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Project Management

*A Common Sense
Guide to the PMBOK,
Part One—Framework
and Schedule*

James W. Marion



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*Project Management: A Common Sense Guide to the PMBOK,
Part One—Framework and Schedule*

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Start it, think about it, do it: A simple guide to building a project schedule using the PMI Project Management Framework.



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ABSTRACT

The Guide to the Project Management Body of Knowledge published by the Project Management Institute provides a roadmap of 49 processes designed to support project managers in all phases of project management. The sheer number of processes and their allocation across process groups and knowledge areas may leave project managers in a quandary about where to start and how to apply the many components of project management processes. This book provides a simple explanatory guide for the layman that clarifies the “big picture” of the PMBOK, explains where a project manager should begin when managing projects, and finally describes how the project manager can easily make use of the PMBOK framework to progress from an initial idea to a project schedule.

KEYWORDS

PMBOK, project management, project, process framework





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PART I

FROM THE PMBOK FRAMEWORK TO PROJECT SELECTION



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CHAPTER 1

INTRODUCTION TO THE PMBOK FRAMEWORK

1.1 THE PMI FRAMEWORK: IT IS ALL ABOUT GETTING WORK DONE

Project management professionals are known for their ability to get things done. Aspiring project managers may wonder why this is said to be the case when they scan the pages of the Project Management Institute (“PMI”) Guide to the Project Management Body of Knowledge (also known as “PMBOK”). What they encounter is a matrix of 47 processes that at first glance seems to defy understanding (and that also seems to grow with every revision of the PMBOK!). What is it about a table of processes that leads to such success in achieving goals? Is there an underlying logic to the table?

Although the table of processes in the PMBOK guide may seem daunting at first, there is an underlying logic to it that, once understood, will go a long way toward demystifying it.

As a first step, consider that the PMBOK includes both a content as well as a process view of project management presented in a very compact manner. Because of its compactness and abbreviated tabular representation, it may be difficult at first glance for a novice to understand where to begin. Before even starting to understand the table of processes, a novice project manager should first understand that project management is a discipline that has evolved to support getting a specific type of work done. The work that a project manager does is temporary. A project is designed to produce specific deliverables and then terminate. This is very different from work that is done in the context of ongoing operations. Until this is understood, the rationale for even using the apparently complex system of processes may be unclear. Fully appreciating the logic behind the

PMBOK first requires an analysis of what it means to carry out work and manage it outside of ongoing operations.

1.2 PROJECTS VERSUS ONGOING OPERATIONS

Projects exist for one reason—and that is to produce specific deliverables. Once the deliverables have been delivered and accepted by the client, the project is over. By way of contrast, ongoing operations seek to achieve long-term goals as they execute against the strategy and mission of the company. What gets done therefore in ongoing operations are activities that contribute to the constant production of products or services for clients, and returns for shareholders and stakeholders of the company.

Because of the temporary nature of projects, project organizations exist outside of the normal ongoing operation. A temporary project team operating within a larger organizational context therefore needs to be authorized, staffed and funded, and provided with a clear scope. This requires policies, procedures, and processes that may not exist to the same degree as it does within an ongoing operation. The special nature of projects, including the highly tangible and short-term focus, has therefore led to the development of a supporting project management process framework. The PMBOK table of processes therefore begins to make more sense when it is understood why it is needed.

The short-term focus of the project manager on producing deliverables also leads to the view of project managers as being highly task-oriented. Leaders of ongoing organizations get things done too—but often within the context of a much longer time horizon. Further, many of the activities carried out in ongoing operations may produce more intangible contributions that support its mission and vision. The longer time horizon and the absence of tangible deliverables provide a contrast to the short-term specific targets of the project manager.

