translating project costs to the base currency used for monitoring and reporting the project's budget (and will be specified in the Cost Management Plan). The objective of estimating is to account for the *likely costs* of the resources required to complete scheduled tasks. *Contingency costs* are therefore also included to account for factors that are likely to affect variances in the performance of scheduled project activities (and hence the cost of those activities) should those factors occur.

The accuracy of project cost estimates is determined by the completeness and quality of the information used to prepare the estimates. The PMBOK identifies a number of inputs that are used in the estimating process (see pages 169-171), of which the following are the most important:

- **Project Scope Statement** – covers the totality of those elements that determine what the project will deliver and how it will deliver the project's products and services. Scope therefore influences cost throughout the project. Scope is comprised of requirements, constraints and assumptions that define the project boundaries and, by extension, what will and will not be paid for as part of the project work. Project *constraints* influence costs in many areas, such as resource availability, access to funding, externally imposed deadlines, etc. *Assumptions* used to develop project plans need to be factored into cost estimates, especially the effect that they might have on estimates should they prove to be false. Project *requirements* that have a legal or contractual influence over how the project is to be performed will also affect cost estimates. Technical policies and standards mandated by the performing organization also affect costs;
- **Work Breakdown Structure (WBS)** – defines the scope and interrelationship of the project's component work packages. How the project's tasks are sequenced and structured provides the project management team with the most opportunities to influence project costs (by looking at alternative ways to perform the scope of work defined by the WBS). There are 170 references to the WBS in the PMBOK. This demonstrates how pervasive and influential the WBS is over the performance of the project. What is the relationship of the WBS to project scope? It organizes and defines the total scope of the project. Note that the cost estimate associated with each project task is included in the WBS Dictionary entry for the documented work package;
- **Risk register** – considers information on risk responses. The response to each risk identified in the project's Risk register will have a cost associated with it that needs to be taken into account when estimating costs. A negative risk event will generally incur increased cost; a positive risk event may provide an *opportunity* to reduce cost;
- **Project Schedule** – Uses the type and quantity of resources coupled with the amount of time to help determine the cost. Resource utilization plays a large part in determining project cost. The cost components associated with resource utilization include availability and quantity of the resources required, and includes the duration for which those resources will be needed. Depending on the nature of the schedule activity and the kind of resources required to perform the activity, costs associated with duration may be influenced by *time-sensitive* factors, such as seasonality, for example; pipelines that can only be laid during spring and summer;
- **Lessons Learned** – provides input to estimates based on the performance of previous, comparable projects. Because they are based on *actual results* and experience, inputs from lessons learned generally improve the accuracy of estimates; and
- **Project team knowledge** – Project team members can provide input to estimates based on their own experience and knowledge of similar projects. The value of this input is limited, and is generally less reliable than lessons learned, because it is based on *personal recollection* and is usually *undocumented*.

Various estimating methods are used to develop the project's costs estimates. You should familiarize yourself with the following methods. Note how and when it is most appropriate to use each of the following methods:

- **Analogous** (or *Top-Down*) **estimating** – uses the actual costs of similar, previous projects as the basis for estimating the cost of the current project. It relies on expert judgment to derive the estimate. It is less costly to perform than other estimating methods, but it is also less accurate. The closer in fact the current project is to similar projects, the more accurate the estimate will be. Top-Down estimating is usually performed in earlier phases of the project, when there is a lack of detailed information. It is often used to get an idea of the *magnitude* of the project cost;
- **Parametric** (or *unit cost*) **estimating** – uses mathematical models to derive a *scaled cost* for the project, based on the *parameters* of the work to be performed. The parameters are represented by standard unit costs associated with the tasks to be performed. Rates applicable to the tasks are selected, usually based on historical data. The model simply multiplies the quantity of the work to be performed by a historical unit rate applicable to the task, to derive a current estimate. For example, the cost to program a new software module might be based on the unit cost of the number of lines of code used in a previous, similar module. External or industry standard unit cost rates may be used as input to the model, where the performing organization does not have the necessary data; and
- **Bottom-Up estimating** – involves estimating the cost of individual work packages or individual schedule activities with the lowest level of detail. In some ways, it is the opposite of analogous estimating. Individual tasks or activities are estimated individually at the level where the work is performed (work package level). The packages are then "rolled up" (or summed at a higher level) to derive an overall cost for all of the work to be performed. Bottom-up estimating takes longer to perform, is more costly than analogous estimating, but is more accurate because it is based on the project WBS (and therefore reflects the total scope of the work to be performed).

Why is bottom-up estimating more accurate than analogous estimating? Because it is performed by the project staff responsible for carrying out the task(s) being estimated.

How can the accuracy of parametric estimates be improved? Positive improvements in the *learning curve* associated with the task being estimated will increase the accuracy of the estimate. This is because the accuracy of the estimate is a direct function of the estimator's skill and experience with the task being estimated. The more efficiently the task is performed, the more accurate the estimate will be. Training that improves the efficiency of task performance will therefore also improve the accuracy of the estimation process. Note that parametric estimating is used as a tool in both the cost estimating and cost budgeting processes.

Where estimates are being provided by an external vendor, it is necessary for the project management team to validate the costs submitted, especially in competitive bidding situations. *Vendor bid analysis* is applied to ensure that the estimates are reasonable and of a magnitude commensurate with the work to be performed under contract. In other words, the estimate represents what the work *should* cost.

All projects are subject to "unknowns," future events that may be uncertain, and must be anticipated. They must therefore be accounted for when estimating the project costs. Events that are classified as "known unknowns" and can be anticipated with a reasonable degree of certainty are accounted for under the category of Contingency Reserves. Most project risks fall into this category. These *discretionary* costs are included in the cost baseline. Contingency reserves can be aggregated and associated with a schedule activity of *zero duration* whose function is simply to hold the reserves for when they are needed. An alternative method is to create a *buffer activity* in the critical chain at the end of the network path for the group of schedule activities for which the buffer activity holds the reserve. Contingency reserves can be used at the project manager's discretion and direction; reserves should be "given back" if unused by the project. Do not confuse Contingency Reserves with *Management Reserves* (see page 177).

7.2 Determine Budget

[Page 167, Figure 7-4. *Determine Budget: Inputs, Tools & Techniques, and Outputs*]

The objective of Determine Budget is to establish a total cost baseline to measure the performance of the project, as based on the aggregation of the estimated costs for each of the project's constituent schedule activities (or work packages). Determining the budget involves the use of aggregation and parametric estimating to derive an overall project cost. An allowance is also made for unplanned but potentially required changes to the project ("unknown unknowns"). This is accounted for in the Management Reserves. These reserves are included in the project budget but are not part of the project's cost baseline. Why? Because earned value calculations (see below) measure project performance relative to the cost baseline (which represents the scope of the project that can be influenced by the project management team). However, management contingency reserves are excluded from the baseline because they are held outside of the project and are reserved for exceptional or unusual events that cannot be anticipated. Unlike contingency reserves, the project manager must obtain approval before disbursing management contingency reserves.

How and when project funds are disbursed is an important consideration when creating the project budget. *Funding limit reconciliation* is used to regulate disbursements and may require the project schedule to be adjusted using date constraints or imposed milestones, where funds are released in tranches, so that project spending conforms to a regular and predictable pattern of expenditure.

Apart from the practical consideration of managing the project's finances, the Cost Baseline, in the form of a time-phased budget, provides the basis for measuring, monitoring and controlling the project's performance. It is usually displayed as an S-curve in which cumulative cash flows are plotted against the cost baseline over the duration of the project (see example on page 178). Note that cash flow represents both outflows (expenditure) and inflows (revenue). Depending on the scope and complexity of the project, more than one baseline may be used to track different categories of cost; for example, external contractor and internal staff costs, or spending and income streams.

The project's total funding requirements (the budget) are represented by the cost baseline *plus* the management contingency reserves. The project is funded in incremental amounts that are released at periodic intervals or key milestones; for example, at the start of a phase.

When would you expect to see increased levels of expenditure during a project? In general, project spending increases during the execution of project activities when resource consumption (staff, materials) is highest.

7.3 Control Costs

[Page 179, Figure 7-7. *Control Costs: Inputs, Tools & Techniques, and Outputs*]

Project Cost Control is a critical part of Integrated Change Control (see pages 93-98). Cost intersects with both Time (=schedule) and Scope (=requirements, including quality). Take a moment to think about what that means and how it affects the project. If any one of these changes, then at least one of the other two is affected. For example, if the schedule increases, and resources are used for longer than planned, then project costs will also increase; if funding is reduced, then the scope of the requirements will also contract or change.

Controlling project costs means knowing what the project costs are. In other words, you must know how much cost is consumed during delivery of the project, and when those project costs will be consumed. The Performance Measurement Baseline helps to manage this by integrating the cost, schedule and scope parameters of the project. It is an approved plan for project work to be performed, against which project execution is compared and deviations from the plan are measured. It helps to answer the question, "*Is the project in control*?"

How is project cost control performed? It involves:

- influencing the factors that cause variance in the parameters that determine the project costs as detailed in the baseline;
- when variances occur, assessing if any corrective actions are required to bring future project performance, and the costs associated with that performance, back into line with the approved baseline;
- when changes occur, assessing what effect, if any, they have had on project performance, and if corrective action is required;
- updating the baseline to reflect all approved changes; and
- ensuring that unapproved changes are not included in the baseline and are not included in project performance measurements.

Performance is monitored continuously throughout the project by the project management team. As an indication of how important this activity is to the success of the project, note that the word "performance" occurs over 614 times in the PMBOK (by contrast, "project manager" occurs only 185 times). At periodic intervals, *project performance reviews* are carried out by the project management team to check that the project is proceeding as planned. If not, any necessary actions identified by the team to bring performance back into conformance with the project plan must be taken.

The following performance reporting techniques are used by the team to assess the project's performance:

- **Variance analysis** – in which the actual performance of project work is compared to planned or expected performance, and any variations are assessed as to their impact on the project. Variance analysis is most often performed on cost and schedule data, but can also include scope, quality, resource and risk assessment;
- **Trend analysis** – in which project performance is assessed over time to determine if the project's performance is improving or deteriorating, or is within an acceptable range of variation;
- **Earned value** – in which planned performance (the baseline) is compared to actual performance.

PMI places great emphasis on the use of cost controlling techniques, like **Earned Value** (*EV*), to objectively assess project performance, because it is the most effective technique for integrating both cost and time when measuring project work. But it is the PMP exam topic that many candidates find the hardest to master, because it is not widely applied by project managers to their own projects. However, recognition of the importance of EV has increased. For example, the 2005 decision of the Office of Management and Budget (OMB) enforced the use of EV management in all IT projects at federal agencies, including compliance with ANSI 748 (the standard that describes industry guidelines for Earned Value Management (EVM) systems), and extended the use of EVM beyond federal defense agencies. PMP candidates should spend as much time as necessary on this topic to memorize the formulas used in EV calculations, to understand what they mean in terms of project performance and to know how to interpret the results of EV calculations. The PMBOK references four formulas under *Earned Value Management* (pages 181-183), three formulas under *Forecasting* (pages 184-185), and one under *To-Complete Performance Index* (pages 185-186). Make sure you understand these, their derivations and the basis for their calculation.

The main objective of EV is to:

- measure any variances in work performed from the planned or expected work;
- assess the extent and impact of the observed variances on the project;
- make any necessary adjustments or corrections resulting from these observed variances to bring the project back into line with the plan; and
- apply any approved changes to the plan and update all affected baselines to correctly reflect the approved changes.

Note that variances may be observed in these periodic measurements, but may not require adjustment to the plan or corrective actions if such variances are within the *tolerance limits* of the parameters being measured. EV is a *decision support tool* for determining *if* action should be taken. It is the size and magnitude of variances that determine the *kind* of action that the project management team may then need to take.

There are three main concepts in EV analysis. The purpose of these is to measure whether the value of project work performed at a given moment in time (when measurements are taken) is *as planned*.

- **Earned Value (EV)** – the estimated value of the budgeted amount of the work actually accomplished or performed when performance is measured. This is alternatively known as the *Budgeted Cost of Work Performed* (*BCWP*);
- **Planned Value (PV)** – the estimated value of the scheduled work that is to be accomplished or completed during the next reporting period. This is alternatively known as the *Budgeted Cost of Work Scheduled* (*BCWS*) ; and
- **Actual Cost (AC)** – the total cost of the work actually accomplished in performing the project work when performance is measured. This is alternatively known as the *Actual Cost of Work Performed* (*ACWP*).

Variances in both project cost and schedule are measured using the following formulae:

- **Cost Variance (CV)** – measures the difference between the estimated value of the budgeted work accomplished and the actual cost of the work accomplished. It answers the question "*Are we on budget*?"
  Formula: *EV minus AC = CV*
  A negative CV value (-) indicates that the project is *over budget*, while a positive value (+) indicates that the project is *under budget*; and
- **Schedule Variance (SV)** - measures the difference between the estimated value of the budgeted work accomplished and the estimated value of the scheduled work that is to be accomplished. It answers the question "*Are we on schedule?*"
  Formula: *EV minus PV = SV*
  A negative SV value (-) indicates that the project is *behind schedule*, while a positive value (+) indicates that the project is *ahead of schedule*.

What can you say about a project's performance that has a positive SV value but a negative CV value? Is the performance of that project any better than one with a negative SV value but a positive CV value? Answer: it depends on the causes affecting schedule and cost performance, and also on what actions may be required to bring performance back into conformance with the baselines.

The following indices are used to measure the project's cost and schedule performance:

- **Cost Performance Index (CPI)** – indicates the rate of return that the project spend is yielding. It answers the question "*For every project dollar we spend, what is the project returning?*"
  Formula: *EV divided by AC = CPI*
  A CPI value greater than 1 indicates that for every dollar spent, the project is earning more than the project spend (that is, costs are running below estimated levels). A CPI value of less than 1 indicates that the project is spending more than it is earning (that is, costs are running ahead of the estimated levels). The CPI value indicates how efficiently the project is being run with respect to costs; and

- **Schedule Performance Index (SPI)** – indicates the rate of project progress compared to the scheduled or planned progress. It answers the question "*If we continue at this rate, will we achieve our project end date as planned?*"
  Formula: *EV divided by PV = SPI*
  An SPI value less than 1 indicates that if the project continues at the same rate of progress as indicated by the SPI value, the project will not meet its planned completion date. For example, an SPI of 0.789 indicates that the project is progressing at 79% of its planned rate. Conversely, an SPI value greater than 1 indicates that the project is progressing at a rate that is ahead of its planned rate, and will therefore achieve its completion date earlier than expected. For example, an SPI value of 1.098 indicates that the project is progressing at about 10% ahead of its planned rate. The SPI value indicates how efficiently the project is being run with respect to schedule.

What does the following sequence of SPI values indicate: 0.656, 0.725, 0.898, and 0.929? An improving trend in schedule performance. Note that an SPI value (or a CPI value) by itself is of limited use. It is simply a snapshot of the project's performance at the moment in time when the measurement was taken. Of greater value is the sequence of SPI (or CPI) values recorded over time that show whether performance is improving or deteriorating, and whether any corrective actions taken by the project management team are having the desired effect of bringing performance back into line with the target completion date, as recorded in the approved baseline schedule. When used in this way, both SPI and CPI are *trend analysis* tools.

What kind of *work performance information* would you need to collect, and what kind of *performance report formats* would you use to support an EV management system?
Answer: see pages 83 and 238, respectively.

EV is also used to forecast performance, to help assess the cost, or amount, of the work remaining to complete the project.

- **Budget at Completion (BAC)** – represents the total planned value of the project work, and it is therefore the sum of all of the budgeted work.
  Formula: *total cumulative PV at completion (PV^c) = BAC*

- **Estimate at Completion (EAC)** – represents the currently expected total cost of the project when performance is measured and applies the current spend rate (expressed in the CPI value) to the total budget, to derive an estimate of what the project will cost at this rate.
  Formula: *BAC divided by CPI = EAC*

- **Estimate to Complete (ETC)** – represents an estimate of how much it will cost to complete the project from this point (when performance is measured) forward. The cost of the work actually accomplished is subtracted from the expected total cost of the project, to derive an estimate of how much more it is now expected to cost to complete the project.
  Formula: *EAC minus AC = ETC*

Note that PMBOK recommends using one of three methods to calculate ETC and EAC based on the risks and constraints associated with the project. These options are:

- **EAC forecast for ETC work performed at the budgeted rate –** predicts that all future ETC can be accomplished at the current budgeted rate. This approach can be used when performance has been low and it can be assumed that future performance will improve.
  Formula: *EAC = AC + BAC - EV*
- **EAC forecast for ETC work performed at the present CPI –** assumes that the project will continue to spend at the present burn rate or CPI.
  Formula: *EAC = BAC / cumulative CPI*
- **EAC forecast for ETC work considering both SPI and CPI factors –** assumes that the cost performance has been negative to date and that the schedule requirement is firm.
  Formula: *EAC = AC + [(BAC – EV) / (cumulative CPI * cumulative SPI)*

Project teams can refer to the Cost Management Plan to determine how cost variances will be managed by the project management team as described in the Cost Management Plan. Note that variances always tend to decrease as the project progresses and more work is completed. But all variances need to be assessed as to their cause and potential impact on overall project performance.

8. Project Quality Management

Project Quality Management (Chapter 8, pages 189-213) comprises three project management processes:

8.1 Plan Quality [*Planning*] – identifying which quality standards should be applied to the project and determining how these will be satisfied (pages 192-200);

8.2 Perform Quality Assurance [*Executing*] – applying quality activities to ensure that the project uses all of the processes needed to meet the project's requirements (pages 201-205); and

8.3 Perform Quality Control [*Controlling*] – monitoring project results to determine whether they comply with relevant quality standards, and identifying ways to eliminate the causes of unsatisfactory performance (pages 206-213)

Quality influences all projects at two levels. It affects how the project is performed and what is delivered by the project. Why is quality so important to projects?

The scope of a project is defined by stakeholder needs, wants and expectations. These represent the requirements the project must meet, no more and no less. Quality in projects is therefore often defined as *conformance to requirements* (delivering what is required) plus *fitness for use* (satisfying real needs), which generally equals *customer satisfaction*.

"Gold plating" the project, by providing extraneous or gratuitous features to a product or service, does not improve the quality of the project's product if those features do not meet the purposes for which the project was undertaken. Remember, if a feature or characteristic of the project's product or service is not defined in the requirements, then it is not required by the customer. This is one reason why requirements analysis is so critical to successful project outcomes. Identifying and managing stakeholder expectations means understanding and meeting their needs and wants; it also means not providing them with something that they neither want nor need.

The PMBOK (page 190) quotes the American Society for Quality (2000) definition of quality as "*the degree to which a set of inherent characteristics fulfill requirements.*" Therefore, the primary focus of Project Quality Management is on influencing and managing the factors that determine satisfaction of the product or service's *inherent characteristics*, expressed in the form of quality attributes, by focusing on the *degree* required, through measuring and calibrating the product or service attributes and applying the same to the processes that are used to create those attributes. Note how this approach to quality integrates the processes required to deliver the product with the results of the project.

Quality Management forms a broad and extensive body of knowledge and practice in its own right. It is beyond the scope of the PMBOK to cover this in its entirety. You may need to consult other sources to supplement the information on quality topics found in the PMBOK. However, for the purposes of the PMP exam, you must familiarize yourself with the most common and important Quality Management concepts and processes that form the background to the PMBOK's approach to quality in projects. This includes the principles and practices established by the four major *quality gurus* of the twentieth century (Deming, Crosby, Juran and Taguchi) who have influenced how quality is implemented and achieved within performing organizations today.

Familiarize yourself with the following:

- **Quality emphasizes prevention over inspection** – the principle that the cost of *preventing mistakes* earlier in the product creation process is generally much less than the cost of *correcting mistakes* that are revealed by inspection of the product later in the process; and
- **Quality implies continuous improvement** – the principle that all processes involved in project performance and creating the project's product should be *continually improved* to reduce costs and improve consistency to attain an optimal state. Similar to the principle of progressive elaboration, the continuous improvement method emphasizes small, incremental steps. The most well known model for continuous improvement is the *Plan-Do-Check-Act* cycle developed by Shewhart and popularized by W. Edwards *Deming*:
  - *Plan* the task or activity, specifying the desired outcome;
  - *Do* the task or activity, as defined in the plan;
  - *Check* the results of the task or activity against the desired outcome; and
  - *Act* to correct or amend the task or activity if the results did not meet the desired outcome.

  This cycle is repeated continuously until the optimal state of the process, task or output is achieved. Continuous improvement models have been developed for specific application areas, such as the Capability Maturity Model (CMM®) developed by the Software Engineering Institute (SEI) covering software development, and PMI's Organizational Project Management Maturity Model (OPM3®), covering project management practices within performing organizations. Such models use *benchmarking* to achieve observable improvements. Benchmarking compares actual or planned practices to those of similar organizations to provide a basis for measuring performance of those practices and to generate ideas for process improvement;
- **Quality means satisfying customer requirements** – the principle that customer requirements define the scope of the quality attributes that need to be met by the project. Because customer satisfaction is based on subjective needs, the PMBOK considers them to be *unquantifiable expectations* (page 110), which are difficult to successfully satisfy. By delivering what the project documented as deliverables (conformance to requirements), and by ensuring that the product or service meets the needs for which the project was undertaken (fitness for use), project managers have a better chance of successfully meeting customer requirements. In many ways, this principle is similar to the *conformance to requirements* view of quality, outlined by Philip B. Crosby.);

- **Quality is a management responsibility** – the principle that management is ultimately responsible for quality within the performing organization delivering the project. Once again, W. Edwards *Deming* is influential in defining the standards associated with this principle. Within manufacturing industries, Deming observed that production line workers are only capable of influencing about 15% of the quality of the production process; the other 85% is influenced by management decisions, through policies, standards, processes, organizational structures, budget, etc., that determine how quality is implemented in the performing organization. This observation by Deming is sometimes referred to as the *rule of 85*. Keep in mind that the project management team is responsible for defining and implementing quality within its own project;
- **Quality is not the same as grade** – the principle that *grade* is a category or rank that is used to distinguish items that have the same functional use but do not share the same requirements for quality (as defined by ISO standard 8402). For example, drill bits can be specified with respect to bore size, durability, hardness, etc., to meet different drilling requirements. If durability is low grade, then the bit may have to be replaced more frequently to complete the drilling. The bit may be *low grade* yet still capable of meeting the requirement of the drilling project. But if the bit's hardness is *low quality* and shatters during drilling, then the project is halted while the problem is being solved. Low quality is always a problem on a project, but low grade may not be. It is the project team's responsibility to determine the required levels of both grade and quality to meet the needs of the project;
- **Precision and accuracy are not equivalent** – the principle that *precision* is defined by observed consistency that the value of repeated measurements are closely clustered and exhibit minimal scatter or dispersion when plotted. *Accuracy* is defined as correctness of the measured value as compared to the true value. An accurate measurement may not necessarily be precise, and precise measurements are not necessarily accurate. As with quality and grade, the project team must determine what levels of accuracy and precision are required to meet the needs of the project;
- **The Cost of Quality (COQ) includes all of the costs related to quality** – the principle, formulated by Joseph M. *Juran*, that the cost of quality includes both the *cost of conformance* and the *cost of nonconformance*. Conformance costs include all prevention and appraisal costs associated with investing in proactive measures designed to assure delivery of quality requirements (validated by customer acceptance). Nonconformance costs (sometimes called *failure costs*) include all costs incurred as a result of error or other quality problems that result in rework, scrap, warranty costs, etc. Failure costs may be categorized as internal failure (discovered by the performing organization) or external failure (discovered by the customer);
- **ISO 9000** – provides for the establishment of quality systems within organizations, and it is administered by the International Organization for Standardization (ISO). Note that ISO 9000 does not mandate quality standards *per se*, only the framework and systems for creating and maintaining quality standards within the performing organization. It can be implemented within any organization;
- **Total Quality Management (TQM)** – based on the principle that if quality requirements are met, then customer requirements are met, TQM provides the primary focus for the ways in which a performing organization will strive to meet those requirements. TQM implies continuous improvement in all processes that drive quality in products and services. TQM can be implemented in various ways depending on the needs of the performing organization;
- **Six Sigma** – an approach to quality management that emphasizes continuous process improvement using statistical measurement to guide improvements and focuses on identifying and solving the root causes of problems. Taken literally, Six Sigma refers to the number of defects in a process. Six Sigma quality, or six standard deviations from the mean, would be equal to around 3 defects per million observations. As outlined in its methodology, taking steps to *define, measure, analyze, improve and control* (*DMAIC*), will limit the appearance of defects.

8.1 Plan Quality

[Page 192, Figure 8-2. *Plan Quality: Inputs, Tools & Techniques, and Output*]

The PMBOK approach to quality management emphasizes one of the key principles formulated by Dr. Genichi *Taguchi*. According to Taguchi, quality is *planned in, not inspected in*. Clearly the PMBOK agrees. In fact, according to the PMBOK, the primary purpose of Quality Planning is to identify which kinds of quality standards are relevant to the project, and then determine how best to satisfy them. This is performed in parallel with other project planning processes because meeting quality requirements often implies changes to the project costs or schedule.

A key input to the quality planning process is the performing organization's *quality policy*, as endorsed by senior management. In the absence of a formal quality policy, the Project Management Team will need to develop one specifically for the project. Where more than one quality policy can apply (for example, in a joint or multi-vendor venture) the Project Management Team will need to develop a policy standard specific to the quality needs of the project. The team is responsible for *communicating* the agreed policy to all stakeholders. The product scope description provides input to quality planning in terms of technical detail, such as product characteristics that are required to meet stakeholder needs and wants.

Product acceptance criteria (described in the Project Scope Statement) influences quality decisions and may significantly increase or decrease project quality costs, especially as meeting the criteria directly affects project success (determined by customer acceptance of the project's deliverables).

Quality planning also requires a *cost-benefit analysis* of meeting the project's requirements, especially where trade-offs between project scope and cost may need to be made. The cost of not meeting quality requirements results in stakeholder dissatisfaction and higher costs incurred by rework required to satisfy stakeholder expectations.

When quality is achieved, both the processes required to create the project's product or service, and the actual product or service itself, are *optimal*. An optimal state is one in which the process or product is as effective or as functional as required by the user of the process or product. Optimization is performed by influencing and adjusting those factors affecting the variables in the process or product that affect quality. A key methodology for identifying and adjusting those factors, also developed by Taguchi, is Design of Experiments (DOE). DOE provides a *statistical* basis for systematically adjusting all factors affecting quality variables in a process or product by examining alternatives.

The output of the quality planning process is the Quality Management Plan. This plan describes how the Project Management Team will implement the performing organization's quality policy. The plan provides for both quality control (QC) and quality assurance (QA), and describes how continuous process improvement will be achieved by the project. The plan needs to be supported by defined measures with which the quality of the project's processes and product or service can be evaluated and verified. Quality Metrics provide specific descriptions (for both processes and products or services) of what is to be measured and how it will be measured (page 200). Quality metrics are used in both QA and QC processes, and includes such metrics as, operational availability, product reliability, process failure rate, data error rate, etc.

Quality Checklists are often used during QC to verify that a set of required steps in a task, process or activity have been performed correctly and according to the defined or mandated sequence. Note that following a checklist precisely may not result in accurate results if any of the steps in the process are deficient or are not optimal. The main purpose of the checklist is to promote *consistency* in the execution of frequently performed tasks or activities.

One of the key planning artifacts that explicitly address process improvement in the quality planning process is the Process Improvement Plan. The purpose of this plan is to identify steps for analyzing processes that will facilitate the elimination of waste and non-value added activities in order to enhance customer value.

As an output from quality planning, a Quality Baseline is created that provides the basis for measuring and reporting quality performance, and is a subsidiary part of the Performance Measurement Baseline (page 267). Which other baseline plans contribute to the overall performance measurement baseline?

8.2 Perform Quality Assurance

[Page 200, Figure 8-8. *Perform Quality Assurance: Inputs, Tools & Techniques, and Output*]

Quality Assurance (QA) is the application of planned, systematic quality activities to ensure that the project utilizes all of the processes required to meet project requirements. Note that continuous process improvement is facilitated by QA and that many performing organizations have dedicated QA or similar functional departments who are responsible for oversight of QA activities. The primary focus of process improvement is the performing organization's business processes, although it can often be applied to other process areas and functions within the organization. The two main tools and techniques used during QA are Quality Audits and Process Analysis.

Quality audits examine whether project activities comply with organizational and project policies, processes and procedures and are conducted using independent, structured reviews. The objective of these reviews is to identify inefficient or ineffective policies, processes and procedures and to promote remedial actions to bring these back into compliance. Quality audits are also used to verify that corrective actions, approved change requests and preventive actions identified by the project have been implemented. Follow-up audits may be conducted to confirm that previous recommendations have also been implemented. Some performing organizations have dedicated audit departments that are integrated within the organization's compliance functions (Legal, Tax, etc.). As the authoritative source for all project management processes within the performing organization, the Project Management Office (PMO) may also perform quality audits as part of its governance function.

The process improvement plan facilitates Process Analysis by defining the steps required to identify needed improvements from both a technical and an organizational perspective. *Root cause analysis* is used in process analysis to identify the underlying causes of problems and to develop preventive actions to correct these and similar problems. This analytical technique drills down deep into the causes of the problem, past the superficial symptoms, until the *fundamental* causes of variance, defect or risk in a process are identified. Where else in the project is root cause analysis used to identify potential solutions to problems? (See page 248.)

8.3 Perform Quality Control

[Page 206, Figure 8-10. *Perform Quality Control: Inputs, Tools & Techniques, and Output*]

Quality Control (QC) focuses on the correctness of work performed. The objectives of QC are to verify that as project work is performed, results comply with the relevant quality standards and actions are taken to eliminate the causes of any unsatisfactory results. QC is performed throughout the project using statistical sampling techniques to continuously monitor project results. Statistical sampling is a technical skill that requires both relevant knowledge and competency to apply correctly within a QC environment. Project management teams need to be knowledgeable about such techniques in order to evaluate the results of QC activities and to take appropriate action as indicated by the results. In order to assess the results of QC activities correctly (and as preparation for the PMP exam), you need to understand the following statistical sampling concepts and terminology:

- **Attribute** – a defining characteristic of a process or product. The attribute is measured to determine if the item or component sampled is acceptable. A unit of measurement is therefore implied as part of the definition of the attribute. For example, as drill bits are manufactured, they will be sampled to ensure that the bore conforms to the specified size as defined in millimeters;
- **Variable** – the characteristic of the process or product that is measured, such as size, shape, weight, etc.;
- **Sample size** – the *number of items*, or representatives, selected in the sample set;
- **Range** – the *limits of a population*, defined by the difference between the largest measurement or value and the smallest in the population distribution;
- **Variance** – a measurement of how far the variable being measured is from the expected value typically associated with that variable (the *norm*);
- **Standard deviation** – a statistical *measure of dispersion* of a sample, represented by the square root of the average of the squares of deviations about the mean of a set of measurements or data. Standard deviation is used to identify the *range of accuracy* that is applied to the results of a defined measurement. It is commonly represented by the sigma (or standard deviation) scale in ascending order of magnitude, as follows:
  - **+/-** 1 sigma = 68.26%,
  - **+/-** 2 sigma = 95.46%,
  - **+/-** 3 sigma = 99.73% (representing 27 in 10,000 occurrences),
  - +/- 6 sigma = 99.99% (representing 1 in 10,000 occurrences);
- **Normal distribution** – across a statistical sample is depicted by a *bell curve* distribution, in which 50% of the curve occurs above the mean (to the right-hand side of the mean point, usually a line dividing the bell curve), and 50% occurs below the mean (the left-hand side of the mean point);
- **Mean** – the *arithmetic average* expressed by the sum of the measurements in a sample set, divided by the number of measurements (the sample size);
- **Median** – the value in a range of data points representing the *midpoint* in the range, and having as many data points above the midpoint as it does below;

- **Mode** – the value in a range of data points that represents the *most frequently observed* value in that range;
- **Statistical sampling** – involves selecting a sub-set of the total population for inspection (the sample set). Statistical sampling is often used to reduce the cost incurred by inspecting a larger part of the population, and also to reduce the time it would take to inspect a larger part of the population. Used correctly, statistical sampling techniques provide highly effective project QC;
- **Attribute sampling** – an audit technique in which representatives of a population are selected (the sample set) and assessed for *absolute conformance* (yes or no);
- **Variables sampling** – an audit technique in which the *degree of conformity* of a sample representative is measured and rated on a continuous scale;
- **Special causes** – unusual events or results observed in a process indicating that it is *not in control*;
- **Common causes** – also known as *random causes*, these are events or results that are attributable to a known variation within the normal working of the process. It is common because it is a known and accepted imprecision within the process, and is random because, though it is statistically predictable, it is not known when the random event will actually occur;
- **Assignable cause** – a single data point, or a pattern of data points, that indicates investigation is required to determine the cause of variation in the process (see Control charts below);
- **Tolerances** – specify the acceptable variations in the attributes of a process, and provide measurement of the degree of accuracy within the tolerable range of variation (acceptable *margin of error*);
- **Control limits** – define the variable limits (upper and lower) within which a process is observed to be *in control*. Control limits are dynamic and should be adjusted when required, to reflect the normal range of operation of the process;
- **Prevention** – includes all of the actions taken to keep errors out of *the process*; and
- **Inspection** – includes all of the actions taken to keep errors out of the hands of *the customer*. The purpose of inspection is to determine if the artifact under inspection (process, component, product, result) *conforms to standards*.

According to the PMBOK (pages 208-213), there are Seven Basic Tools of Quality. These are the most commonly used QC statistical analysis tools and techniques. Familiarize yourself with these so that you know how they function, what purpose they serve, and how to interpret their results. For example, you should know how to recognize the occurrence of a rule of seven (see below), and what such an occurrence means in terms of quality.

- **Cause and Effect Diagrams** – also known as *fishbone* or *Ishikawa* diagrams, cause and effect diagrams are used to depict and aid *analysis* of how various factors may contribute to, or be linked to, potential problems or effects. Where else might you expect to use this *diagrammatic technique* to analyze the potential causes of a problem? (See page 248.);
- **Control Charts** – are used to determine whether or not a process is stable or exhibits predictable performance (is *in control*). The chart depicts the behavior of a process observed over time. It is a tool for *detecting trends*. The data points gathered in a control chart are used to identify special cause variation, that is, evidence that the process is inconsistent or unpredictable in its behavior (it is *not in control*). Examination of the data points that appear on the chart in *non-random patterns* may point to changes in the normal operation of the process that require further investigation and adjustment of the process. A process in control will be indicated by a random and regular distribution of data points between the Upper Control Limit (UCL) and the Lower Control Limit (LCL) and around the mean line (in the center of the chart representing the average). Both the UCL and the LCL are usually set at +/– 3 Sigma (or standard deviations). As long as the process performs within these limits, it does not need to be adjusted. A non-random data pattern that is indicative of problems with the process under examination is the *Rule of Seven*. The rule of seven is indicated by at least seven or more data points *occurring contiguously* in sequence, in either the upper or lower part of the control chart (between either the LCL and the mean line or the UCL and the mean line). Other indications that the process may no longer be in control are evidenced by data points that *fall outside* of the UCL and LCL (are outside the bounds of normal variation). Similar to the rule of seven, data points that occur persistently near to, or on, either the LCL or UCL (a pattern sometimes referred to as *hugging the line*) may indicate that there is a problem; or that the boundaries of the process may need to be recalibrated to more properly reflect the true operating range of the process. A control chart depicts the statistical behavior of a process so that when operating normally, it is *statistically* in control. Therefore, because control limits are dynamic, the boundaries may be adjusted when required. On the control chart you will also see an Upper Specification Limit (USL) and a Lower Specification Limit (LSL). These boundaries represent the customer requirements (performance and quality) of the process being monitored. For the process to meet customer requirements, the range of operation defined by the USL and the LSL must be *within* the boundaries of the UCL and LCL (i.e. the USL and LSL will be the outermost boundaries on the chart). Otherwise, although the process may be operating as expected, it will not meet customer requirements. Note that the USL and the LSL are fixed and cannot be recalibrated to accommodate variation in process performance. In addition to monitoring repetitive tasks (such as a manufacturing process), control charts may be used to monitor and evaluate project performance over time, with respect to variances in costs, schedule and other project performance parameters;
- **Flowcharting** – is used to analyze *how* problems occur through the depiction of the interrelation of elements within a process. The depiction of the process flows may vary in their graphical representation but usually consists of activities, decision points and the order of processing. A typical flowchart shows inputs, process actions and outputs. Flowcharting is used by the project team as a *predictive tool* to identify where problems might occur in the process, and to aid development of approaches for dealing with these potential problems. Note that a *fishbone*, or *Ishikawa* (see below), diagram is a type of flowchart;
- **Histograms** – are bar charts that show the distribution of variables where each bar (or column) represents an attribute or characteristic of a problem or event. Histograms are used to identify the *cause of problems* in a process by looking at the shape and width of the distribution;

- **Pareto Chart** – is a specific kind of *histogram* in which the causes of a problem or event are ordered by frequency of occurrence, and displayed by category or type of cause. Pareto charts are used to identify and evaluate nonconformities in processes. The rank ordering of the occurrences is used as a *guide to corrective action* by focusing the project team's attention on the small, but critical number of problems or factors that are causing the largest number of defects or errors in the process. Pareto charts illustrate *Pareto's Law*, which states that a relatively small number of causes will typically generate the largest number of problems or errors. Also known as the *80:20 rule,* because 80% of the problems are attributable to 20% of the causes;
- **Run Chart** – is used to *track* and *analyze trends* in performance over time. Data points are plotted in the order in which they occur on a line graph so that patterns of variation in the process or results (including both improvement and deterioration) are captured over time. The trends are analyzed to *forecast* future performance based on historical results. A run chart can be used to monitor both technical and cost and schedule performance; and
- **Scatter Diagram** – depicts the pattern of relationships between two variables, and is used to analyze the possible relationships between changes observed in the two variables. Dependent versus independent variables are plotted. Scatter diagrams are used to *identify* which variables in a process may be more closely related than other variables. They *aid analysis* of the potential influence that those relationships might have over the process. Data points that are more closely related appear closer to a diagonal line on the diagram than other data points.
- **Statistical sampling** – involves selecting a sub-set of the total population for inspection (the sample set). Statistical sampling is often used to reduce the cost incurred by inspecting a larger part of the population, and also to reduce the time it would take to inspect a larger part of the population. Used correctly, statistical sampling techniques provide highly effective project QC;
- **Inspection** – involves the examination of work products to determine if it conforms to documented standards. Typically includes measurement and are often called a peer review, audit or a walkthrough.
- **Approved Change Requests Review** – is used to verify that change requests were implemented as intended.

If any defects are detected during QC, these must be repaired so that the process, product or component can be brought back into compliance with the relevant requirements or specification. This is accomplished using *Defect Repair Review*, performed by the QC department.

9. Project Human Resource Management

Project Human Resource Management (Chapter 9, pages 215-241) comprises four project management processes:

9.1 Develop Human Resource Plan [*Planning*] – identifying and documenting project roles, responsibilities and reporting relationships, as well as creating the staffing management plan (pages 218-222)

9.2 Acquire Project Team [*Executing*] – obtaining the human resources required to complete the project (pages 225-229)

9.3 Develop Project Team [*Executing*] – improving the competencies and interactions of team members to enhance project performance (pages 229-235); and

9.4 Manage Project Team [*Controlling*] – tracking team member performance, providing feedback, resolving issues, and coordinating change to enhance project performance (pages 237-241).

One of the most important questions a performing organization must answer when selecting and initiating a project is: "*Do we have the capability to do this successfully?*" This does not mean just financial and technical, but also human resource capability, in terms of availability of the necessary skills, knowledge, experience and manpower to satisfy the requirements of the project and to meet them successfully. Effectively managing a project's human resources is therefore critical to the success of the project.

The effectiveness of the human resource capability within the project environment is affected by a number of factors. Managing human resources means understanding, controlling and influencing those factors to achieve desired results. This is accomplished through Project Human Resource Management: the application of relevant processes to organize and manage a project team.

Many performing organizations believe that they must have the *best* people working on their projects to assure success. In fact, success is more likely if you have the *right* people working on the project. This is the primary focus of project human resource management: to secure the *right kind* of human resource to meet the project's needs, and to enhance and maximize the skills, knowledge and experience of those resources to achieve the *best results*.

The PMBOK approach to project human resource management emphasizes the important role that both the project management team and project manager play in influencing, directing and managing all project activity. The PMBOK uses the following definitions to describe the relationships and roles of the various staff engaged in a project. In particular, note the difference between "project team" and "project *management* team." You do not need to memorize these definitions, but as you read the PMBOK, you should note which resource group is responsible for which activities or processes.

- **Project staff** – alternatively referred to as *project team members*, they include all staff performing project work as a regular part of their assigned duties. Project staff report directly or indirectly to the project manager;
- **Project team** – includes the project manager, the project management team and, on some projects, the sponsor, too;
- **Project management team** - a sub-set of the project team, alternatively known as the core, executive or leadership team, who are responsible for project *management* activities. On small scale projects the project management team may be comprised of most of the project staff; and
- **Project manager** – the person assigned by the performing organization to achieve the project objectives.

Note that the PMBOK's glossary definition (page 444) emphasizes the fact that the project manager is *assigned*. This is why the charter is so important to project initiation, as it confers *formal authority* on the project manager to apply organizational resources to project activities (page 443). A project manager's authority is defined by the extent to which he or she can command and direct the necessary (human) resources to achieve desired project outcomes.

Although stakeholders are acknowledged in this process domain, the requirements to influence, direct and manage their project needs and wants are primarily addressed under Project Communications Management (see section 10.4 below).