1.3 DIGITAL VERSUS ANALOG

Beyond the comparison of projects with operations, it could also be said that project management represents a different way of thinking about getting work done. This way of thinking mirrors the way that the world has changed in terms of how we communicate and carry out our jobs and professions within the information age in which we live. Consider for example how telecommunications has shifted from analog methods to digital techniques. Why this transition happened provides a useful framework for

thinking about the how and why of project management. During the old days of analog communication—if one person wanted to speak to another person, the telecommunications system would need to set up a dedicated connection from one speaker to another in order for communication to take place. Setting up a connection tied up resources to support the call during the entire duration of the call. This same situation applied when setting up and carrying out videoconferencing. The Internet and the associated digital methods of transporting calls overtook analog communications in its various forms due to the increased efficiency of digital communications. Instead of tying up dedicated lines and communications channels, the conversation—be it audio or video conferencing—would be broken into pieces or packets, numbered according to its sequence, addressed to its final destination, and routed through a nearly endless series of nodes. The resulting pieces of the conversation—or packets—were then reassembled at the call destination and presented to the receiver. As a result, no dedicated resources were engaged, multiple calls could be processed using the same resources, and as a result, the tightly controlled disassembly, routing, and reassembly—made possible by new thinking and new technology—created vast improvements in telecommunications efficiency.

Likewise, traditional organizations and operations in the era of mass production could be viewed as essentially “analog” or continuous rather than discrete in their approach to doing work (Figure 1.1). Such operations excelled at doing one thing—and doing it well over a long period of time. The organization was dedicated to its primary function and was limited in its ability to manage multiple product lines and lacked flexibility to adapt to changes. The assumption of an ongoing operation was stability. In a stable market—dedicating an ongoing operation to primarily one thing was

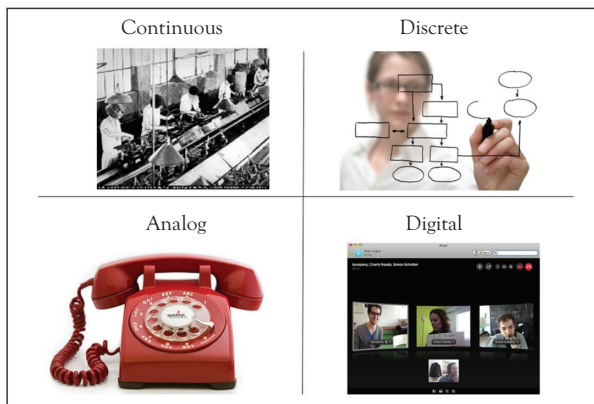


Figure 1.1. Project management as discrete business processes.

a realistic business model since the cost of the overall organization could be allocated to the mass production of one major product for an extended period of time.

In a similar manner, using the analogy of the dedicated circuit in telecommunications—the old telecommunications business model functioned well so long as the users of the dedicated line were willing to absorb the higher cost. Today, this is no longer the case.

Likewise, in the information age in which we live—price pressure is intense and product life cycles tend to be quite short. Operations may be required to launch multiple products at one time and as well, launch different products throughout the year in order to survive and compete. Further, product launches may be accompanied by software and services deliverables. This shift in the business model of companies delivering products and services makes it impossible for companies to fund an operation that makes only one primary product and relies on the sales of the product for an extended period of time.

By way of contrast with the ongoing operations, and traditional analog technology, project management is a “digital” or discrete method of carrying out work. Projects begin and then end once the deliverables are produced. Further, as in the case of digital communications, work is broken down into smaller pieces, carefully quantified, labeled, and assigned by means of the work package, and then routed to resources in the organization that are capable of executing the pieces of work. The work that is completed by organizational resources is assembled together into the final project deliverables. The thinking behind this discrete approach to getting work done mirrors the underlying philosophy of digital communications. Organizational resources are not occupied by being dedicated to the development and manufacture of a single product. Rather, organizational resources are assigned as needed to complete work packages and then freed up to do other work as work packages are completed. The act of breaking down the work into small pieces and assigning it by means of clearly described and closely managed work packages maintains tight control over the work activities. Further, this method of doing work enables the close monitoring of progress and resource usage. As is the case in the digital communications infrastructure that we use everyday—the discrete approach to doing work made available by project management processes leads to increased efficiency and organizational flexibility. Project management is therefore a management discipline designed for an age of great change and instability in the market—rather than that which existed during more stable times of the mass production era. Project management as a discipline could well be described as the set of business processes for

doing the work of the dynamic and rapidly changing work environment of the information age.

1.4 THE PROCESS GROUPS AND WHAT THEY MEAN IN PRACTICE

It is one thing to understand why a process framework is useful. It is quite another level of difficulty to actually carry out the processes as given within the PMBOK framework. How do project managers implement the apparently complex project management process framework? How specifically does the PMBOK process framework help the project manager get the job done? A good place to start is to examine the process groups one by one.