9.1 Develop Human Resource Plan

[Page 218, Figure 9-2. *Develop Human Resource Plan: Inputs, Tools & Techniques, and Output*]

The objectives of Human Resource planning are to determine the roles, responsibilities and reporting relationships of project participants (both individuals and groups), and to create the project's staffing management plan. The plan must address all of the factors that determine the effectiveness of the project's human resource capability that will, in turn, influence how the project is performed and the success of its results. Therefore, the scope of the plan must address such issues as:

- *Staff acquisition* - How and when are staff acquired by the project (to achieve optimal resource utilization)?
- *Staff release* - How and when are staff released from the project (to give back resources to benefit other projects)?
- *Organizational influence* - What effect will the project's staffing requirements have on the performing organization (on normal business operations or on other projects)?
- *Training* - What new or enhanced skills may be required by staff to complete the project (by identifying training needs and promoting skills acquisition)?
- *Motivation* - How will staff be recognized and rewarded for their efforts (to encourage positive behaviors that meet the needs of the project's requirements)?
- *Compliance* - What kind of compliance considerations need to be taken into account when planning how staff will be used on the project (for example, health and safety, statutory or union regulations, etc.)?

When planning how human resources will be used, the project management team needs to be aware of how Enterprise Environmental Factors specific to the project might influence the development of roles and responsibilities, and how the performing organization might be involved in the project. These factors include:

- **Organizational** – identifying which functional units or departments will be involved in the project, how those departments interact and interrelate, what methods of working they use, etc.;
- **Technical** – identifying the technologies and technical resources available to meet the projects needs, including technical operating standards, mandated technology use, standard operational workflow processes, etc.;
- **Interpersonal** – identifying candidates for the project team, including their job descriptions, how they interact with other staff and departments (formal and informal), reporting relationships, supervisor-subordinate relationships, customer-supplier relationships, levels of cooperation, trust, respect, etc.;
- **Logistical** – identifying the logistical constraints that may determine the effectiveness of team member interactions and cohesion, including geographical proximity (collocation) or dispersion (different areas of the country or different countries), time zone differences, etc.; and
- **Political** – identifying different stakeholder agendas and goals, informal relationships that support such agendas and goals, how and where stakeholders exert influence within the organization (especially informally) and how that might affect project performance.

Enterprise environmental factors exert a large influence over project performance. They may enhance or constrain project capability depending on the type of factor and the needs of the project. Their widespread influence is evidenced by the fact that they occur as inputs in over one-third of all project management processes described in the PMBOK. Human resource planning is one instance of their occurrence. Can you identify the other 15 processes in which they occur?

In addition to the above factors, the project management team may also find its human resource planning *constrained* by the following:

- **Collective bargaining agreements** – union and other employee agreements with the performing organization may limit the project management team's ability to flex roles and working arrangements to meet project needs;
- **Economic conditions** – may impact the kind of human resources that can be secured and utilized effectively. These conditions include, for example, restrictions on travel due to budget constraints (dispersed team members cannot meet face-to-face), hiring freeze (having to work with available resources), lack of funding to meet training needs (ability to acquire new or enhance existing skills is limited), etc.; and
- **Organizational structure** – the performing organizational structure directly impacts how the project is performed with respect to the amount of influence and authority that the project manger and project management team can exert in securing and directing the necessary resource and priority to successfully complete project activities.

Performing organizations may be structured in a number of ways to meet both business and project needs. How projects are accommodated within organizations is indicative of the importance that organizations place on projects to support their business goals. From a project performance perspective, an organization's structure will determine the organizational constraints that the project management team will need to work with in order to deliver the project.

Organizational structures are defined by the interactions and relationships between the various constituent functions or departments of the performing organization. The relationships are generally determined by the business needs of the organization. Interactions between functions or departments often create relationships in which the outputs, resources or activities of a group or department are interdependent, or shared across the organization. These relationships are typically represented in a matrix diagram. A *matrix organization* is one in which the project manager *shares responsibility* with the various functional managers for assigning priorities and for directing the work of staff who are assigned to the project.

Organizational structures can be categorized according to an ascending scale of project management influence and authority. Note that as you ascend the scale,

- the authority and influence of the project manager increases;
- resources allocated to the project increase; and
- the number and scale of projects sponsored by the performing organization increases.

The PMBOK recognizes five types of organizational structures that can be distinguished according to the extent to which they support and promote projects within a performing organization (see pages 27-32). You must be able to recognize these types, and understand how they limit or enhance the ability of the project manager and project management team to influence and direct organizational resources to meet project needs.

- **Functional** – in a functional organization, each specialist department or group has ultimate authority over any project work performed by its staff, and will defer to other departments for work outside of its specialization. Projects are performed in accordance with the hierarchical structure of the company. The project manager has a part-time role with little or no authority, project management is subsumed within functional roles, the project budget is controlled by functional managers, and very few staff are assigned full-time to project work;
- **Weak Matrix** – functional departments still exert strong control over resource allocations and budget, and the project manager's authority is limited. However, as much as 25% of staff may be assigned full-time to project work in a weak matrix;
- **Balanced Matrix** – the project manager begins to share authority with functional managers for directing and assigning staff to project work, as well as sharing in control over the project budget. As much as 60% of staff may be assigned full-time to project work;
- **Strong Matrix** – control and influence over resources and budget assigned to projects is shared with functional managers, though the project manager exerts the stronger authority over these. As much as 95% of staff may be assigned full-time to project work; and
- **Projectized** – Performing projects *is* the business of the organization, and functions and departments are primarily aligned to support the execution of projects. Project managers have full authority (and responsibility) for directing and controlling project resource and budget, with strong reporting lines into the project manager from departments performing project work. Up to 100% of the organization's staff may be assigned full-time to project work.

These organization types are not mutually exclusive. Organizations can accommodate more than one type of structure if the needs of their business demand it. For example, a weak matrix organization may create a highly projectized structure within the company in order to deliver a business critical benefit, as was the case with many companies who needed to respond to potential Y2K threats within their regular business functions.

The diagram on page 28 of the PMBOK (*Figures 2-1, Organizational Structure Influences on Projects*) summarizes the characteristics of these organizational types. In particular, note how the project manager's role title changes from one type to the next. The role titles are indicative of the kind of organization that is performing the project work. For example, if a project manager is called a *Project Officer*, then the kind of organization he or she is working in is probably a *Balanced Matrix*. Note also that the more an organization exhibits traits of a Weak Matrix organization, the stronger the project manager's negotiation skills will need to be in order to acquire resources from the owning functional managers. For the purposes of the PMP exam, it's essential to know the limitations that each organizational structure imposes on the project manager's authority and influence.

Whatever the structure of the performing organization, the roles, responsibilities and reporting relationships of project participants must be clearly delineated and understood. Clarity contributes to success by unambiguously identifying the kind of contribution expected of each participant (their role), and how those contributions fit within the overall project framework (their responsibilities).

Roles and responsibilities are typically described and depicted in the following formats:

- **Hierarchical-type chart** – in which project activities and deliverables are mapped to the functional group or department responsible for executing those activities and delivering artifacts in accordance with the project management plan. The company *org chart* generally provides the base map;
- **Matrix-based chart** – in which the level of responsibility for a project task or deliverable is explicitly identified with a team member or group. Similar to an organizational matrix, the responsibilities assigned to each project member are expressed in terms of a level of authority over a specific task or activity. These levels define the interrelationships between team members at the task level;
- **Text format** – in which much more detailed descriptions of roles, responsibilities, levels of authority, qualifications, competencies, etc., can be provided than in a hierarchical or matrix chart format. Alternative names for such text-based formats include *Role-Responsibility-Authority form* and *Position descriptions*.

Whichever format is selected, the purpose of these is the same: to ensure that each work package has an accountable owner assigned, and that all project participants have clearly defined roles and responsibilities. A key source of conflict within projects is ambiguity over *who* is responsible for *what*. This problem can be further exacerbated by ambiguity regarding authority over project activities and the assignment of priorities where trade-offs may need to be made to ensure delivery of an expected contribution.

Hierarchical charts are similar to WBS charts in format. The *Organizational Breakdown Structure (OBS)* is used to map project activities or work packages to the performing organization's departmental hierarchy to show which departments or units are responsible for which project contributions. A similar kind of chart is used to identify types of resources deployed across the project. The *Resource Breakdown Structure (RBS)* is useful for tracking costs associated with resource types and can be aligned with the performing organization's accounting systems. Note that the RBS can be used to track resource types other than human resources. There is also another RBS that is referred to in the PMBOK, the *Risk Breakdown Structure* – see page 280. Do not confuse this RBS with the Resource RBS.

At a lower level of granularity, *matrix-based charts* are generally used to identify which project members are responsible for which project activities or deliverables (although this is sometimes done at the group or department level). A *Responsibility Assignment Matrix (RAM)* is a chart that shows not only who is responsible for what, but also the level of authority they exert over the task or activity. Using the project WBS or similar structural breakdowns, the RAM lists project tasks or activities along one axis, and the team members' names along the other axis of the matrix. For each activity, a responsibility is assigned to a team member according to the level of authority that they have over that activity. This is sometimes called a *RACI* chart, after the names of the levels of authority identified as follows:

- **R***esponsible* – the team member who has *ultimate authority* for executing the task or activity meeting the needs of the project;
- **A***ccountable* – the team member who has *ultimate responsibility* for ensuring that a task or activity has been completed as required by the needs of the project;
- **C***onsult* – the team member who must be consulted about the performance of the task or expected outcome, as it may impinge or directly affect the performance of activities or tasks for which they are responsible; and
- **I***nform* – the team member who must be made aware of the performance of a task or outcome so that they can respond, if appropriate, from an informed perspective.

See page 221 of the PMBOK for an example of a RAM chart. Only one person should be identified as the *accountable owner* of a task or activity. Ideally, only one person is *responsible* for a task, but often there may be more that one responsible team member (for example, the QA team is responsible for project QA tasks). More than one team member may be *consulted* or *informed* about a task.

Note that a RAM provides unambiguous clarity about each team member's role in relation to the performance of a project task or activity. Why is that so important? A RAM is a communications tool among team members that helps to avoid misunderstanding and conflict over levels of ownership around project activities.

RAMs identify formal relationships between project participants. But equally important to team cohesion and project performance are informal relationships that arise from *networking*. Networking includes all extra-project relationships and interactions that provide project participants with information, knowledge and experience that are used to enhance project performance.

All roles and responsibilities required by the project must be identified and defined as a result of the human resource planning process. At the very least, the following must be documented:

- **Role** – the part that the team member will play in the project. Each team member is ultimately accountable for the role assigned to them;
- **Authority** – confers rights to make decisions, apply resource and sign approvals. The level of authority exercised by each team member derives from their designated and agreed upon project responsibilities;
- **Responsibility** – is defined by those accountabilities which the team member must perform or execute to meet project needs; and
- **Competency** – is defined by a team member's skills and capacity to perform tasks assigned to them to meet project requirements. Team member competency impacts, both positively and negatively, project performance.

The Staffing Management Plan is the formal planning document that describes how and when the project's human resource requirements will be met and is comprised of the following components:

- **Staff acquisition** – addressing how and where project staff will be added to the project, including costs of acquisition (determined by the skills, knowledge, and experience required to meet project needs);
- **Timetable** – identifying when staff will be added to the project and how long they will be utilized on project activities. A *resource histogram* can be used to plot staff utilization (scheduled versus actual). The rank ordering of utilization rates across staff categories can be used to identify where *resource leveling* may be required to better manage peaks, or to balance over-extended use of staff;
- **Release criteria** – defining when and how staff will be released from the project and returned to their functional department or transitioned to another project. Diligently planning and managing the end of project assignments can enhance staff motivation and morale and help avoid diminished performance or poor utilization of resources;
- **Training needs** – identifying how required competencies will be acquired by staff to meet the project's needs;

- **Recognition and Rewards (R&R)** – defining criteria and behaviors by which team members will be rewarded for their project efforts. The scope of an effective R&R scheme must be based on those activities that a team member can *personally influence* and *control*. Effective R&R schemes reinforce positive behaviors by encouraging contributions that enhance project performance. For example, working extra hours to make up for time not accounted for in a poorly planned schedule should not be rewarded, as it implies acceptance of a flawed schedule. Meeting a milestone on the date scheduled, on budget and to the agreed level of quality should be rewarded. Why? Because project performance is defined as "*delivering what we said we would deliver*." Behaviors that support that result should always be encouraged. For this reason, R&R schemes are an integral part of the Develop Project Team process;
- **Compliance** – identifying how the project will ensure that it meets the requirements of human resource policies, statutory regulations, union agreements, etc.;
- **Safety** – identifying relevant health and safety policies and procedures that may affect staff in the performance of their project work.

In this list, note how some of these components specifically address the needs and wants of project staff (training, recognition and rewards, safety). The behaviors of team members affect project performance. Understanding the factors that create and shape behavior in the work place is supported by a substantial body of organizational theory and research. It is not necessary to know this in detail, but you should be aware of the general factors that influence worker motivation, and be familiar with the following theories of behavior.

People work in expectation of compensation, recognition and gratitude for the work that they perform. This is the most widely held explanation of worker motivation. In line with this positive view, another view, known as *McGregor's Theory Y*, holds that most workers want to perform the work that they do, and that they find their work satisfying (otherwise, why would they work?). A contrary view, known as *McGregor's Theory X*, holds that most workers dislike what they do and will try to avoid doing it. Whichever of these behavioral viewpoints is held by management (including the project manager) will influence how staff are managed. For example, managers who have a Theory X viewpoint have an *authoritarian* management style, in which staff are strongly supervised and must be coerced into working to meet management objectives. On the other hand, Theory Y managers exhibit a *participative* management style, in which workers are viewed as responsible and are encouraged to contribute in shaping their own work. How team members themselves behave can reinforce or undermine the viewpoints held by management. In general, which is the better management style?

Behaviors arise from our needs and wants. The relative importance and influence of these needs and wants changes over time as they are met. This insight underpins a model of behavioral development known as *Maslow's Hierarchy of Human Needs*, in which the individual progresses from satisfying basic physiological needs to satisfying higher, cognitive needs. The levels of progression are usually represented in the form of an ascending pyramid, beginning with physiological needs at the lowest level.

- **Physiological needs** – representing the basic or fundamental needs of existence, such as shelter, food, clothing, etc. The primary objectives of these needs are self-preservation and comfort;
- **Safety needs** – representing the avoidance of risk, pain or harm. These needs are met by anything that promotes and assures stability, order and security;
- **Social needs** – representing companionship, family and social relationships;
- **Esteem needs** – represented by our sense of status, derived from achievements and responsibilities that are recognized, acknowledged and rewarded; and
- **Self Actualization** – representing the cognitive level at which the individual realizes their full potential, attaining self-fulfillment.

Looking at the characteristics of each level, how do they relate to workplace behaviors? Each of these needs may influence an individual's behavior more strongly than others at various times in their life (and will fluctuate as needs are met or not met). Not meeting these needs may have negative consequences. For example, problems and issues from outside of the immediate work environment (such as social or physiological) may affect how the individual performs within the work place.

Various factors in the work place itself can determine how satisfied or dissatisfied the worker feels and hence how well (or badly) the worker will perform. *Herzberg's Motivation-Hygiene Theory* is similar to Maslow's needs hierarchy in that it acknowledges both the physiological and the psychological needs of individuals, and how these are met (or not) in the work place. Herzberg identified a number of factors in the work environment from which worker dissatisfaction may arise. These *hygiene* factors comprise such elements as company policies, work conditions, pay, relationships with line management and peers and levels of supervision. These elements are primarily intended to maintain and govern the work environment, but Herzberg realized that they are also the biggest source of worker dissatisfaction. Though they help to regulate the work environment, hygiene factors by themselves do not create worker satisfaction. Like the esteem and self actualization levels in Maslow's needs hierarchy, Herzberg's *motivation* factors focus on achievement, recognition, work itself, responsibility, advancement and personal growth. It is from these elements that workers derive their deepest sense of satisfaction, and this leads to enhanced performance and increased productivity.

9.2 Acquire Project Team

[Page 226, Figure 9-7. *Acquire Project Team: Inputs, Tools & Techniques, and Output*]

Building the project team involves acquiring staff with the *right level* of skills, knowledge and experience to complete project activities according to the needs and requirements of the project. The project management team's ability to *select* the right staff to do this may be constrained by enterprise environmental factors, such as staff availability, the competencies of the staff available (inc. relevant experience of similar projects), the cost of acquisition (salaries, overtime, bonus payments, fees for external contractors, etc.) and the interests of staff (inc. motivation in working on the project).

The project management team may need to *negotiate* with functional managers or other project managers to acquire staff for their own project. Where companies initiate more projects than they have staff available to meet the demands of those projects, the project management team may have to *compete* with other projects for resources. Functional managers therefore play an important role in *prioritizing* how they will assign their staff to multiple projects. Companies with a robust project selection process can help functional managers make the right priority calls by guiding them in assigning resources to those projects that best meet the performing organization's business goals. Note how the project charter helps functional managers make resource assignment decisions. The performing organization recognizes the project through the issuance of the project charter, and this, in turn, supports the project team acquisition process by *authorizing* the project manager to apply resources to the project (see section *4.1 Develop Project Charter*).

As with formal negotiation, informal *networking* may also help the project management team acquire resources. Where the team is unable to acquire resources internally to complete all project activities, they will have to go outside of the company and engage *external contractors*, or *subcontract* to external organizations, for any deliverables that cannot be met internally. Building a *virtual team* is an effective means of acquiring geographically dispersed or time-zone separated resources. The dispersed characteristic of a virtual team provides flexibility and opportunity for team members to participate in potentially more projects than their physical location might ordinarily allow. Virtual teams also provide the project management team with greater access to required skills and knowledge because the size of the resource pool is not constrained by a single, physical location. Virtual project teams can also be found in matrix organizations, where resources may need to be *shared* and managed across multiple projects in the same location at the same time. Because team members in virtual teams rarely meet face-to-face, the effective use of communications channels (e-mail, teleconferencing, videoconferencing, etc.) plays an important part in assuring team cohesion and performance, and becomes an important consideration when performing project communications planning (see section *10.2 Plan Communications*).

9.3 Develop Project Team

[Page 230, Figure 9-9. *Develop Project Team: Inputs, Tools & Techniques, and Output*]

No project team can spontaneously realize its full potential. How well project teams perform results from the conscious direction and intervention of the project manager and the project management team in developing, enhancing and harnessing the competencies and interactions of all team members to meet project objectives.

Maximizing team performance is therefore focused in two areas: assuring the successful execution of project tasks through *skills improvement* actions, and improving team working using techniques that will create and maintain team *cohesion* and *trust*. Developing the project team is a continuous process that occurs throughout the project life cycle. Team formation and development tends to follow a commonly observed dynamic in which performance improves as trust increases and conflict among team members decreases. On an increasing scale of team cohesion, the phases through which the team members progress in this process are referred to as:

- **Form** – the initial stage of team development in which team members are unsure of their peers, are relatively reserved or guarded about expressing their opinions and views, relationships have not yet been established and the team needs a high degree of direction in order to function;
- **Storm** – in which team members are actively establishing their position in the team, are openly expressing their views, will challenge and confront other viewpoints and will try to influence and shape the direction of the team to suit their own agendas. The team environment can appear chaotic and sometimes feel hostile. During this phase the team requires maximum direction and support from the project management team;
- **Norm** – in which differences and conflicts between team members are being resolved or accommodated, effective relationships are becoming more established and individual agendas are increasingly focused on meeting the needs of the project. The team requires less direction and support from the project management team;
- **Perform** – in which trust between team members guides action, individual performance is enhanced and supported by strong cohesion, the team is self-directed and requires a minimum of support from the project management team and it is completely focused on meeting the goals of the project;
- **Adjourn** – during the closing stages of the project, in which team members are moving on to new projects or returning to their functional department and may be reluctant to leave or sever relationships with the team. During this stage, team members need direction and support from the project management team to help them transition out of the project effectively.

Remember this sequence of progression and that the ideal state for optimal team performance is *Perform*. The quicker the project team can progress through the Storm and Norm stages to attain the Perform state, the sooner the project will benefit. Just as control over project activities is best exercised at the task or work package level, assuring the successful execution of project tasks begins with developing the skills and competencies of each *individual* responsible for performing those tasks. Managing the team really means managing the individuals in the team. It also means managing the relationships between individuals in the team. Actions that promote and establish team cohesion should be applied as early as possible, and continue throughout the project life cycle. Actions that help promote team cohesion include soft skills, training, team building, establishing ground rules, co-locating team members, recognition and rewards and team performance assessments.

Project managers in particular, but also project management team members, need to develop and apply their own *general management skills* to help reduce problems and increase cooperation. These *soft skills* include:

- **Empathy** – the ability to step into another team member's shoes, not just to see their perspective on an issue or problem, but to "*understand with feeling*" what the issue or problem really means to that team member. Though it can help in achieving empathy, shared subject knowledge is not necessary to exercise empathy effectively;
- **Influence** – the ability to achieve a desired outcome or state in the mind of a project participant, without having to give explicit direction or exert overt pressure to achieve that result. Influence derives from a combination of factors, including knowledge, experience and position. Being able to exercise influence effectively is a characteristic of successful leadership. Note that successful project managers are actually project *leaders*;
- **Creativity** – the ability to find solutions to problems using available resources in imaginative or ingenious ways. Creative solutions to problems are often "*outside the box*," and can be contrary to what analysis of the problem might indicate the solution should be. Effective root cause analysis will often result in creative solutions to the underlying causes of the problem. This applies equally to resolving people problems; and
- **Group facilitation** – comprises various interpersonal techniques that are used to mediate the contributions of individuals to ensure balanced and full participation in team activities by each individual.

Competencies of all team members, including both technical and soft skills, should be developed and enhanced through *training* activities appropriate to the demands of project execution. Skills can and should be developed as part of the project work. Remember, training itself can be a deliverable of the project – it is within the scope of required project activities. Training plans are a part of the Staffing Management plan. Each team member should have a personal development or training plan. Training also enhances quality. From a quality perspective, training is a component of the *cost of conformance*. Project performance appraisals are conducted with team members during the Manage Project Team process. These appraisals are used to confirm that training already taken is resulting in the desired benefit and to identify if further training is needed.

Team building includes all communal activities that encourage and enhance positive interactions between individual team members. On most projects, team building usually begins with a "*kick-off*" meeting at the beginning of the project. Depending on the size and scope of the project, the meeting may be held off-site and include problem solving exercises that are designed to encourage cooperation among team members and initiate bonding. Kick-off meetings are also used to establish shared goals and objectives. Activities that are performed as part of the project can also contribute to team building. For example, developing the WBS is a planning activity that increases team communication and encourages interaction to solve a shared problem ("*What do we need to do to deliver the project*"). Each team member has their part to play, but developing the WBS involves understanding how each of the pieces fit together as a whole. The emphasis is on "*we*," not "*I*" or "*you*," and this helps to increase team cohesiveness. Informal activities and communication between team members also build trust and establish good working relationships. The informality of an off-site meeting is often used to encourage this. Because of the challenges presented by geographical or time-zone dispersion, team building activities are especially important in the formation of effective virtual teams.

Individual behaviors have a strong influence over the performance of the team. Therefore, *ground rules* must be explicitly identified so that expectations of acceptable behavior among team members are established. These should be collectively developed and agreed upon through group discussion. This provides an opportunity for team members to discover each other's values. This collective process also establishes shared responsibility for enforcement of, and adherence to, ground rules. Ground rules are most commonly used to mediate desired behaviors in team meetings ("*Be respectful of other team members' contributions*"). Early commitment by team members to these rules decreases misunderstandings and increases productivity.

Team cohesion is most often increased when team members are *co-located*. This engenders a strong sense of belonging and community, and improves communication between team members. A sense of team unity can be further enhanced by setting aside dedicated facilities that are available only for use by the project team, such as a project meeting room (sometimes called a *war room*).

Teams are made up of individuals, and motivating the team means motivating the individual. However, this needs to be done in such a way that it does not fracture cohesion or impair the collective performance of the team. *Recognition and rewards* schemes therefore need to be weighted towards rewarding behaviors that promote positive contributions to team performance. A win-lose (zero sum) reward scheme can undermine team cohesiveness if it imposes limits on who can win. An equitable scheme that rewards win-win behavior will tend to increase support among team members. When developing appropriate recognition and rewards schemes, the project management team needs to be sensitive to any cultural differences in using the scheme to shape desired behaviors. This is especially true where the project team is comprised of different nationalities working in their own countries.

The net result of these actions should be an increase in the overall effectiveness of the team's performance in meeting project objectives. Using the Team Performance Assessment process, the project management team looks for indications of this by assessing improvements in skills, competencies and sentiment (for example, how motivated and committed are team members to the project?), as well as reductions in staff turnover and increases in staff retention.

9.4 Manage Project Team

[Page 236, Figure 9-11. *Manage Project Team: Inputs, Tools & Techniques, and Output*]

Managing the project team is a continuous process that involves

- monitoring the performance of team members;
- providing active feedback to team members on their performance;
- resolving issues among team members; and
- coordinating changes that may impact the team to enhance project performance.

Many organizations operate under a matrix structure where staff often have more than one reporting line. Managing the project team needs to take account of this dual accountability, where staff report into both a functional and a project manager. The project manager is primarily responsible for managing these relationships. Since this can be a source of conflict, it is the responsibility of the project manager and the project management team to manage and resolve conflict.

The ability of a project manager to command resources, influence decisions and shape performance is an important skill that must be continuously exercised and developed if the project is to meet its objectives. Depending on personal style, preference, experience and circumstance, project managers may exert influence and authority over projects in different ways. The *power* that project managers exert derives from a combination of the limits of their *influence* and the level of their *authority*. There are five commonly recognized sources for this power. These are:

- **Reward** – in which bonus, promotion and other incentives are used to encourage positive behaviors that enhance project performance;
- **Expert** – in which knowledge and expertise (technical or specialist) are used to establish credibility and build confidence among team members in the leadership abilities of the project manager. This is how most project managers begin their careers;
- **Referent** – in which reference to the authority of someone in a higher position or via association is used to establish leadership. Such reference may also be based on personality or knowledge;
- **Penalty** (or *Coercive*) – in which rewards are withheld or actions are penalized on the basis of non-performance, usually via formal disciplinary procedures. In all cases, the objective of these actions is to correct negative behaviors that impair or disrupt project performance; and
- **Legitimate** (or *Formal*) – in which the leadership of the project manager is officially recognized by the performing organization. The level of authority exerted is based on a hierarchical position.

Which form of power does a project charter confer on a project manager? What are the limitations of this kind of power? Which is the best form of power for a project manager to have? *Hint*: the project manager's objective is to foster behaviors in the team that will positively impact project performance. Think about the best way of achieving that from the project team member's perspective. Understand the limits and advantages of these different sources of power.

A project manager does not just manage the project: he or she also *leads* the project. What are the differences between managing and leading a project? Closely related to the exercise of power are different styles of *leadership* that a project manager can assume. But one size does not fit all. Project managers need to understand how and when to use different leadership styles, and to apply them appropriately to the demands of the project as it progresses from one phase to the next. For example, at the beginning of a project, during the Storm stage of team formation, a project manager must often give much more *direction* to the team to keep them focused on project objectives than during later phases of the project. But if a project manager becomes overly directive, then he or she will be perceived by team members to be *autocratic,* which may create barriers to effective team work. During planning phases, where active input and contribution from team members and stakeholders is required, project staff need more *coaching* or *support* from the project manager to ensure full participation. If a high degree of coordination among the activities of project participants is required during execution of project tasks, the project manager should adopt a leadership style that emphasizes *collaboration*. In this case, a *consultative* approach, inviting help and expertise from within the project team, would be more effective than *dictating* what is required.

In addition to the influence that a project manager exerts over the project team using power and leadership styles, a variety of techniques are also used to manage project staff.

The manner in which project team members perform tasks assigned to them can sometimes provide the project management team with alternative indicators of performance that supplement more formal measurement. Team member sentiment can provide insight into levels of motivation and commitment. Data on staff sentiment is typically collected through *observation* of behavior and active listening during *conversation* with, and between, the team members.

Though informal channels yield positive results, formal feedback should still be covered by the project management team. The project management team should always perform Project Performance Appraisals of team members. This generally involves collecting *360 degree feedback* from peers, line management, project management, direct reports and other staff with whom the team member interacts. Effective *360 degree feedback* focuses on collecting data on *observed behavior* – not only on *what* the team member did, but *how* they did it. Project performance appraisals are also opportunities for discovery and exploration of unresolved issues. As a result of the appraisal, a Personal development plan is created to address performance issues using training, coaching or mentoring appropriate to the issues identified.

Conflict impairs project performance and must always be addressed and resolved. Unresolved conflict destabilizes team cohesion. The successful resolution of conflict results in positive working relationships among team members that enhance performance. Energies that might have been wastefully expended in creating and coping with conflict are channeled into more productive activities. High performance (or conflict-free) teams exhibit higher levels of *discretionary* effort (acting proactively, going the extra mile, providing cover and support for colleagues, etc.) than other teams.

Conflict can arise in many areas of the project. The main sources of conflict are:

- **Schedule** – created by the tension between the desire to complete project tasks according to an *idealized* timetable, and the performance of those tasks according to the constraints of the *actual* project environment;
- **Priority** – divergent or conflicting views on the order of accomplishment of the project activities, or between one project assuming (or being assigned) precedence over another;
- **Resource** – lack of availability or access to the right kind of resources to perform project tasks; and
- **Technical viewpoint** – divergent opinions regarding the best way to perform project activities, especially those involving alternative choices over technology decisions.

For example, key specialists required by a project are being used by another project with a higher priority for longer than planned in order to fix customer problems. What are the likely effects on the lower priority project that is planning on using those same resources?

The project's schedule will be impacted due to lack of required resource at the planned time. As a result, the project may be forced to revisit technical decisions based on availability of those technical specialists. If those resources are critical to the project's deliverables, then they may need to be acquired externally, requiring unbudgeted funding. Note how each one of these sources compounds and intensifies conflict within the project environment. Other sources of conflict may include:

- **Administrative** – which involves not being able to successfully navigate or understand how the performing organization's business processes operate (perceived negatively as bureaucracy or red tape);
- **Cost** – which may arise in relation to overspend on budgeted or unbudgeted activities, or contention over limited funds; and
- **Personality** – in which personal styles and preferences become a barrier to effective working relationships.

Conflict between project staff should always be resolved by those staff directly involved in the conflict, because conflict resolution is a collaborative process. Ultimately, the staff affected must resolve and reconcile any difficulties themselves, in order for the source of the conflict to be acknowledged and addressed. Without the involvement and commitment of all parties involved, the root causes of the conflict will not be identified and resolved. If required, the project manager should facilitate resolution. As with performance problems, and depending on the nature of the conflict, facilitating resolution among staff should always progress from informal or private means (typically, an offline discussion) to more formal or public means (for example, following the performing organization's disciplinary procedures).

Approaches to dealing with conflict may vary according to management style and personal preference, but there are six commonly recognized approaches. These are:

- **Avoidance** (or *withdrawing*) – in which management ignores the conflict, and the problem continues unresolved;
- **Accommodation** (or *smoothing*) – in which common ground between the protagonists is identified by emphasizing those areas on which there is agreement, but does not address areas of disagreement. The source of the conflict is deemphasized but is not resolved;
- **Compromise** (or *bargaining*) – in which the protagonists negotiate over the issues causing conflict, and jointly arrive at a *win-win* position by giving something up in return for gaining something. The outcome of this process may not be each party's *ideal* position, but it is the one on which both parties can *agree*;
- **Forcing** (or *dictating*) – in which a specific solution to the conflict is imposed on the protagonists. One party usually gains more than the other (*win-lose*). The source of the conflict is only partially addressed, and may re-surface, but in a different form;
- **Collaboration** (or *consensus*) – similar to compromise but more effective, because the multiple viewpoints of the protagonists are acknowledged and accommodated within the solution. Collaborative solutions emphasize *working together*, and this is a very effective way of resolving conflict; and
- **Confrontation** (or *problem solving*) – in which the sources of the conflict are discussed and examined by the protagonists in an open-minded dialogue. The root causes are identified and acknowledged, and alternative solutions to the conflict are accepted. Confronting directly the root causes of the problem is the most effective way of resolving conflict.

Creating a team environment that values trust, honesty and respect as early as possible in the project life cycle provides the foundation for robust and beneficial disagreement. Establishing ground rules that emphasize respect for differences of opinion can help. When managed properly, differences of opinion are healthy for projects. They provide alternative solutions to problems that result in better decision-making and increased productivity.

Many project issues that are potential sources of conflict often arise due to a lack of knowledge or lack of clarity about what the potential impact of the issue on the project might be. For example, if the critical dependency on specialist resources in the example above had been identified in the project's issue log, then the team could have been more proactive in managing the conflicts that ensued. Using an Issue Log helps the project management team better manage sources of potential conflict by encouraging and enforcing ownership and accountability for resolving project issues among team members. Note that an issue log is also defined as a communications tool (page 240).

10. Project Communications Management

Chapter 10 – Project Communications Management Changes was modified slightly from the Third Edition of the PMBOK. The most significant change in the Fourth Edition is the addition of Identify Stakeholders process to the Communications Knowledge area. This change reflects PMI's continued emphasis on managing stakeholders as a key element for successful project management.

Project Communications Management comprises five Knowledge Area processes:

10.1 Identify Stakeholders [*Initiating*] – identifying key stakeholders for the project;

10.2 Plan Communications [*Planning*] – identifying the communications needs of stakeholders;

10.3 Distribute Information [*Executing*] – the timely distribution of project information to stakeholders;

10.4 Manage Stakeholder Expectations [*Controlling*] – managing project communications to satisfy stakeholder information needs; and

10.5 Performance Reporting [*Controlling*] – collecting and disseminating project performance information to stakeholders and others.

It is generally acknowledged that project managers spend about 90% of their time engaged in one form or another of communication activity because project success is underpinned by successful communications. The PMBOK recognizes that although communication skills are related to project management communications, they are not the same thing. However, it is important for project managers to understand how successful communications are achieved.

Communications comprises a substantial body of knowledge in itself that is outside the scope of the PMBOK. However, at a minimum, you should be familiar with the following communications concepts:

- **Sender-receiver models** – the mechanics of successful communication. This includes understanding the dynamic of active feedback loops (between sender and receiver) and barriers to successful communication. A breakdown at any point in the communications model may compromise the quality of the information being communicated and may create misunderstanding that can impair project performance.
- **Choice of media** – selecting the optimal form in which the message is sent to ensure that it is correctly understood by the receiver. For communications to be successful, it is necessary to deliver the message in a form appropriate to the nature of the content. You need to recognize when it is appropriate to use written versus oral communication, formal versus informal, verbal (face-to-face) versus disembodied (e-mail, telephone, instant messenger), etc. For example, using a formal written specification to update your globally dispersed project team on changes to the technical characteristics of the project's product (a communication requiring precise, unambiguous delivery of information) versus an informal briefing via teleconference.
- **Writing style** – selecting the appropriate components of written communication to ensure that the correct message is delivered. This includes elements of style (formal, informal), vocabulary (technical, colloquial), authorial voice (active, passive) and structure (memo, white paper, technical specification, etc.), all of which determine how information is presented, evaluated and processed.
- **Presentation techniques** – using a variety of techniques to enhance and assure that information is interpreted in the correct manner. This includes the use of visual aids and diagrams to present data and other information in pictorial form, as well as using meta-linguistic cues, such as voice tone, body language and facial expression (paralingual elements) when delivering information verbally.

- **Meeting management techniques** – using a variety of techniques to ensure that group communications among project participants contribute to the project's purpose. This includes controlling the meeting environment using agendas to define scope, purpose and duration of meeting, and using ground rules to aid conflict resolution, so that information disseminated will lead to desired outcomes.

A successful communication results in the transfer of information from one party to another, such that what was sent by the sender was received correctly by the receiver. It sounds simple, but given the variety of ways and means by which information is communicated, it is necessary to understand how that process works.

The five components are:

i. **Encode** – the process by which thoughts or ideas are translated into a public language (i.e., can be commonly understood and transmitted to others);

ii. **Message** – the output of the encoding process (i.e., the message to be transmitted);

iii. **Medium** – the method used to carry the message from the sender to the receiver;

iv. **Noise** – anything that may impede or distort the transmission of the message or the interpretation (understanding) of the message by the receiver (for example, using excessive technical terminology when communicating with a non-technical audience); and

v. **Decode** – the process by which encoding is reversed and the received message is translated back into thoughts and ideas.

Active feedback (from receiver to sender and vice-versa) is an important feature of the communications model. For the communication to be successful, the receiver must acknowledge receipt of the message by the sender. The sender must also confirm that the receiver is, in fact, responding to the message sent, and that they have correctly decoded and understood (interpreted) the content of the message.

Successful communication enhances and assures performance across many areas of the project. For example, the WBS is an important communications tool for defining and organizing the complete scope of the project. It is a formal, written communication that provides all project participants with a universally accessible, unambiguous and logical view of the work to be completed.

Review the Tools & Techniques used in other process areas and identify how you would describe them in terms of their communications characteristics, including the degree of formality and format appropriate to the optimal use of the tool or technique to achieve a successful outcome. For example, to ensure proper management and communication of project risks to stakeholders, what form should the Risk Register take?

Did you note how the Risk Register is developed during the Risk Identification process, updated during the Qualitative Risk and Quantitative Risk Analysis processes, and then further updated as a result of the Risk Response Planning process? Through progressive elaboration, the information contained in the Risk Register becomes more detailed and precise in the project risks it addresses, and thus enhances the effectiveness of Risk management. This is the goal of all successful communications activities: to more effectively manage project processes. Identify the different kinds of communication techniques and interactions that may be used to facilitate this continuous process.

10.1 Identify Stakeholders

[Page 246, Figure 10-2. *Identify Stakeholders: Inputs, Tools & Techniques, and Output*]

Since Project Managers spend a majority of their time engaged in one form or another of communication activity identifying the right people to communicate with is critical for the success of the project. Not only is it important to understand WHO to communicate with but it is also important to understand HOW all interested parties should be engaged and addressed when important news about the project needs to be shared. This includes presentation, frequency, approach and many other aspects of communication. Simply put – the notion of equal treatment for all stakeholders does not hold true when it comes to the communication of a project's status. Key individuals within an organization will have the power and interest to either help or harm the progress of a project depending on how they choose to react to the information that is presented before them. Going into a project with a clear plan on how to manage these key relationships is critical for the success of the project.

Understanding how to identify and categorize key stakeholders are the main points to comprehend for this section. These efforts should be covered during a formal Stakeholder Analysis rather than being left to chance. This Stakeholder Analysis generally follows three steps:

- **Step 1: Identifying All Stakeholders** – the method for discovering all stakeholders and noting their expectations, levels of influence, and roles within the organization. Carefully identifying ALL stakeholders through a series of interviews will help project teams with;
- **Step 2: Identifying the Power and Influence of All Stakeholders** – the method for classifying stakeholders that have been according to their ability to influence the project and their interest in doing so. The PMBOK offers examples on how to map these factors onto a grid or matrix for quick reference so that it might be used to help with;
- **Step 3: Assessing How Stakeholders Will React to Different Scenarios** – the method for determining how stakeholders might react to positive and negative information about the project with the intention of either successfully building support or limiting damage for the project.

General results of the Stakeholder Analysis, like name, organizational position or expectations can be recorded in the team's Stakeholder Register. The results of a more detailed analysis should be included in the team's Stakeholder Analysis Matrix. This document will include strategies and approaches for increasing support from or minimizing the negative impact from critical stakeholders.

10.2 Plan Communications

[Page 252, Figure 10-6. *Plan Communications: Inputs, Tools & Techniques, and Output*]

The purpose of Communications Planning is to identify the information needs of stakeholders and determine the best means by which the project will meet those communications needs (hence, the importance to the project manager of understanding how communications work, and being adept at communications skills). Planning begins with an analysis of the project's communications requirements.

To a large extent, a project's communications requirements are influenced and shaped by the project's organizational structure. Other factors influencing project communication requirements include:

- **External interfaces** – to identify how the project will meet the communication needs of stakeholder groups external to the performing project organization. For example, keeping local communities appraised of construction work that may impact their environment;
- **Company and departmental organization charts** – to identify how and where potential project resources are organized by the performing project organization, including understanding the interactions between departments and groups (as documented in methods of working or operational procedures);
- **Roles & responsibilities** – to understand the functions and activities for which individuals and groups are accountable for within the performing project organization;
- **Internal communications** – to identify mandatory or other regularly required communications requirements within the performing project organization, for example, monthly project status reports for the Project Management Office;

Note how these factors may constrain the way in which project communications are implemented and managed.

Project communications must be optimal to ensure that resources are focused on communicating information that contributes to successful project outcomes or where lack of communication might undermine or jeopardize the success of the project. In optimizing project communications, an indicator of a project's possible communications complexity can be found in the number of potential communications channels or paths. Project managers need to be aware of the extent of the interactions between stakeholders, as represented by the number of potential communications that might be required and how these channels will be served. The following formula is used to determine the magnitude of these potential communication channels:

Formula: $n(n-1)/2$ where n = number of stakeholders

If there are 10 project stakeholders, then the potential number of communications channels is 45. If you double the number of stakeholders to 20, does the number of channels double? Increasing the number of stakeholders not only increases the complexity of the communications channels numerically, but also increases how the communications requirements of those additional stakeholders will be met. Identifying all of the project's stakeholders is critical to ensuring successful project communications.

Following analysis of the project's communications requirements, the means (or methodologies) by which those requirements will be met must be identified. These can vary significantly from project to project, and may range from informal conversations with stakeholders to web-based collaborative tools combining e-mail, instant messaging, document sharing and database access. Each project must determine its own Communications Technology methods as determined by its communications needs.

The Communications Management Plan is the key output from Communications Planning and is contained in, or is a subsidiary plan of, the Project Management Plan. The degree of formality and level of detail in the Communications Plan are determined by the needs of the project. Remember, the primary purpose of the Communications Management Plan is to communicate to stakeholders how project communications will be managed, and to refer back to the plan throughout the project.