1.5 THE FIVE PROCESS GROUPS

The 47 processes of the 5th Edition of the PMBOK are organized into 5 process groups. The process groups are labeled Initiating, Planning, Executing, Monitoring and Controlling, and Closing. These processes are similar to the common-sense approach typically taken to getting work done in daily life. To get something done, we start it, we think about it, we do it, we “stay on top of it” by making sure that things are progressing according to plan, and finally, we finish it. The “finish” element of the five process groups distinguishes the project from the ongoing operation which may be repetitive and does not finish within a reasonable time horizon. Also, this intuitive sequence of activity is similar to the Deming “Plan-Do-Check-Act” cycle. The process groups in the PMBOK could be alternatively described as “Start-**Plan-Do-Check-Finish**.” The five process groups are therefore viewed as a step-by-step sequence that is followed as project managers and project teams produce their deliverables. It is the order of events in the process group sequence that breaks down the overall process framework into executable action by the project manager.

1.6 BEYOND THE FIVE PROCESS GROUPS

A new project manager is likely to intuitively understand the sequence of the five process groups. What may be less clear is why these five groups include so many additional processes. Could project management really

be that complicated? Referring back to the “analog versus digital” analogy, it pays to consider that analog is the natural way of doing things. When work is done in an ongoing, continuous organization—work may be successfully accomplished with a minimum of policies and procedures. Employees report to supervisors, supervisors report to managers, and work assignments and directions naturally flow from the top down.

A project organization, by way of contrast, is an innovation that is more complex than a traditional organization. It therefore requires more policy, procedures, and instructions regarding what to do, when to do it, and how it should be done. This is because direction provided to those carrying out the work may come from different sources. Lines of reporting are less clear than they are in a structured organization that is part of an ongoing operation. In short, the efficiency gains of project management require additional complexity as well as additional management sophistication and know-how. This mirrors the complexity of digital versus analog computing and communications infrastructure. We experience the efficiency and simplicity when we interact with the technology because the deep complexity of the technology is largely hidden from view within the underlying hardware and software. Efficiency therefore comes with a cost, and in project management, this cost is associated with developing an understanding of the processes required to carry out work in a project environment. The processes are many, but the good news is that they are largely intuitive and can become second nature with practice. The efficiency gains and the flexibility offered by project management make the additional effort spent to learn the process all worth it!

1.7 WHY PROCESS GROUPS AND PROJECT LIFE CYCLES ARE NOT THE SAME THING

The very fact that projects begin, they evolve as deliverables are developed, and then end at some point suggests that projects may be characterized by a life cycle. The project life cycle is typically described in terms of phases as the purpose of the project is articulated, plans are developed and then executed, and finally, the project deliverables are launched. The common-sense sequence of the process groups sounds rather like the sequence of steps that might be taken to deliver an entire project from beginning to end. Projects after all, begin, and like the sequence of process groups, they end. Why not then refer to the process groups as a project life cycle rather than a set of process groups? The reason for the use of this nomenclature is that the PMBOK process groups have a broader applicability beyond that of life cycle phases. When companies execute

projects, they do so for any number of reasons including developing unique products or services to deliver to the market, developing strategic plans, or implementing strategic initiatives—to name but a few. When companies manage projects, they typically start by performing activities such as defining what they intend to deliver, refining the product concept, or conducting a feasibility study. As a result, typical project life cycles may begin with a stage referred to as “Define.” The PMBOK, industry practice, and many other texts refer to similar generic project life cycles. Given that there are various approaches to governing a project from start to finish using a life cycle—where then do the PMBOK process groups come into play? Process groups are used to execute any work that is complex, uses resources, is unique, and takes multiple steps to complete. In fact, project life cycle stages fit this definition—and as a result—each stage of the overall life cycle may be executed using the process groups. For example, if a project life cycle begins with a phase referred to as “Feasibility” or “Concept Definition,” the phase must be initiated, planned, executed, monitored and controlled, and closed. Because process groups are used to execute any category of complex work—not just complete projects—they are referred to as process groups rather than a project life cycle. A process group will have, in effect, a bundle of related processes for carrying out specific activities as the work done by the project progresses. If the management work that is carried out in a project is thought of in terms of layers, the project management process groups could be thought of as occupying a layer “underneath” the project life cycle layer (Figure 1.2).