10.3 Distribute Information

[Page 258, Figure 10-9. *Distribute Information: Inputs, Tools & Techniques, and Output*]

Information Distribution results from executing the Communications Management Plan, and is dependent on competently exercising general communications skills, as well as the means by which project information is collected and retrieved and the use of appropriate distribution channels and other mechanisms to disseminate project information to stakeholders. Accuracy, completeness, timeliness and appositeness (*"Am I using the best or right communications method to provide information to this stakeholder?"*) are key criteria when distributing project information. In reviewing this section, project managers should think about the ways in which the failure of any one of these criteria may compromise the quality of the information distributed, and how this may impact project performance. For example, following Risk Response Planning, what is the impact of a Risk Register that is not updated to the level of completeness and precision commensurate with the priority of any newly identified risks and planned responses to those risks? Or what might happen if it is updated but not communicated to stakeholders impacted by the risk events identified, and who are, therefore, unaware of the need to prepare responses to address such risks?

Understanding the *appropriate* distribution of information is the key to adequately mastering this section. Past PMP exams asked a large number of questions on the correct distribution of information. As in all cases, PMP candidates should resist the temptation to use anecdotal or work experience examples as their guide to answering these questions. In practice, e-mail or written memos may be the common method for formally documenting and distributing some information. However, from the perspective of PMI, it may not be the *best* method. Project managers will need to know which method is considered *best* to score effectively on the PMP exam.

As part of the performing project organization's Organization Process Assets, the Lessons Learned Process is a key tool in shaping Information Distribution. Note that the PMBOK places great emphasis on Lessons Learned in a number of process areas (it is mentioned 54 times). In particular, it states that: *"Project managers have a professional obligation to conduct lessons learned sessions for all projects with key internal and external stakeholders, particularly if the project yielded less than desirable results."* We learn from our failures, not from our successes. It is because communications plays such an important role in assuring project success that the PMBOK describes the Lessons Learned Process under this process area. Lessons Learned become part of the project body of knowledge for the performing organization, and are often archived in a historical database for future reference. They provide future project teams with information that can improve and enhance project execution by avoiding the errors and mistakes made by previous projects. The efficient distribution of information (which includes collection and retrieval) therefore leads to improvements in project knowledge, and these are reflected in updates to the Organizational Process Assets via Lessons Learned documentation, project reports, presentations, feedback from stakeholders and other project records. If, as a result of executing the Information Distribution process, modifications or amendments are required, then these should be formally requested, reviewed and managed through the Integrated Change Control process.

10.4 Manage Stakeholder Expectations

[Page 262, Figure 10-11. *Manage Stakeholder Expectations: Inputs, Tools & Techniques, and Output*]

Before opening the PMBOK, a project manager should know that in order to influence project performance, he or she must proactively manage the project's stakeholders and their needs. The most important aspect of this process is managing communications to satisfy stakeholder needs. Additionally, the project manager must actively address and resolve all stakeholder issues that may threaten to impair or disrupt project performance. To do this effectively, the project manager must be fully aware of the stakeholders' goals, objectives and expectations with respect to the project. These are identified, analyzed and documented in the Communications Management Plan.

Effective management of stakeholders is dependent upon using methods of communication appropriate to the needs of the stakeholders (hence, the importance of recognizing and documenting these in the Communications Management Plan). It is important that the right kind of communications channel is selected to fully resolve any issue raised by stakeholders. Using the wrong communications channel may exacerbate rather than solve the issue. For example, bringing attention to the failure of a project team member to meet a deadline in a group email is likely to further undermine that individual's performance. Ultimately, it's better to meet face-to-face and to have an informal discussion with the team member.

An Issue Log (alternatively referred to as an Action Item Log) is noted by PMI as an effective communications tool for formally tracking the status and resolution of issues as they arise. Seasoned project managers will be familiar with the use of an Issue Log. Here again, candidates should remember not to depend too much on their anecdotal knowledge of an Issue Log, and should focus more on PMI's interpretation on the correct use of this tool.

As described in the PMBOK, issues arise from interactions among stakeholders, and actively managing issues is an effective way of managing stakeholders in a controlled environment. The use of this communication tool encourages constructive discussion, assigns ownership, and demonstrates to stakeholders and team members that issues are important to the project. The PMBOK clearly states the importance of resolving all issues, since an unresolved issue may cause conflict and disagreement that will undermine project performance. Note that issues may arise in any part of the project, between different organizational and departmental interfaces, and at any management level.

10.5 Report Performance

[Page 266, Figure 10-13. *Report Performance: Inputs, Tools & Techniques, and Output*]

Reporting Performance is one of two Monitoring and Controlling processes within Project Communications Management. Its purpose is to ensure that all stakeholders receive timely information about current project performance relative to baseline planning information. Performance reports focus on how project resources are being utilized to achieve project results and on any variances from forecast (planned) results. They provide stakeholders with relevant information on the status of project deliverables in addition to scope, schedule, cost and quality, as well as risk and procurement. Work Performance Information provides details on what has been achieved at the point in time when performance measurements are taken, versus expected results at that same point in time (and as detailed in the Performance measurement baseline that integrates scope, schedule, cost and quality). As a result of these measurements, corrective actions may be recommended to bring project performance back into line with expected results as documented in the Project Management Plan. Any consequent changes to project scope, cost estimates (budget) or activity durations are raised and approved through the Integrated Change Control process.

The format, frequency and distribution of Performance reports are prescribed by the Communications Management Plan. Performance information is presented as required by the needs of the project and as required by stakeholders. Some typical performance report formats include:

- Bar charts
- S-curves
- Histograms
- Tabular

Formats should be selected to present the most accurate view of project performance. Other formats may be required to meet specific stakeholder needs; for example, traffic-light, or Red-Amber-Green (RAG), reporting as input to Balanced Scorecard or similar project dashboard reports used by Project Management Offices. Earned value analysis data is frequently presented in Performance reports. Again, depending on the needs of stakeholders, a format should be used that will enable stakeholders to act in line with the status of the project.

The purpose of Reporting Performance is not simply to monitor and communicate results passively, but to be proactive in managing project performance (raising change requests, taking corrective action, updating lessons learned).

You should familiarize yourself with the various kinds of performance report formats and note how these are used to manage project performance (for example, compare these formats with those used to capture and communicate quality metrics). Additionally, candidates should review the references to sections in other chapters, and be prepared to see questions on these sections as part of larger questions around communications management.

11. Project Risk Management

Project Risk Management (Chapter 11, pages 273-311) comprises six project management processes:

11.1 Plan Risk Management [*Planning*] – identifying how the project will plan, manage and execute risk management activities (pages 276-281);

11.2 Identify Risks [*Planning*] – identifying and documenting all risks that may influence or impact project outcomes (pages 282-288);

11.3 Perform Qualitative Risk Analysis [*Planning*] – analyzing risks as to the probability of their occurrence and impact, and prioritizing these for subsequent analysis or action (pages 289-293);

11.4 Perform Quantitative Risk Analysis [*Planning*] – analyzing identified risks using numerical techniques to assess their impact on project outcomes (pages 294-300);

11.5 Plan Risk Responses [*Planning*] – developing responses and alternative approaches to enhance opportunities and reduce threats to project outcomes (pages 301-307); and

11.6 Monitor and Control Risks [*Controlling*] – as the project progresses, tracking and monitoring risks, responding to risks as and when required, identifying new risks, and new responses, and assessing the effectiveness of response strategies continuously throughout the project (pages 308-311).

"*If it can go wrong, it will go wrong*." This is how many project managers view the threat from risks to the successful outcome of their projects. Although risk generally has a negative connotation, it also has an upside that is often neglected when performing risk management.

Definition: "Risk – An uncertain event or condition that, should it occur, has either a positive or a negative effect on the project's objectives".
[*Glossary*, page 446.]

It is the *uncertain* characteristic of an event or condition that defines it as a risk, not the fact that it could have a negative impact on the project. Risk management actually means *managing uncertainty*.
The Risk Management Knowledge Area processes focus on identifying and managing those aspects of the project where uncertainty is highest. These aspects typically have the largest impact on project outcomes because they are unknown, and their effect is uncertain. Risks include both threats and opportunities. Why would an opportunity be considered a risk? It sounds like a good thing. An opportunity may be just as disruptive or challenging to the agreed project outcomes as a threat. Just as a threat can distract and divert resources from focusing on achieving project objectives, so can an opportunity. Think about your own experience, when a customer or sponsor sees an opportunity for the project to deliver something new, or an addition to the deliverables already defined and agreed upon. Is that a good thing or a bad thing for the project? It probably depends on how you respond. Risk management means increasing the probability and impact of opportune or positive events, and decreasing the probability and impact of adverse or negative events. Positive events are those that enhance the probability of project success while negative events put the project at risk (of failing). When they occur, risk events (whether opportune or adverse) always have a direct impact on the project. Depending on the characteristics of the risk event, it may impact any of the project's cost, schedule, scope or quality objectives. Risks can emanate from anywhere within the project environment, can result from more than one cause and can have more than one impact on the project. Because of the inherent complexity in both the causes and effects of risk events, a systematic and comprehensive approach to risk management is required that addresses:

- *probability* of the risk event (how *likely* is it to occur?);
- *consequences* or outcomes of the risk event (what will the *cost* to the project be?);
- *causes* or circumstances of the risk event (what will *trigger* it, and how will it become manifest?);
- response appropriate to the risk event (what *actions* are required if it occurs?);
- *timeframe* in which the risk event is likely to become manifest (*when* is it likely to occur?); and
- likelihood of *repetition* of the risk event (is it a one-time event or is it likely to *recur*?).

The approach taken by the Project Management Team to managing the project's risk will be influenced by the amount of risk that the performing organization is willing to tolerate. The *risk tolerance* of the performing organization is shaped by strategic considerations that will influence the kinds and amounts of risk that the company is willing to assume in striving to meet its business goals. The team must also be cognizant of individual stakeholder risk tolerance and take this into account when assessing the impact of risks. Why? Because the actions of stakeholders directly influence project performance, and stakeholders who are *risk averse* will affect how responses are planned and executed. However, a risk can be accepted if the threat to the project is balanced (or outweighed) by the benefits of acceptance.
All of these factors need to be explicitly acknowledged and taken into consideration when performing risk management planning.

11.1 Plan Risk Management

[Page 277, Figure 11-2. *Plan Risk Management: Inputs, Tools & Techniques, and Outputs*]

The Risk Management Planning process establishes the specific approach to managing risk that the project will take. It ensures that the approach taken:

- aligns with the performing organization's tolerance for risk;
- provides a consistent and comprehensive basis for evaluating project risks; and
- allocates time and resources to meet the requirements of risk management activities identified in the plan.

Risk management planning is an inclusive and collaborative process. This is usually facilitated via planning and analysis meetings in which the project manager, project team and stakeholders create the framework for the risk management plan. The Risk Management Plan describes the framework for how risk management will be performed throughout the duration of the project, and covers:

- **Risk Categorization** – defining which kind of categories and the criteria that will be used to identify, analyze and assess the impact of risks to the project. Risk can emanate from many, very different aspects of the project, and categorization is a technique that enables risks to be grouped and analyzed around common characteristics or sources of risk, such as technical, environmental, regulatory, government, market, etc. A template in the form of a Risk Breakdown Structure (RBS) can be used to facilitate categorization. See *Figure 11-4* on page 280 for an example of an RBS. Do not confuse this with the Resource Breakdown Structure, which is also referred to as *RBS*;
- **Roles and Responsibilities** – describing who is responsible for which parts of the risk management activities;
- **Timing** – identifying when risk management processes will be performed throughout the project, including when risk management activities will be included in the project schedule;
- **Budgeting** – identifying the resources and costs associated with the project's risk management approach, accounted for in the cost baseline;
- **Stakeholder tolerances** – identifying the risk tolerance profile of each stakeholder, as revised by the risk management planning process;
- **Methodologies** – describing the tools, techniques and processes that will be used to manage risk;
- **Definition of Risk Probability and Impact** – defining how probability and impact will be applied during the Qualitative Risk Analysis process (see 11.3 Qualitative Risk Analysis)
- **Probability and Impact matrix** – defining how risks will be prioritized according to their probability and impact on the project's objectives;
- **Tracking** – describing how risk activities such as outputs and artifacts will be recorded and documented, including lessons learned. Also included is reference to how risk management activities will be audited; and
- **Reports** – describing the content and format of the Risk Register and project risk reports.

11.2 Identify Risks

[Page 282, Figure 11-6. *Identify Risks: Inputs, Tools & Techniques, and Outputs*]

Because risks are uncertain and can arise anywhere within the project at any time, it is necessary that all project participants should be engaged in the identification of risks. This includes project team members, stakeholders, the customer, the sponsor and subject matter experts, both within and outside of the performing organization, who bring their collective experience and knowledge to bear on the discovery of risks. You can never have too many risks on a project. Take a moment to think about what that means. It means that risk should be *proactively* identified (and managed) continuously throughout the project in an iterative cycle of identification, response and analysis. All identified risks should be assigned ownership and accountability for assessment, monitoring and response. The more risks you can uncover and identify on the project, the better they can be managed because they are acknowledged or known. Unknown risks pose the greater risk because uncertainty is higher. Risk identification is therefore primarily concerned with identifying all risks that might potentially impact the project, and documenting their characteristics to the fullest extent possible. Why? Because describing and documenting a risk to the most detailed level possible diminishes the uncertainty associated with that risk. Remember: managing risk means managing uncertainty.

As it does in other process domains, the PMBOK Guide describes the processes performed in project risk management sequentially. However, it does acknowledge that although the risk identification process ordinarily leads to qualitative risk analysis, depending on the experience of the project manager, it can lead to the Quantitative Risk Analysis. In some cases, identifying the risk suggests an appropriate response that leads directly to the risk response planning process. The point here is that the discrete processes involved in risk management can and do overlap and interact in ways not documented in the PMBOK. You need to understand the sequence of the processes as described in the PMBOK, but be aware that through iteration those processes may sometimes interact in different sequences when repeated.

A number of different techniques are used to gather information on potential risks. These include:

- **Delphi technique** – in which ideas and opinions about potential risks are collected from experts, and a consensus view on the risks is developed. The steps involved in this process are:
  - a questionnaire is circulated to the experts to solicit risk ideas;
  - responses are summarized and then circulated to the experts for review and comment; and
  - updated responses which are re-circulated for further review and comment.

  The process is repeated until a consensus view is derived. The effectiveness of this technique derives from the fact that the identity of the expert participants is kept anonymous so that no one expert can exert more influence than another over the view derived, thus removing bias;
- **Brainstorming** – in which idea-generation is facilitated with the project team and relevant subject matter experts to explore, uncover and identify areas of potential project risk. A risk breakdown structure (RBS) can be used to initiate brainstorming;
- **Interviews** – in which project participants, subject matter experts and stakeholders are interviewed to identify project risks based on their experience. This is one of the main methods used to collect risk data;
- **SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis** – in which potential risks are identified by looking at each of the SWOT characteristics as they apply to the project. SWOT analysis is often used by the performing organization to evaluate the strategic positioning of projects and ensure that they are aligned with business goals; and

- **Root Cause analysis**– in which the underlying causes of risks are identified and analyzed. Causation characteristics can be used to categorize similar risks and formulate responses. The effectiveness of risk responses are enhanced by performing root cause analysis.

Note that *assumptions* also need to be assessed as a source of risk. Why? Because the Project Management Team must identify what the potential impact on the project might be if any assumption made during planning is subsequently proved to be invalid.

Diagramming techniques are also used to identify how process flows, interactions, activity sequences and other project interactions may give rise to risks. These include:

- **Cause and Effect Diagrams** – also referred to as *fishbone* or *Ishikawa* diagrams; and
- **Flowcharting** – also referred to as *system* or *process flow charts*.

Where else in the project would you use these techniques for problem identification? When performing quality control (see pages 206-214). Influence Diagrams are also used to depict the relationships between variables that can influence the outcome of events, processes or other interactions.

The output from the risk identification process is the project Risk Register. This is a component part of the project management plan that is used as both an input and output in the subsequent Qualitative Risk Analysis, Quantitative Risk Analysis, risk response planning and risk monitoring and control processes. The initial risk register provides:

- An initial list of all risks identified from the risk identification techniques enumerated above;
- A list of responses to those risks where risk identification also generated a potential response to that risk;
- Any root causes that were identified during risk identification; and
- Any updates to risk categories resulting from the list of risks identified.

11.3 Perform Qualitative Risk Analysis

[Page 289, Figure 11-8. *Perform Qualitative Risk Analysis: Inputs, Tools & Techniques, and Outputs*]

Qualitative Risk Analysis answers the question, "*Where should we focus our attention?*" when considering the order in which risks should be addressed, by considering both the *probability of occurrence* and the *magnitude of impact* on the project's objectives. The objective of qualitative risk analysis is therefore to prioritize risks. The risks that present the biggest threat to the project in terms of highest probability of occurrence and biggest impact to project objectives must be addressed by the Project Management Team before risks with a lower probability and lower impact. Prioritizing risks helps to focus resources and responsiveness to areas that may have the biggest impact on project performance and objectives. It is a relatively quick and cost-effective way to rank risks. However, there is a degree of *subjectivity* in the process that derives from the risk tolerance of the project team and the performing organization and, hence, it is a *qualitative* assessment of risk.

Each risk event is assessed as to its *probability* of occurrence and the *magnitude* of its consequence or impact. Both probability of occurrence and magnitude of impact can be scored using a relative scale, such as High, Medium, Low, or a numerical scale, such as 1, 2, 3, 4, etc. The scale and scoring method are defined during Risk Management Planning and reflect how risks are *perceived* and *evaluated* by the project. Both the probability of occurrence and the magnitude of impact for each event are combined with other risks identified and presented in a Probability and Impact Matrix. The matrix is used to identify risks with the highest probability of occurrence and the highest (usually negative) impact on the project should they occur. In prioritizing risks, the matrix aids the process of risk response planning by drawing attention to risks that are High probability and High impact, meriting closer attention than others. Some performing organizations convert the resultant combined score to a value denoting the urgency and importance of management attention to the threat using, for example, a dashboard or traffic-light system (Red, Amber, and Green) which is based on risk rating rules that are usually defined by the organization for all projects. *Figure 11-10,* on page 292, shows a commonly used Probability and Impact Matrix format. The value of the matrix is that it provides a consistent and standard evaluation method to compare risks within and between similar projects. Because the matrix is a decision-making tool, the accuracy of the data used in Qualitative Risk Analysis must be evaluated to ensure it is of sufficient quality to support such decisions.

The output from qualitative risk analysis is an updated Risk Register that provides:

- **Ranking** – providing a relative ordering of the significance of the risks evaluated on the project. This should include sufficient information about the risk event, and how it has been evaluated to enable decisions about how to respond;
- **Categorization** – identifying root causes or patterns of risk for further evaluation;
- **Trend analysis** – noting any observed trends in risk events. Categorization helps with this process. Note that this is required for performance reporting, to evaluate if and how the risk profile of the project changes as it progresses;
- **Low priority risk watch list** – identifying low probability and/or low impact risks that do not require immediate attention but should be monitored by the project team;
- **Near term risk responses** – identifying those risk events that require urgent attention by the project management team; and
- **Additional analysis and response** – identifying those risks that do not pose an immediate threat to the project but require further evaluation.

11.4 Perform Quantitative Risk Analysis

[Page 295, Figure 11-11. *Perform Quantitative Risk Analysis: Inputs, Tools & Techniques, and Outputs*]

Quantitative Risk Analysis answers the question "*What is the cost of this risk to the project*?" The process takes the prioritized list developed during Qualitative Risk Analysis and, focusing on those risks that have the highest impact, assigns a numeric value that denotes the potential magnitude of the risk event's consequences on project objectives. Impact is primarily evaluated with respect to its effect on project cost and time, but may also include scope and quality. The Quantitative Risk Analysis process should be repeated after Risk Response Planning and performed as a part of Risk Monitoring and Control. Why? To determine if the probability or impact of risks events has changed, and if so, in what ways (increasing or decreasing?).

The steps involved in Quantitative Risk Analysis are:

- gather probability and impact data on the high priority risks identified;
- apply sensitivity analysis to risks to identify risks that are likely to have the biggest impact on the project;
- perform expected monetary value (EMV) analysis to determine what the cost to the project is of the risk event;
- perform decision tree analysis to determine alternative EMV and other consequences of the risk event under different scenarios for that event; and
- model the project outcomes (for cost and schedule) under repeated simulations using, for example, the Monte Carlo technique, to derive a distribution of multiple outcomes.

Interviewing is used to gather probability and impact data on the identified risks. Data is gathered that supports probability distribution analysis using, for example, the three-point estimate technique. Continuous probability distributions are used to represent uncertainty in the cost and time estimates collected. Discrete distributions are used to represent uncertain events. Taking account of the variables that may influence uncertainty in the risk event, *sensitivity analysis* is performed to identify which risks may have the biggest impact on the project.

An important concept in Quantitative Risk Analysis is Expected Monetary Value (EMV), which expresses the impact of the risk event as a product of the probability of that event, multiplied by the value of the consequences of that event, to derive an *expected monetary value*. For example, if the Medium probability of a risk event occurring is represented by a 15% probability, and the value of the consequence is $56,000, what is the EMV? It is $8,400, or $56,000 multiplied by 15%. What happens to the EMV if the High probability of the risk event increases to 20%? EMV increases to $11,200. If the probability fell to a Low probability of 5%, then the EMV would decrease to $2,800. The EMVs for different risk events can be calculated and compared to identify those risk events that have the highest outcomes. Multiple EMVs can be calculated for the same risk event, based on changes in the probability of the event occurring or changes to the value of the consequence. An average EMV for the same risk event can be calculated by summing the multiple EMVs, then dividing by the number of calculations. In the above example, the average EMV is $7,467, which represents a 13% probability.

This technique is also referred to as *analysis under uncertainty*. Given that managing risk means managing uncertainty, you can see how EMV helps to provide the Project Management Team with insights into which variables they might want to try to influence in order to reduce the EMV in the case of negative risk events (threats), or to increase EMV in the case of positive risk events (opportunities). Note that a negative EMV value represents a risk, while a positive EMV value represents an opportunity. In the above example, a negative EMV would represent a cost.

EMV helps in project decision-making. For this reason, it is often used in conjunction with *decision tree analysis*. A decision tree is a diagramming technique that allows for alternative scenarios to be constructed using binary decision nodes (Yes/No, True/False, etc.) to generate consequences based on specific sequences of future events, tasks or circumstances. At each decision node, the alternate paths can be evaluated as to the cost, probability and EMV of the outcome on that path. The total EMV for each path passing through the decision nodes can then be calculated. This represents the expected value or outcome of the chain of decisions made (see *Figure 11-15* on page 299). Make sure that you understand how to resolve decision trees and calculate EMV values. Questions in the PMP exam may ask you to do this or to comment on the results of such calculations.

The Monte Carlo technique is also used to *model uncertainty* by simulating multiple outcomes generated from a random distribution of variables, representing a range of potential project costs and durations (schedule). In other words, it translates uncertainty into impacts that affect the project outcome. It helps to provide an answer to the question "*Given the risks we face, what is the probability that we will deliver the project on time and to budget?*"

As an output from Quantitative Risk Analysis the Risk Register is updated to include:

- **Probabilistic analysis** – which combines the cumulative distribution, derived from the potential project costs and durations, with stakeholder risk tolerances to size, cost and time contingency reserves that are commensurate with managing the risk of project overruns to an acceptable level;
- **Probability of achieving project cost and time objectives** – which quantifies the probability of achieving project objectives under the current plan, taking into account the threats and opportunities assessed during Quantitative Risk Analysis. This is usually presented in the form of a cumulative distribution, from which the most likely outcome can be identified (see *Figure 11-16* on page 300);
- **Prioritized list of quantified risks** – which identifies those risks that are likely to have the biggest influence over project outcomes;
- **Trends in quantitative risk results** – which identifies risk patterns that may require further investigation or attention during risk response planning.

Note that the processes involved in the quantification of risk events are less subjective than those used in Qualitative Risk Analysis.

11.5 Plan Risk Responses

[Page 302, Figure 11-17. *Plan Risk Responses: Inputs, Tools & Techniques, and Outputs*]

The objective of Risk Response Planning is to develop options that are appropriate to the specific risks faced, and to identify actions that will reduce the threat of negative risks and enhance the opportunity of positive risks. Effective risk response planning involves:

- assigning ownership for each risk identified (the Risk Response Owner);
- ensuring that the response is cost effective;
- agreeing upon the response with all parties involved;
- ensuring that the response is timely; and
- confirming that the response is commensurate with the significance and potential impact of the risk to the project.

The PMBOK identifies the seven most commonly used strategies for responding to risks. The first three strategies address negative risks (or threats), the second three address positive risks (or opportunities) and the last strategy listed can address either kind. Remember these for the exam. You must be able to understand how these strategies are used to address project risk and to identify the appropriate response to either a negative or a positive risk event.

- **Mitigation** (*threat response*) – in which either the probability and/or the impact of the risk event (and hence, its consequences on project objectives) are reduced. Mitigation is a *proactive* strategy whose effectiveness is enhanced when action is taken before the risk event occurs to ameliorate the effects of the risk, should it occur. Building redundancy into a mission critical system, for example, is an effective mitigation against the risk of system failure;
- **Avoidance** (*threat response*) – in which the threat is eliminated by changing the circumstances that invite the threat. This may be achieved by, for example, reducing scope or extending the schedule, or changing some other component of the project management plan. The project management team must ensure that in avoiding a threat from one source, they do not expose the project to risk from another, new source;
- **Transference** (*threat response*) – in which ownership of the risk is transferred to a third party. Note that this does not remove the threat. It is a means for engaging a third party in the management of a specific risk. This strategy is used most effectively as a response to financial risk. A number of arrangements are used to transfer risk, for example, insurance, performance bonds, warranties, guarantees, etc. Depending on the nature of the risk, third parties may expect a premium for assuming risk on behalf of the performing project organization. Contracts are instruments designed to share risk between these parties in the performance of project work that is subject to risk. In a fixed-price contract, the third party assumes risk for schedule overruns, while in a cost-type contract, the performing organization assumes the financial risk for the third party's cost performance;
- **Enhancing** (*opportunity response*) – in which the size of the opportunity is enhanced by increasing either the probability and/or impact of the positive event. Like mitigation, enhancing is most effective where it is used to exert influence over outcomes before they occur;
- **Sharing** (*opportunity response*) – in which the ownership and rewards of the positive risk are shared with a third party. Joint ventures are vehicles for creating such opportunities. For example, an established company that needed to acquire new technology in order to launch a new product might partner with the start-up company that developed the required technology. In return, partnering with the established company might provide the start-up with access to a market that its scale might otherwise prohibit it from entering;
- **Exploitation** (*opportunity response*) – in which the performing organization deliberately acts to enhance the occurrence of the opportunity. An example of exploitation would be using the best technical resources on the design phase of a project to create more value in the functionality of the product delivered;
- **Acceptance** (*both threat & opportunity response*) – in which the risks, either positive or negative, are accepted by the performing organization. All projects carry risk, and risk cannot be eliminated entirely from projects. Passive acceptance of risk is an acceptable response, so long as the project team explicitly acknowledges that they will address threats or opportunities as and when they occur. Active acceptance acknowledges that risk exists, both known and unknown. A *contingency reserve* is established, based on accepting "known unknowns," that holds sufficient budget, time and resource to respond to such risks, should they arise. What kind of reserve is used to respond to risks that are "unknown unknowns?" See page 151. Note that *reserves* are provided for in the Project Management Plan to address both cost and schedule risk (see *Glossary* definition on page 445).

In addition to the above general risk response strategies, responses may also be planned by the project team to address risks that occur under specific, predefined circumstances. In other words, the response to the risk is *contingent* upon certain conditions being met.

Following risk response planning, updates to the Risk Register include:

- prioritized list of risks on the basis of Qualitative and Quantitative Risk Analysis;
- detailed descriptions of each risk, including causes and impact on project;
- identified risk owners, assigned responsibilities for each risk;
- agreed risk response plans or strategies;
- identified actions to implement risk responses selected;
- list of triggers (symptoms or warning signs) for each risk event;
- contingency plans identified for specific risks, including triggers that will invoke such plans;
- list of risks that have been accepted, either actively or passively
- contingency reserves (time, cost) identified, that are commensurate with stakeholder risk tolerances and the expected value of project risks;
- fallback plans identified in the event that the primary response is ineffective;
- list of residual risks that may persist after responses have been implemented; and
- identified secondary risks that may arise in response to implementing a primary risk response.

Contracting or other arrangements to transfer risk to a third party should also be established.

11.6 Monitor and Control Risks

[Page 308, Figure 11-19. *Monitor and Control Risks: Inputs, Tools & Techniques, and Outputs*]

Monitoring and Controlling Risks is a continuous and iterative process that is performed throughout the project as project tasks are executed and work is completed. The variables and circumstances that influence risk, and upon which project risk assessments (probability, impact, consequences, etc.) are made, must be constantly analyzed and evaluated as work is performed to determine if and how the risk profile of the project has changed. Risk monitoring and control is a proactive process that includes:

- monitoring *variances* in work results to identify if risk factors are affecting outcomes;
- analyzing *trends* in work results to identify if risk factors are causing an improvement or deterioration in project performance (remember: risks can result in positive and negative outcomes);
- verifying that project *assumptions* are still valid;
- monitoring low level risks on the *watch list* to ensure that they have not changed or increased in the significance of their impact, requiring immediate attention;
- monitoring *risk response triggers* for contingency plans;
- checking if *contingency reserves* (cost, schedule) need to be modified in alignment with any changes to the risk profile of the project;
- reviewing risk responses after *corrective actions* have been taken (are the responses still applicable or appropriate to the risks identified? If not, how should they be modified);
- evaluating the *effectiveness of risk responses* executed, ensuring that they achieved the desired result as planned in the response and did not create any new risks;
- identifying *new risks and responses* as the project progresses and changes;
- ensuring that the risk management *policies and procedures* defined in the risk management plan are being followed and adhered to;
- updating *lessons learned* and *organizational process assets* (for example, risk management templates) to reflect actual results and experience of project risks;
- monitoring *residual risks*;
- reevaluating risks using *qualitative and quantitative analysis*;
- running *Monte Carlo analysis* simulations to determine if the probability of delivering the project on time and to budget has changed (has uncertainty increased or decreased?);
- *communicating* the status of project risks to stakeholders;
- executing *contingency plans* when triggers are invoked;
- executing *fallback plans* if primary risk responses do not achieve the planned mitigation of the risk; and
- executing *workarounds* in response to unexpected risk events. Note that unlike a contingency plan, a workaround is an *unplanned response* to a risk event.

This list is not exhaustive. What other activities should be performed as part of risk monitoring and control? *Risk reassessment* is an important, proactive activity that the project management team should perform on a regular basis to ensure effective risk management. From the perspective of the performing organization, an *audit* of the effectiveness of risk management processes, planned responses and actual responses may be performed to ensure that the right level of control and management is being exercised, commensurate with the overall business risk that the project is carrying. As risk events occur throughout the project, reserve analysis should be performed to ensure that the amounts remaining in the cost and schedule reserves are sufficient to respond to the remaining risk events that may occur in the future.

12. Project Procurement Management

Please note that Chapter 12, Project Procurement Management, was modified a fair amount from the *Third Edition* of the PMBOK. The most significant change in the *Fourth Edition* is the consolidation of six processes into four processes. Specifically, this means that the old opening sections, Sections 12.1 Plan Purchases and Acquisitions and 12.2 Plan Contracting, are now incorporated into one section – 12.1 Plan Procurements. Also, subsequent sections, Sections 12.3 Request Seller Responses and 12.4 Select Sellers, were combined to create 12.2 Conduct Procurements. Finally, a new concept, Teaming Agreements, is introduced in the *Fourth Edition* of the PMBOK.

Project Procurement Management (Chapter 12, pages 313-344) comprises four project management processes:

12.1 Plan Procurements [*Planning*] – identifying what needs to be acquired or purchased, including how and when, to meet specific project objectives (pages 319-324);

12.2 Conduct Procurements [*Executing*] – documenting the requirements defining the project need and identifying third parties that can potentially meet those needs (pages 328-333);

12.3 Administer Procurements [*Monitoring & Controlling*] – managing the contract relationship between the project and the third party, and ensuring that work performed by the third party meets the contract specifications (pages 335-340);

12.4 Close Procurements [*Closing*] – administering the close out processes that will formally terminate the contract on completion of the work (pages 341-344);

What did you notice about the introductory summary of Project Procurement Management processes above? Read through them again. Note that every process domain is represented except for *Initiating* (which is unique to Project Integration Management). Which other project management process group (or groups) covers these four domains? If you've already memorized these, you know that none of them do. Project Procurement Management is unique insofar as all four domain processes are engaged, from start to finish, to enable the project team to acquire capability, products, services, resource or work from an external party that the project cannot provide internally to meet project objectives. These processes define the *contract life-cycle*. Procurement forms a project within the project. Any of the required external elements can be contracted in by the project team. As we saw in the previous chapter on project risk management, contracting may also be used to transfer risk or to share risks and rewards, both of which are strategies for achieving project objectives. You may think you know what a contract is, but here is the PMBOK definition:

Definition:"A contract is a mutually binding agreement that obligates the seller to provide the specified product or service or result and obligates the buyer to pay for it." [*Glossary*, page 429.]

From the contracting entities' perspective, this concept is very important. A contract provides *legal remedy* in the event of *non-performance* by either party, if the seller fails to deliver or the buyer refuses to pay. Project work or even completed projects that are performed *under contract* need to be specified in detail to prevent misunderstanding about performance. Contracts are a tool for managing both parties' expectations about performance. Because of this, the development of the contracting relationship and of the contract itself must be:

- *formal* – systematically and accurately documented, and subject to extensive commercial and legal review and approval;
- *specific* – the contract must be sufficiently detailed to ensure that there is no ambiguity about what meeting the terms of the contract means (for both parties);
- *time-bound* – the contract should refer not only to *how* the terms of the contract will be met (the products, services, results or other deliverables), but also *when* they will be met. Contracts incorporate schedules specifically for this purpose, to ensure that milestones are being met. For lengthy projects, the contract may make a provision for mutual renewal on, for example, a specified anniversary date, at which point performance may be reviewed and the contract terminated (according to the termination process documented in the contract); and
- *managed* – changes to the contract terms and conditions must be reviewed, approved, and administered according to formally agreed change control processes and procedures.

The contracting relationship between the contracting parties is formally developed throughout the contract life-cycle. This is reflected in the changing roles of the parties as they progress through the contract processes. For example, the seller (or supplier), in relation to the buyer (or acquirer), who is a *bidder* during the Request Seller Responses process, becomes the *selected source* during the Select Sellers process, and finally becomes the *contracted supplier* prior to commencement of the Contract Administration process. From the seller's perspective, during this cycle the buyer's role will evolve from an initial *service requestor* (or *acquiring organization*) during the Request Seller Responses, to the potential *client* (or *customer*) during the Select Sellers Process, and finally becoming the *contractor* when the contract is awarded to the seller.

Depending on the scope of work requested, a seller may, in turn sub-contract part of the work to another seller. In this case, the seller is a buyer to the sub-contractor. Contracting relationships can be very complex. This is reflected in the different role titles that the PMBOK identifies. Note, for example, that to the seller, the buyer is also a *stakeholder* whose needs and expectations must be managed. It follows that the Contract Statement of Work, which is a narrative description of the goods, services or products to be supplied under contract, is a key input for managing those expectations.

In its simplest form, a contract involves an *offer* by the buyer and *acceptance* by the seller. A contract also implies *legal capacity* between the two contracting entities. These two entities have the right and the capability to make such an agreement, and make sure that the agreement is, in fact, legal. A contract also expresses the concept of *consideration* – performance of the work by the seller will be rewarded by the buyer with something of value. Most contract considerations are met by monetary payment to the seller. However, in some contracting relationships, the consideration may be met, for example, by the seller getting to share in the value of the intellectual property, developed by the buyer, resulting from the contract work.

In describing the processes in the contract life-cycle, the PMBOK makes the following assumptions:

- the project manager is fully involved in the contract creation processes described;
- the seller is external to the performing project organization;
- the buyer is represented by the (internal) project team; and
- the processes are described from the perspective of the buyer, the performing project organization's perspective (project manager, project team).

In many cases, project managers are often brought into a project after a contract has been signed. If that is your experience, note that this is not the (correct) way it is done, according to the PMBOK.

Many project managers have limited experience with contracting. This is either because they normally acquire all of their required project capabilities and resources internally, or their performing organization has an external, third party relationship management function that acquires such capabilities and resource on their behalf. For that reason, some PMP candidates find Project Procurement Management one of the more difficult topics to prepare for the exam. Spend as much time as you need so that you understand how the contract life-cycle process works, what steps are involved in the life-cycle and in particular, that you are able to recognize the different contract types and understand why and how these are used to acquire products and services and manage cost risk associated with the project (see pages 322-324). The description of the contract life cycle that follows is written from the perspective of a single contract between a buyer and a seller. Keep in mind, however, that a buyer may contract out various sub-components of the overall project to multiple sellers (contractors) and that those contractors may, in turn, sub-contract work to other sellers.

12.1 Plan Procurements

[Page 317, Figure 12-2. *Plan Procurements: Inputs, Tools & Techniques, and Outputs*]

The objectives of the Plan Procurements process include the documentation of the purchase decision, selecting the procurement approach and identifying a list of potential sellers. The first step in doing this is to determine which project needs can be best met internally by the performing organization and which needs can be best met by an external third party. Once a project team has identified products, services or other work to be acquired externally, the most appropriate contracting arrangements to do this must be selected.

The process of determining which project needs might be best met externally involves consideration of the scope of the project and the factors that influence delivery of the scope (cost, schedule, risk). The project scope statement sets the boundaries of the project by identifying constraints, assumptions and requirements. It follows that if these are valid and cannot be met internally then the project team must consider alternative options outside of the capability of the performing organization to meet these. This decision is achieved by performing a *make-or-buy analysis* (alternatively referred to as *build-or-buy analysis*). This decision-making process is usually driven by consideration of the project budget. In doing this, the question, "*Which is the more efficient (less costly) means of satisfying project objectives?*" is examined. For example, if a company wants to enter a new market and it has the budget capability to do so, it may be cheaper to acquire a company that is already established in that market than to build internally the services and products (and other supporting business infrastructure) required to compete in the new market. On the other hand, if the company is creating a new product that will give it a significant competitive advantage in an existing market, it may decide to create the product from available internal resources and capabilities in order to control intellectual property, and manage all aspects of the product's creation in a confidential and closed environment. Most projects, though, contract out discrete project deliverables.

In making the buy decision, consideration also needs to be made as to whether it is less costly to *buy outright* or to *rent* the capability, products, services, resource or work required to meet project objectives. The cost of ownership therefore needs to be compared to the rental cost. In *renting*, a constant, recurring charge is paid for the duration of the period that the materials, services, capability or work is required. In a *leasing* arrangement, an upfront fee is paid and then the remaining cost to acquire outright is paid off in increments. A *breakeven* point can be calculated at which the cost to buy (lease) and the cost to rent are the same. If the materials, services, capability or work are required beyond the breakeven point to meet an ongoing need then it is cheaper to buy (lease) than to rent. Ultimately, though, the performing organization can decide to buy even if it is cheaper. One example, in which this option might be exercised, would be if an organization elected to build internally if the acquired capability was aligned with meeting the organization's future, strategic objectives.

When costing build or buy alternatives, both *direct* and *indirect* costs need to be factored into the comparison. For example, if a performing organization employs its own staff on a project task, the work rate cost (per hour) includes salary (direct costs) as well as benefits and other staff overheads (indirect costs). A contracted staff rate should be cheaper (but is not always the case, especially when contracting for specialist skills). Note that the outcome of build or buy decisions need to be taken into account in both the Estimate Activity Resources process (see section *6.3*) and in the Develop Schedule process (section *6.5*).

Assuming a project team has already been committed to the procurement of a product or service, a critical input to consider will be the presence of a pre-existing Teaming Agreement. Simply stated, a Teaming Agreement is a temporary legal contractual arrangement between parties or entities for the purpose of taking advantage of a business opportunity. The PMBOK defines a Teaming Agreement as:

Definition: "Teaming Agreement – A legal contractual agreements between two or more entities to form a partnership or joint venture or some other arrangement as defined by the parties. The agreement defines buyer-seller roles for each party." [page 319]

The mechanism of a contract is primarily designed to share and transfer risk between contracting entities as expressed in costs and rewards. The specific terms of the contract are selected to influence behaviors that will positively contribute to meeting project objectives through performance of the work contracted. The following are the main types of contracts used in projects. Note that risk is gradually transferred from seller to buyer as you descend this list.

You should familiarize yourself with these contract types, understand their characteristics (advantages and disadvantages to seller or buyer), and be able to distinguish whether the seller or the buyer is assuming the most risk when choosing between different types of contract.

- **Fixed Price** (**FP**): this type of contract sets a fixed total price for the product or service. Financial incentives may be included for exceeding specified project objectives, like a delivery date or a quantified performance measurement. Exam candidates should be familiar will all three primary forms of fixed price contracts:
  - Firm Fixed Price (FFP)
    - seller carries most risk (cost of work can increase);
    - strong focus on controlling scope (to contain and manage costs);
    - seller requires detailed scope specification;
    - seller may price risk into the cost of performing the work (contingency against scope creep);
    - used by risk-averse buyers to cap costs; and
    - purchase order is the most common form of this contracting arrangement.

- Fixed Price Incentive Fee (FPIF)
  - reduction in risk assumed by the seller;
  - seller requires detailed scope specification;
  - same as FP but includes incentives to the seller for meeting schedule and cost targets (for example, early completion or reduction in costs); and
  - uses a ceiling price in the contract formula which represents the *point of total assumption*. This is the point after which the seller assumes all responsibility for increasing costs (this is the incentive mechanism to cap costs).
- Fixed Price with Economic Price Adjustment Contracts (FP-EPA)
  - protects both buyer and seller;
  - used when sellers work spans multiple years;
  - includes special provision allowing pre-defined final adjustments to the price of the contract based on changes in conditions, like inflation;
  - the final economic price adjustment is commonly attached to a reliable financial index.

- **Cost Reimbursable Contracts:** this type of contract involves payment to the seller for legitimate actual costs incurred for completed work plus a fee representing a profit for the seller. Exam candidates should be familiar will all three primary forms of cost reimbursable contracts:
  - Cost Plus Fixed Fee Contracts (CPFF)
    - risk more evenly balanced between seller and buyer;
    - seller is reimbursed allowable project costs;
    - seller receives a fixed fee payment (based on a percentage of costs); and
    - fixed fee is tied to project scope (fee does not change unless there is an approved change of scope or the incentive is on the seller to control costs).
  - Cost Plus Incentive Fee Contracts (CPIF)
    - some risk sharing between seller and buyer;
    - specified costs are reimbursable to the seller;
    - a bonus (incentive fee) is paid to the seller for meeting performance targets (usually based on cost reduction);
    - contract specifies formula to be used to calculate bonus and sharing of cost savings (seller component may include a fixed or capped fee); and
    - scope focuses more on performance of the work rather than on the technical aspects (which is what the buyer is purchasing from the seller).

  - Cost Plus Award Fee Contracts (CPAF)
    - seller carries more risk;
    - costs are reimbursed to seller for performing contract work;
    - majority of fee is earned based on the satisfaction of subjective performance criteria;
    - final fee delivered is at the buyer's discretion;
    - final fee is not subject to an appeal.
- **Time & Materials** (**T&M**): this type of contract is considered a hybrid contractual arrangement since it contains aspects of both cost reimbursement and fixed-price contracts. Important aspects of this contract type include:
  - more risk carried by buyer;
  - combines elements of both cost reimbursable and fixed price contracts;
  - scope can be simply defined (usually repetitive work activities or tasks);
  - T&M based on a fixed per unit (or per hour) cost, but duration is indeterminate;
  - total cost (to buyer) is unknown;
  - potentially open-ended unless expected effort (duration) or output (unit quantities) are well defined by the buyer before work commences; and
  - most cost effective for repetitive, well defined tasks of short duration (for example, filling a gap in human resources to cover absence).

For Incentive Fee (IF) type contracts, given a Target Cost (the expected cost of the contract work), a Target Fee (how much the buyer is expecting to pay the seller for work performed) and a Sharing Ratio (which describes how any profits will be shared between buyer and seller), you may be asked in the exam to calculate the Actual Cost (of the contract work performed), the Actual Fee and the Final Price (of the contract) – Actual Cost plus Actual Fee.

Which contract type might you use to contract for a pipeline project? If the scope was residential infrastructure (for example, supplying units in a subdivision with main water) then a T&M contract is probably appropriate. If the scope was for a transcontinental natural gas pipeline, then a CPFF or CPIF contract might be more appropriate. What factors influence that decision? Complexity of the scope of work and who carries the risk associated with performing that work are the primary considerations. A contract is a tool for managing risk, which means managing uncertainty. In the case of the transcontinental pipeline, where there might be a high degree of geopolitical uncertainty, sellers can expect to be rewarded for successfully assuming project risk, so some form of FPI contract might be used by the buyer to engage the seller in managing that risk.

The output from the Plan Purchases and Acquisitions process is the Procurement Management Plan, which is a subsidiary or contributing plan to the project management plan that describes how procurement will be managed throughout the contract life cycle (page 324). Additionally, a Contract Statement of Work (SOW) is also developed for those parts of the project scope that have been identified to be contracted out. Derived from the project scope statement, the WBS, and the WBS dictionary, the contract SOW should describe the procurement needs in sufficient detail to enable prospective sellers to determine if they have the capability to deliver against the contract SOW. The contract SOW is modified and updated following discussions with, and review by, the successful bidder, and is formally incorporated within the final version of the signed contract.

Templates and standard forms from previous procurement life cycles are used as the basis for the Procurement Documents that will be used to solicit proposals from prospective sellers. Terminology for the solicitation documents varies by application area and by usage. A distinction can be made, however, between soliciting bids on the basis of price (or cost) and on the basis of technical approach. "Proposal" is a generic term that is generally used for the latter, while such terms as "tender," "quotation," or "bid," tend to be used to denote the former. In general, however, there is no strict usage and the content of the procurement document should be clear about what is being solicited and the basis of the solicitation. Some common types of procurement documents include:

- Request for Proposal (RFP)
- Invitation for Bid (IFB)
- Request for Information (RFI)
- Request for Quote (or Quotation) (RFQ)
- Tender Bid (TB)
- Etc.

Whichever format or type is selected, the procurement document should contain:

- a clear and unambiguous *scope statement*, including an explicit statement about what is not in scope, which will help manage seller expectations once the contract is awarded;
- a *response format* for how the prospective seller is to respond;
- the *timeframe* for responses to be received by the buyer from prospective sellers;
- any *contracting provisions* will be made in the contract, for example, non-disclosure agreements, payment cycles, etc.;
- the *constraints* the contracted work will be subject to, for example, pipelines can only be laid during the spring and summer;
- the *selection criteria* that will be used to identify the prospective sellers and award the contract;
- details about any *bidder conferences* that may be conducted by the buyer, including formats for presenting information at the conference;
- details about any *due diligence* to be performed by the buyer to verify the seller's technical competency; and
- details about the level of *financial disclosure* required of the seller to prove financial capability.

Once the seller proposals have been received by the buyer, these will need to be evaluated and scored. This process is facilitated by developing Evaluation Criteria that are relevant in evaluating whether the prospective seller will be able to meet the requirements of the contract. Some of the types of evaluation criteria typically used are mentioned in the preceding checklist of procurement document content. Other criteria include evidence that the prospective seller understands project need and life-cycle cost, and that they have a management approach that is capable of delivering against the contract requirements (pages 327 - 328).

12.2 Conduct Procurements

[Page 329, Figure 12-4. *Conduct Procurements: Inputs, Tools & Techniques, and Outputs*]

The objectives of the Conduct Procurements process include collecting responses from sellers, selecting a seller, and completing a contract. Through this process the team will receive a number of bids and proposals from potential vendors. Once the team has received all bids and proposals how might the project team accomplish the vendor selection faster and with less bias in the process? One way advocated in 12.1 Plan Procurements is to already have predefined selection criteria. Once these criteria have been developed the project team can assign weights to any criteria that are deemed critical to the project. For instance, if the scope of work being procured is exceptionally large then the project team may put extra emphasis on the financial or production capacity of the final selected vendor. Another way to speed the vendor selection process is to use a predefined list of qualified sellers. In using one of these lists of sellers, the project team will have the benefit of knowing past organizational experience with a vendor before reviewing that vendor's proposal. A *Qualified Sellers List* can either be created by the project management team for the purpose of their vendor selection process or created by an organization's procurement function and used on a recurring basis by many project teams. When using an 'in-house list' the project team can still supplement the list with vendors gathered from other qualified contact sources, such as company directories, trade association membership lists, etc.

The solicitation of seller proposals is a major focus for the Conduct Procurements process. *Advertising* in newspapers or in specialist trade, industry or other publications ("Invitation for Bids") is used to solicit proposals. This is a common method used for government tenders. The advertisements provide summary information about the scope of the work, a tender reference number and contact details for further information. Alternatively, *Bidder Conferences* are also held with prospective sellers to help them prepare proposals. This provides a forum for prospective sellers to meet with the buyer, to share information, clarify requirements and to answer any seller questions. As a result, procurement documents may be updated to incorporate additional information collected during the conferences, and re-circulated to all bidders to ensure a *level playing field* in the proposals submitted to the buyer. Sellers respond with their proposals. Proposals must provide information in the format and as requested in the seller's procurement document. They need to be able to demonstrate that, should the contract be awarded to the prospective seller, that they can meet <u>all</u> of the contract requirements. This is an important consideration when selecting the seller. A seller may have the technical capability and the financial resource to meet the requirements, but if its management approach is weak or is not congruent with the management approach of the buyer's performing organization, it may not be able to operate efficiently to deliver against the buyer's schedule, for example.

One important thing to remember when reviewing this section is that a contract is really a two-way relationship. Although the Conduct Procurements process emphasizes the fact that it is the buyer who selects the seller, you need to be aware that the seller, in some sense, also selects the buyer when presenting themselves as a prospective contractor. If the seller misunderstands the expectations of the buyer, or vice versa, then the outcome for both parties will be unsatisfactory and the (legal) consequences may be costly. How the selection process is conducted, therefore, is important to assuring the satisfactory completion of the work to be performed under contract.

Initial evaluation of the proposals submitted by the sellers may establish a short list of qualified suppliers, who the buyer may then wish to interview further. This meeting can, in turn, lead to more detailed negotiations until a winning bid is finally selected from among the competing sellers by the buyer. Whichever process is used, the procurement documents must be very clear on how the final selection will be made. If there are *preferred bidders* from the solicitation process, the buyer must be explicit about this. As with personal relationships, trust is important to a successful contracting relationship (and is especially so when disputes arise between contracting parties). Although trust cannot be legally mandated in the contract, such elements as transparency, openness and fair dealing during the selection process will help to promote a productive contracting relationship.

All proposals submitted are reviewed against the criteria listed in the procurement documents. Proposals may be *screened* to ensure that they meet the minimum requirements for performing the work. As part of the screening process, an initial *ranking* of the best qualified bidders may be established. A *scoring* and *weighing system* can be used to quantify the extent to which each bidder satisfies the selection criteria. The result of each criterion is scored (weighted numerically), and is then combined with other scores via multiplication to derive an overall score. Most scoring systems are qualitatively based, representing a degree of subjectivity that emphasizes the importance to the buyer of each of the criteria. These mainly focus on performance characteristics (budget, technical capability, schedule, risk management, etc.). Weighting converts these *qualitative assessments* into a *quantitative measure*. Results may also be validated with reference to *independent estimates*, for example, comparing the seller costs submitted to estimates (and actual costs) for similar work performed in the past. *Expert judgment* is also used as part of the proposal review process to ensure the right level of competent scrutiny and specialist knowledge is applied. The past performance of sellers can also be evaluated using a *seller rating system*. This information should be available to the project team from performance and other data collected and archived during contract administration on previous projects (page 333). A part of this process, in which the seller actively participates as a selector, is during *procurement negotiation*. The structure and terms and conditions of the final contract (the binding agreement that is to be signed by both parties) are mutually agreed upon by the seller and the buyer. There is a substantial body of guidance and opinion on the art of negotiating. A successful outcome to negotiation is a *win-win* situation for both parties. This is important from a seller motivation perspective: the buyer wants and needs the seller to perform the work to completely meet all requirements.

The select seller process ends with the *contract award*. The form, scope, structure and content of the final contract will be determined by the specific circumstances of the work to be contracted. Complex requirements will need to be specified to a much greater level of detail than simple requirements. How the contract is to be administered also needs to be agreed upon and documented before any work can commence. Note that the contract management plan is a subsidiary or component plan of the project management plan.

12.3 Administer Procurements

[Page 335, Figure 12-6. *Administer Procurements: Inputs, Tools & Techniques, and Outputs*]

The Administer Procurements process ensures that the contractual obligations of both parties to the signed contract are being met. This means that the seller is performing to meet the contractual requirements of the buyer and, in return, the seller is receiving the agreed consideration (usually in the form of monetary payments) from the buyer for meeting those performance requirements. Procurement administration also ensures that the legal rights of the contracting parties are being observed and met.

Work performed under contract is a part of the project, and needs to be fully integrated with other project work. It is not separate from, or outside of the project. The integration of work under contract is accomplished during contract administration using the same processes as if the work were being performed by the buyer.

Due to the legal basis of contracts, Procurement Administration is usually performed by a specialist Procurement or Contract Administrator, who can be a dedicated resource on the project team or part of a separate contract administration department within the performing organization. Due to compliance and control reasons, the latter is the more common way of managing contract administration functions.

Contract Administration is comprised of the following activities:

- **Performance review** – in which the buyer reviews the performance of the seller to ensure that work is being performed as specified in the contract SOW and to meet the agreed budget, schedule and quality parameters of the project work. The results of performance reviews may indicate the need to take corrective action to bring performance back into line with what is required (expected);
- **Change Control** - The contract must be maintained and updated according to a formal change control process, as agreed by both seller and buyer and as defined in the project procurement management plan. All authorized changes are applied to the contract;
- **Performance reporting** – in which information about the performance of the seller in meeting the contract work objectives is collected and evaluated. Project performance measures, such as EVM, may be applied;
- **Seller payment** – in which payments are made to the seller according to the agreed contract terms. Payments can be made according to a calendar or as milestones are met or, on completion of work packages, when the seller submits an invoice triggering payment. Payments are approved by the project and are usually disbursed via the performing organization's Accounts Payable function;
- **Audits** – or *inspections*, may be conducted by the buyer, and as agreed with the seller, to ensure that the seller's work processes and deliverables continue to meet the buyer's requirements and are in conformance with the representations made by the seller during the solicitation and bidding phases of the contract life cycle;
- **Record administration** – provides for the systems, processes and procedures required to manage, administer, archive and retrieve contract and related documents, such as correspondence. The records management system used for this purpose is a part of the Project Management Information System (PMIS); and
- **Claims administration** – involves those processes required to document, process and archive claims arising from disputes between the seller and the buyer.

Disagreements between seller and buyer over performance of the work under contract can arise where there are changes to the scope of work that are undocumented or not formally approved. When changes occur, the seller will expect to be compensated for taking on additional work (or risk). If the buyer does not recognize that there has been a change, then any additional work is at the expense of the seller and will not be paid for by the buyer. Note how important a formal and robust change control process is to ensure that both parties recognize and agree that a change has taken place. If they cannot agree, and contest that a change has or has not taken place, then seller and buyer are "in dispute." A *dispute* (also referred to as a *claim* or *appeal*) is usually resolved with reference to the dispute resolution procedures as defined in the contract. This may invoke legal remedy such as *arbitration* or *litigation*. Contract Administration must ensure that all changes, such as scope of work, milestones, deliverables, etc., or to contract terms and conditions, such as payment formulas, for example, are accurately reflected in the contract and are agreed and approved by both parties.

12.4 Close Procurements

[Page 341, Figure 12-8. *Close Procurements: Inputs, Tools & Techniques, and Outputs*]

Closing out the contract is an input to the Close Project process (see section *4.6*). Close out occurs when either the contract work is completed or when the contract is terminated early, prior to completion of the contract work. In either case, the same process is applied. Just as the contract specifies how disputes will be resolved, so it also identifies the conditions under which *early termination* can take place and how early termination will be performed. As well as providing for administrative closure (the payment of final invoices, archiving of documents, etc.), contract closure documents the final state of the deliverables that were created by the work under contract. In early termination, the same applies: deliverables are documented, to the fullest extent possible, in the state that they had achieved when termination occurred. Why is that important? Because *product verification* is a part of customer (that is, buyer) acceptance of the deliverables, and payment will only be made to the seller for those parts of the scope of work that have been satisfied. Note that early termination can occur either by *mutual consent* of the contracting parties, or if one of the parties is in *default* (a failure to fulfill an obligation of the contract). Even in cases where the contract is completed and contract closure has occurred, *contested claims* can still arise, especially if there is a final lump sum paid by the buyer which is less than the seller anticipated. Note that administrative closure cannot occur after the contract has been closed out.

Procurement audits are also conducted during contract closure. These provide for an evaluation of the effectiveness of the procurement processes used in managing the contract life cycle. These can highlight changes and improvements that may need to be made so that the next project can benefit from the experiences of the project being audited.

Interpersonal Skills (Appendix G)

Past versions of PMP Exam have been notorious for using large banks of questions from sources outside of the PMBOK or hardly mentioned within the PMBOK. For this reason, exam candidates should at least be familiar with Appendix G: Interpersonal Skills prior to taking the exam. The good news is that, more than any other topic covered within the PMBOK, an individual's personal experience should be in close alignment with the key objectives stressed in this section.

Since project managers accomplish work primarily through the work of others, effective project managers will need to master the following interpersonal skills:

- Leading team members
- Motivating team members
- Building a close and coherent team
- Communicating with others
- Influencing decisions and actions of others
- Making Decisions
- Staying politically and culturally aware
- Negotiating with others

Amongst these interpersonal skills, decision making is one area that the PMBOK sees as having a pre-determined approach that a project manager can practice to become more effective. The model described includes:

- Defining the problem
- Generating possible solutions
- Selecting the best solutions
- Planning actions
- Post-implementation analysis
- Evaluating outcomes and realizing benefits

Effective negotiation is another point of emphasis for the PMBOK's section on Interpersonal Skills. Negotiation is described as a strategy for reaching a compromise or shared agreement amongst parties with opposing positions. The PMBOK advocates using the following skills and behaviors for successful negotiation:

- Analyzing the situation carefully.
- Differentiating between wants and needs.
- Focusing on interests and issues.
- Asking high and offering low.
- Be willing to concede but do so slowly.
- Always make sure both parties feel like they have won.
- Listen and speak carefully.

Professional and Social Responsibility

The PMBOK Guide does not address Professional and Social Responsibility, although the PMP exam will test you on this. You should read and understand the PMI's PMP Code of Professional Conduct before you take the exam. The code describes the professional standards that are expected of a project manager.

Professional and social responsibility covers four areas. The project manager should:

- ensure individual integrity and professionalism;
- contribute to the project management knowledge base;
- enhance individual professional competence; and
- promote interaction among and balance stakeholders' interests.

When reviewing the code, you should consider the influence that each of these elements has on managing a project. This is the perspective that the PMP exam questions take – they emphasize the role that professional conduct plays in influencing project outcomes. Therefore, when you review any of the process areas think about how the professional conduct of the project manager can enhance and assure the performance of that process by following this code.

Although it is primarily aimed at the PMI membership, the code establishes a professional code of conduct for all project managers. It addresses how project managers should conduct themselves as representatives of their profession and what it means to be a project management professional. It stresses ethical behavior when interacting with project management peers, stakeholders, and others in the practice of project management.

Project managers must exhibit integrity through fair dealing, cooperation and trust. Professional responsibility also implies sharing industry best practices (promoting the project management knowledge base) and mentoring and coaching other project managers to maintain and raise the standard of project management practice, and to enhance individual competency. Project managers should observe legal standards and ethical behavior at all times. For example, when working on a project in a foreign country, it may be an acceptable local practice to provide a "special" payment to officials in order to secure work permits. If this payment is not required by local laws or regulations, then it may be illegal, and is certainly unethical. Project managers must understand and respect personal, cultural and ethnic differences. Diversity is a strength on projects, because it provides opportunities to apply alternative approaches to project problems that a monoculture does not. A project manager has a professional duty to report any violations of policies, laws or other ethical standards to a responsible authority. The proactive behavior of the project manager in dealing with such aspects of the project as risk should also be applied to confronting conflict between stakeholders and resolving the causes of the problem directly.

A project manager should act in confidence on behalf of their client and respect confidentiality. If the project manager cannot resolve a conflict of interest, then they should avoid it. Why? Because it will compromise project performance. Look at the PMBOK processes. Their aim is to promote transparency, clarity and objectivity in performing project work. Likewise, similar ethical qualities in the project manager, such as truthfulness, reinforce the successful execution of these processes.

Most exam candidates find this topic relatively easy in comparison to other topics. Despite the wording of some of the situational questions, there are no "grey areas." There is always one answer that represents the "right thing" to do. If you understand the ethical and professional basis of the code, then you should not encounter much difficulty in answering questions correctly.

Practice Questions

Chapter 1

1. The Project Management Information System is: Select the best answer.

   - ❍ A. An identified area of project management defined by its knowledge requirements and described in terms of its component processes, practices, inputs, outputs, tools, and techniques.
   - ❍ B. A standardized set of automated tools available within the organization and integrated into a system.
   - ❍ C. A class of computer software applications specifically designed to aid the project management team with planning, monitoring, and controlling the project, including: Estimate Costs, scheduling, communications, and collaboration.
   - ❍ D. A repository that provides for collection, maintenance, and analysis of data gathered and used in the risk management processes.

Chapter 2

1. The Configuration Management System is a collection of formal, documented procedures used to apply technical and administrative direction and surveillence to: Select the best answer.

   - ❍ A. Control any changes to such characteristics.
   - ❍ B. Record and report each change and its implementation status.
   - ❍ C. Identify and document the functional and physical characteristics of a product or component.
   - ❍ D. All of these.

2. Project assumptions tend to be listed in both the project charter and detailed project scope statement. Which description provides the BEST explanation of the relationship between assumptions appearing in the project charter and the detailed scope statement? Select the best answer.

   - ❍ A. Assumptions appearing in the project charter are more numerous and more detailed than those appearing in the project scope statement.
   - ❍ B. Assumptions appearing in the project scope statement are more numerous and more detailed than those appearing in the project charter.
   - ❍ C. Assumptions appearing in the project scope statement are less numerous but more detailed than those appearing in the project charter.
   - ❍ D. None of these describe the relationship between assumptions appearing in the project charter and the detailed scope statement.

3. During the process of estimating activity durations, it is critical to document all of the ____ and _____ used to create the activity duration estimate. Select the best answer.

   - ❍ A. Dependencies, constraints.
   - ❍ B. Data, contraints.
   - ❍ C. Contraints, assumptions.
   - ❍ D. Data, assumptions.

4. At High Dollar Consulting, Inc., you are mentoring a less experienced project manager during the Develop Schedule process. Your colleague is very concerned right now, because she has presented the first draft of the project schedule to the client, and the client has referenced a time constraint for the project that needs to be observed. You advise your colleague to take which of the following steps? Select the best answer.

   - ❍ A. Perform schedule compression to crash the project schedule.
   - ❍ B. Perform network analysis to crash the project schedule.
   - ❍ C. Perform parametric estimating to crash the project schedule.
   - ❍ D. Review the signed project scope statement document.

5. As a senior project manager at VegiSoft, you occassionally perform some program management duties. One of these duties involves performing the Control Schedule process on projects that are scheduled for release within the next 12 months. When doing this, what type of information would prove to be the MOST helpful in beginning this process? Select the best answer.

   - ❍ A. A copy of the resource requirements document.
   - ❍ B. A phone interview with the project manager.
   - ❍ C. A summary prepared and emailed from the project manager.
   - ❍ D. A review of project status reports from the past 4 weeks.

6. After completing the Develop Schedule process, you could expect to see all of the following outputs EXCEPT: Select the best answer.

   - ❍ A. A project schedule presented in the form of a bar chart.
   - ❍ B. A schdule baseline.
   - ❍ C. A resource breakdown structure.
   - ❍ D. Supporting data for the project schedule.

7. The cost management plan helps provide consistency and accepted guidelines for the project when performing the Estimate Costs, Determine Budget or Control Costs processes. Based on this information, you would expect to see which of the following in a cost management plan? Select the best answer.

   - ❍ A. Variance thresholds for costs.
   - ❍ B. Units of measure used for budgeting.
   - ❍ C. The level of precision needed for estimates.
   - ❍ D. All of these.

8. The practice of planning for "known unknowns" in a project is also known as: Select the best answer.

   - ❍ A. Vendor bid analysis.
   - ❍ B. Determine Budget.
   - ❍ C. Reserve analysis.
   - ❍ D. Cost aggregation.

9. All of the following are examples of organization charts that could be included as part of human resource planning EXCEPT: Select the best answer.

- ❍ A. A hierarchical chart.
- ❍ B. Responsibility assignment matrix.
- ❍ C. A text-oriented outline of responsibilities.
- ❍ D. All of these.

10. All of the following would explain the variance for contractor expense EXCEPT: Select the best answer.

- ❍ A. The baseline for the project budget was changed.
- ❍ B. The project sponsor required a set of new requirements.
- ❍ C. Estimated costs were understated.
- ❍ D. Contingency allowance was understated.

11. The sequence diagram assumes that all activity dependencies are _____ . Select the best answer.

- ❍ A. Finish-to-Start.
- ❍ B. Finish-to-Finish.
- ❍ C. Start-to-Start.
- ❍ D. Start-to-Finish.

12. Given the information in the diagram what is the CRITICAL path between milestone A and milestone B. Select the best answer.

- ❍ A. Activity 1 - Activity 2 - Activity 3 - Activity 4.
- ❍ B. Activity 1 - Activity 2 - Activity 4.
- ❍ C. Activity 1 - Activity 3 - Activity 4.
- ❍ D. Activity 1 - Activity 2 - Activity 3.

13. Which of the following is NOT considered a cost-reimbursable contract? Select the best answer.

- ❍ A. Cost-Plus-Fee.
- ❍ B. Cost-Plus-Incentive-Fee.
- ❍ C. Lump-sum.
- ❍ D. Cost-Plus-Fixed-Fee.

Chapter 3

1. In many organizations a quality assurance department will oversee quality assurance (QA) activities. In this instance, the department provides QA support activities for the project team and the project stakeholders. This QA group also provides another important function. What is it? Select the best answer.

   - ❍ A. Recommending recognition and rewards for the project team.
   - ❍ B. Continuous process improvement.
   - ❍ C. Establishing ground rules for the project team.
   - ❍ D. Quality Management Planning.

2. When performing the quality assurance process for a project, you can expect to use which of the following to begin the process? Select the best answer.

   - ❍ A. Quality Metrics.
   - ❍ B. Work performance information.
   - ❍ C. Quality control measurements.
   - ❍ D. All of these.

3. As a project manager working for Minx Software, you are managing an upgrade of an accounting system for a global auto manufacturer. Many of your project team members work for the client auto manufacturer and are located at the company's various locations throughout the world. During the week of the implementation, you are requiring that core project team members travel to headquarters to assist with the implementation. This is an example of: Select the best answer.

   - ❍ A. Recognition and rewards.
   - ❍ B. Establishing ground rules.
   - ❍ C. Co-location.
   - ❍ D. Team-building.

4. In addition to the price of the bid, what other considerations should a buyer have when trying to maximize the value from selecting a bid? Select the best answer.

   - ❍ A. The bidder's relationship to the seller.
   - ❍ B. The type of product to be delivered.
   - ❍ C. The speed with which the vendor can deliver the product or service.
   - ❍ D. Whether the bidder criteria clears the screening system.

Chapter 4

1. The relationship between the Quality Control process and the Scope Verification process can best be explained by the fact that: Select the best answer.

   - ❍ A. Quality control can be performed before the Scope Verification process.
   - ❍ B. Quality control can be performed at the same time as the Scope Verification process.
   - ❍ C. Two of these choices.
   - ❍ D. Neither of these choices.

2. Assuming that the number of measurable instances increases, which of the following could be used for the purposes of quality control? Select the best answer.

   - ❍ A. Pareto charts.
   - ❍ B. Flowcharting.
   - ❍ C. Statistical sampling.
   - ❍ D. Histograms.

3. Which of the following is NOT true about Risk Reassessment? Select the best answer.

   - ❍ A. Risk reassessment should be scheduled regularly during the project.
   - ❍ B. Risk assessment is typically very detailed.
   - ❍ C. Risk reassessment can be incorporated into regular project status meetings.
   - ❍ D. Risk reassessment can have a significant impact on planned risk responses.

Chapter 5

1. The Close Project or Phase Process will be influenced heavily by the organization's process assets. Activities performed during the Close Project or Phase Process could include all of the following EXCEPT: Select the best answer.

   - ❍ A. Implemented Defect Repair.
   - ❍ B. The collection and archiving of project records.
   - ❍ C. Gathering Lessons Learned.
   - ❍ D. Analysis of project success or failure.

2. During Administrative Closure, a project team is MOST LIKELY to use the Configuration Management System for which of the following? Select the best answer.

   - ❍ A. Identifying the functional characteristics of a product.
   - ❍ B. Developing an index for project documentation.
   - ❍ C. Formally approve submitted change requests.
   - ❍ D. Recording or reporting product audit results.

3. Client satisfaction can be gathered at the close of a project by carrying out which of the following combinations? Select the best answer.

- ❍ A. client surveys, small-group interviews.
- ❍ B. review of emails, review of memos.
- ❍ C. oral presentations, 360-degree surveys.
- ❍ D. assessment of the seller's project manager, assessment of the seller's project team.

Chapter 6

1. After six difficult weeks you begin to suspect that your project team's morale is beginning to decline. In a recent status meeting, the participation from the team was minimal, and prior to the meeting there was little or no casual conversation. To address this situation, your BEST response would be to do which of the following? Select the best answer.

- ❍ A. Give a motivational speech to the group asking for their increased participation.
- ❍ B. Stop working on the project for a day so that everyone on the team can participate in a team building activity.
- ❍ C. Dismiss project team members that continue to exhibit characteristics of bad morale.
- ❍ D. Move forward with the project.

Answers & Explanations

Chapter 1

1. Answers: B

Explanation A. Incorrect. This describes a project management knowledge area.

Explanation B. Correct. A PMIS is a standard set of tools in a system that can help in the creation of project documents or deliverables.

Explanation C. Incorrect. Project Management Software focuses primarily on the Develop Schedule and subsequent controlling processes for a project.

Explanation D. Incorrect. This describes a risk database.

More Information: PMBOK - pg 73

Chapter 2

1. Answers: D

Explanation A. Incorrect. The Configuration Management System's primary intent is control, but there are other options in the answer set that would also apply.

Explanation B. Incorrect. Tracking changes is an essential control measure used in the Configuration Management System, but there are other options in the answer set that would also apply.

Explanation C. Incorrect. Documenting the original function or physical characterisitic is the first step in configuration management, but there are other options in the answer set that would also apply.

Explanation D. Correct. All of the listed options are valid and important functions of the Configuration Management System.

More Information: PMBOK - Pg 78

2. Answers: B

Explanation A. Incorrect. Assumptions appearing in the project scope statement tend to be more numerous and more detailed in comparison to assumptions found in the project charter.

Explanation B. Correct. Assumptions appearing in the project scope statement tend to be more numerous and more detailed in comparison to assumptions found in the project charter.

Explanation C. Incorrect. Assumptions appearing in the project scope statement tend to be more numerous and more detailed in comparison to assumptions found in the project charter.

Explanation D. Incorrect. Assumptions appearing in the project scope statement tend to be more numerous and more detailed in comparison to assumptions found in the project charter.

More Information: PMBOK - Pg 112

3. Answers: D

Explanation A. Incorrect. Neither constraints nor dependencies would be noted here.

Explanation B. Incorrect. Data would be noted, in this instance, but not constraints.

Explanation C. Incorrect. Assumptions would be noted, in this instance, but not constraints.

Explanation D. Correct. Both data and assumptions behind the duration estimate need to be documented. It is important to understand the basis on which estimates are made. Assumptions that are subsequently proved to be invalid or false may adversely affect the accuracy of estimates.

More Information: PMBOK - Pg 146

4. Answers: D

Explanation A. Incorrect. You may be forced to do this at some point but determining what the agreed upon time constraint is would be the first step at this point.

Explanation B. Incorrect. You would not be able to use network analysis to crash a project schedule.

Explanation C. Incorrect. You would not be able to use parametric estimating to crash a project schedule.

Explanation D. Correct. The project scope statement will have time constraints documented for the project. Review of this document, after this turn of events, is key.

More Information: PMBOK - Pg 152

5. Answers: D

Explanation A. Incorrect. This information would not be of much help while evaluating a project's adherence to a project schedule.

Explanation B. Incorrect. This would prove helpful but not as helpful as examining a progress or performance report when beginning. Diaglogue with the project manager will be needed though.

Explanation C. Incorrect. This would prove helpful but not as helpful. The PMBOK prefers formal communication in most cases, and this would not be an exception. Diaglogue with the project manager needs to happen though.

Explanation D. Correct. The status reports provide formal communication and a record of the project's status. Performance reports would also be very helpful when doing this.

More Information: PMBOK - Pg 160

6. Answers: C

Explanation A. Incorrect. A project schedule, presented graphically or otherwise, is an output that you can expect to see at the conculsion of the Develop Schedule process.

Explanation B. Incorrect. A schedule baseline is an output that you can expect to see at the conculsion of the Develop Schedule process.

Explanation C. Correct. A resource breakdown structure is an output from the Estimating Activity Resources process.

Explanation D. Incorrect. Supporting data for the project schedule is often included with the delivery of the project schedule. Both are considered outputs that you can expect to see at the conculsion of the Develop Schedule process.

More Information: PMBOK - Pg 157

7. Answers: D

Explanation A. Incorrect. Control thresholds can be included, but other options in the answer set could be as well.

Explanation B. Incorrect. Units of measure can be included, but other options in the answer set could be as well.

Explanation C. Incorrect. The precision level can be included, but other options in the answer set could be as well.

Explanation D. Correct. All of the options in the answer set could be included in a cost management plan.

More Information: PMBOK - Pg 165

8. Answers: C

Explanation A. Incorrect. Vendor bid analysis involves reviewing the Estimate Costs provided for deliverables during a competitive bid process.

Explanation B. Incorrect. The Determine Budget deals with adhering to an established baseline cost for work packages and deliverables.

Explanation C. Correct. Reserve analysis is the practice of adding additional cost or contingency reserves into estimates to factor in the chance of a risk occurring.

Explanation D. Incorrect. Cost aggregation involves aggregating cost estimates at the work package and WBS-levels.

More Information: PMBOK - Pg 168

9. Answers: D

Explanation A. Incorrect. A hierarchical chart would be an acceptable way of representing organizational responsibilities within the project, but there are other options in the answer set that would also apply.

Explanation B. Incorrect. A responsibility assignment matrix would be an acceptable way of representing organizational responsibilities within the project, but there are other options in the answer set that would also apply.

Explanation C. Incorrect. A text-oriented outline of responsibilities would be an acceptable way of representing organizational responsibilities within the project, but there are other options in the answer set that would also apply.

Explanation D. This is correct. All of the options presented in the answer set would apply.

More Information: PMBOK - Pg 218

10. Answers: A

Explanation A. This is correct. Changing the baseline for the project budget would allow the budget to expand and most likely have a lower variance from actual costs.

Explanation B. Incorrect. Changes to scope is a possible explanation for an increase in contracting expense. This is particularly true if a new skill-set was required that had not been accounted for internally.

Explanation C. Incorrect. The cost estimates for the contracting expense could have been simply estimated at an amount that was too low.

Explanation D. Incorrect. If more contingency allowance had been included, then some of the variance would be accounted for.

More Information: PMBOK - Pg 181

11. Answers: A

Explanation A. This is correct. Finish-to-Start is the most commonly used type of precedence relationship in the precedence diagramming method (PDM).

Explanation B. Incorrect. Finish-to-Start is the most commonly used type of precedence relationship in the precedence diagramming method (PDM).

Explanation C. Incorrect. Finish-to-Start is the most commonly used type of precedence relationship in the precedence diagramming method (PDM).

Explanation D. Incorrect. Finish-to-Start is the most commonly used type of precedence relationship in the precedence diagramming method (PDM).

More Information: PMBOK - Pg 136

12. Answers: C

Explanation A. Incorrect. This path is not the critical path between the milestones.

Explanation B. Incorrect. This path is not the critical path between the milestones.

Explanation C. This is correct. The start-to-start and finish-to-finish relationships for Activity 3 make that activity the critical step in the process. Since its duration exceeds the total duration of all other activities, it becomes part of the critical path between Milestone A and Milestone B.

Explanation D. Incorrect. This path is not the critical path between the milestones.

More Information: PMBOK - Pg 136

13. Answers: C

Explanation A. Incorrect. Cost-Plus-Fee is a type of reimbursable contract that allows the fee to vary based on the actual cost of the project.

Explanation B. Incorrect. Cost-Plus-Fee is a type of reimbursable contract that provides the seller an incentive for surpassing expectation thresholds.

Explanation C. This is correct. Lump-sum is a type of fixed-price contract. No costs are reimbursed in this type of contract.

Explanation D. Incorrect. Cost-Plus-Fixed-Fee is a type of reimbursable contract that does not allow the fee to vary based on the actual cost of the project.

More Information:PMBOK - Pg 316

Chapter 3

1. Answers: B

Explanation A. Incorrect. This activity is typically carried out by the project manager.

Explanation B. This is true. Continuous process improvement is viewed by the PMBOK as a central theme for Quality Management. Ultimately, continuous process improvement reduces waste and non-value-added activities that can adversely affect project delivery.

Explanation C. Incorrect. This activity is typically carried out by the project manager.

Explanation D. Incorrect. This activity is carried out by the project team.

More Information: PMBOK - Pg 201

2. Answers: D

Explanation A. Incorrect. Quality metrics are an input when performing quality assurance activities for a project, but there are other options in the answer set that would also apply.

Explanation B. Incorrect. Work performance information is an input when performing quality assurance activities for a project, but there are other options in the answer set that would also apply.

Explanation C. Incorrect. Quality control measurements are an input when performing quality assurance activities for a project, but there are other options in the answer set that would also apply.

Explanation D. This is correct. All of the options presented in the answer set would apply.

More Information: PMBOK - Pg 201

3. Answers: C

Explanation A. Incorrect. Rewards and recognitions involves providing incentives for desirable behavior on the project team that supports project objectives.

Explanation B. Incorrect. Establishing ground rules is a good practice at the outset of a project. This practice is intended to set clear expectations regarding acceptable behavior for project team members.

Explanation C. This is correct. Co-location involves placing portions of the project team at one location for a period of time, usually as a means of promoting team cohesion and interaction in order to achieve project objectives.

Explanation D. Incorrect. Team-building activities are intended to build cohesion amongst the project team. They can range from short and informal activities to professionally-facilitated day-long activities.

More Information: PMBOK - Pg 229

4. Answers: C

Explanation A. Incorrect. In a bid process that is based primarily on price, the relationship between the buyer and seller could bias the selection process. In more complex proposal selections, a previous history could be a requirement but not in this case.

Explanation B. Incorrect. The requirements of the proposal will be set by the buyer and not the seller. Only in rare cases will a company give a company free rein to develop a 'surprise me' product or service, as in the case of an advertising or creative marketing campaign.

Explanation C. This is correct. The lowest priced bid could result in a product or service that is delivered several months or years away. In addition, a bid that promises to deliver immediately could result in additional utility that outweighs the extra cost spent to the seller.

Explanation D. Incorrect. The screening system is used for the purposes of proposal selection and not bid selection. The screening system is also a tool of evaluation criteria, which at this point are being defined.

More Information:PMBOK - Pg 328

Chapter 4

1. Answers: C

Explanation A. Incorrect. Quality control is generally performed prior to the beginning of the Scope Verification process, but it can be performed at the same time in certain instances.

Explanation B. Incorrect. Quality control can be performed at the same time as the Scope Verification process, but it is generally performed prior to the beginning of that process.

Explanation C. Correct. Quality control can be performed either at the same time as the Scope Verification process or prior to the beginning of that process.

Explanation D. Incorrect. Quality control can be performed either at the same time as the Scope Verification process or prior to the beginning of that process.

More Information: PMBOK - Pg 123

2. Answers: C

Explanation A. Incorrect. Pareto charts could be used, but there is not necessarily a connection between the use of pareto charts and having more measurable instances.

Explanation B. Incorrect. Flowcharting is used to determine the steps involved in a process.

Explanation C. This is correct. As more measurable instances emerge, statistical sampling helps measure the quality of the entire population without having to measure across the entire population of data points.

Explanation D. Incorrect. Histograms could be used, but there is not necessarily a connection between the use of histograms and having more measurable instances.

More Information: PMBOK - Pg 206

3. Answers: B

Explanation A. Incorrect. Risk reasessment should occur reguarly. Project status meetings are one medium for covering reassessment at regular durations.

Explanation B. This is correct. The level of detail actually varies greatly. The objectives and size of the project will contribute to determining the level of detail required for the risk reassessment.

Explanation C. Incorrect. Risk reassessment can be incorporated into project status meetings. A part of regular project status meetings should cover risk management planning, which helps ensure that risks to the project are being adequately addressed.

Explanation D. Incorrect. Risk reassessment can lead to changes in planned responses if the planned responses are found to be inadequate to address the risk identified.

More Information: PMBOK - Pg 308

Chapter 5

1. Answers: A

Explanation A. Correct. This is an activity or output from project management execution (Direct and Manage Project Execution) and not project closure.

Explanation B. Incorrect. The collection and archiving of project records is typically included in Administrative Closure.

Explanation C. Incorrect. Gathering Lessons Learned is typically included in Administrative Closure.

Explanation D. Incorrect. During Administrative Closure, the project team will often analyze the relative success or failure of a project.

More Information: PMBOK - Pg 101

2. Answers: B

Explanation A. Incorrect. Identifying or documenting the functional characteristics of a product is recorded in the Configuration Management System but usually during project planning.

Explanation B. Correct. During Administrative Closure, project teams will use the Configuration Management System to develop an index for project documentation.

Explanation C. Incorrect. Formal approval of submitted change requests is recorded in the Configuration Management System but as part of project execution and not project Administrative Closure.

Explanation D. Incorrect. Recording or reporting product audit results is recorded in the Configuration Management System also, but this is performed as part of project execution and not project Administrative Closure.

More Information: PMBOK - Pg 93

3. Answers: A

Explanation A. This is correct. Client surveys and small-group interview sessions provide the BEST approach in gathering client satisfaction information.

Explanation B. Incorrect. Emails and memos are not considered formal communication channels. There is also a risk of taking comments out of context through this medium.

Explanation C. Incorrect. Oral presentations are typically used during the proposal process. 360-degree surveys are used as self-assessment not client-assessment tools.

Explanation D. Incorrect. Assuming that the seller is delivering the project to the client, the seller's perrspective on their own quality would not be useful in determining the client's satisfaction.

More Information: PMBOK - Pg 380

Chapter 6

1. Answers: B

Explanation A. Incorrect. This is a positive response that could have some impact but it is not necessarily the BEST response, though.

Explanation B. This is correct. Building team communication and morale is important to the cohesivesness and motivation of team members in contributing to a successful project outcome. Sacrificing a day's worth of work could have a positive impact in the long-term.

Explanation C. Incorrect. A firm hand can be useful in certain instances, but not in this case, and might actually make the situation worse than it is.

Explanation D. Incorrect. Avoidance will rarely become the recommended action unless in extreme cases.

More Information: PMBOK - Pg 418