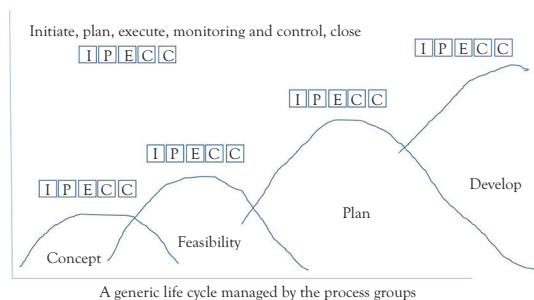


Figure 1.2. Managing the life cycle using the process groups.

1.8 KNOWLEDGE AREAS: A CONTENT VIEW OF WHAT HAPPENS WITH PROCESS GROUPS

The sequence of the PMBOK process groups provides a straightforward approach to getting work done. However, the steps in the process groups

are not sufficient to complete an overall project undertaking. What is missing is the description of and instructions for the content or skills that are applied within each process group. The 10 knowledge areas of the PMBOK fill in this gap, and are listed and described as follows:

- Project Integration Management
- Project Scope Management
- Project Time Management
- Project Cost Management
- Project Quality Management
- Project Human Resource Management
- Project Communications Management
- Project Risk Management
- Project Procurement Management
- Project Stakeholder Management

1.8.1 INTEGRATION

The knowledge areas begin with integration. The term integrate generally refers to “the act of combining one thing with another so that they become a whole.” Project integration describes the high-level plans that tie together all aspects of the project. Integration begins in the initiating process group with the project charter. The charter is the formal authorization of the project. Why does a project need authorization? Remember that this is because a project is a one-time only, unique sequence of activities. It therefore acts outside of the normal processes of the organization. The project needs the authority to acquire resources, to spend money, and dedicate time to the work of producing the project deliverables. Since the authority given to the project relates only to what the project team is assigned to do, some brief mention of scope and constraints is included in the project charter. In some cases, the scope may not be completely clear. An example of a project such as this is a project chartered to develop a new product for launch to the market. On the other hand, a project chartered to produce deliverables according to a contractual commitment may begin with a project scope that is well understood. In either case, all plans of the project link back to the project charter as the first step in the integration knowledge area.

1.8.2 SCOPE

The project scope relates to *what* the project will deliver. A project produces deliverables, so the scope knowledge area provides processes for

planning, monitoring, and controlling scope. The management of scope is one of the fundamentals of successful project management. Project managers clarify exactly what will (and will not!) be completed by the project, and as well, outline how the scope of the project will be contained throughout all phases of the project life cycle. Why use the term “contained?” Because scope has a tendency to grow due to additional requests from clients, and from additional work uncovered as the project progresses. The scope knowledge area exists to provide support to the project manager in managing this very challenging and essential element of project management.

1.8.3 TIME (SCHEDULE MANAGEMENT)

How long does it take to carry out the project? When will the project be completed? These are questions that are not easily answered by inspection. The time knowledge area provides a number of techniques for defining, sequencing, and analyzing the duration of individual activities within the project as well as the overall project. Since the analysis of time in the project context results in the creation of the project schedule, the latest version of the PMBOK, PMBOK 6, now refers to the Project Time Management knowledge area as “Schedule Management.”

1.8.4 COST

How much will this project cost? What is the timing of project cash expenditures? These are questions that processes within the cost knowledge area aid project managers in answering. The cost knowledge area involves guidance for important topics such as estimating, budgeting, and cost control.

1.8.5 QUALITY

The scope, time, and cost knowledge areas are collectively referred to as the “triple constraint” or the “iron triangle.” This is because each of these elements of a project may be traded-off between each other. For example, if a client prefers to receive deliverables sooner, then the deliverables will likely either cost more (cost), or be delivered with fewer features (scope). Quality is sometimes referred to as a fourth constraint because quality is a variable that must be taken into account with project deliverables. That being said, quality is closely related to performance in the level of quality

depends upon the performance requirements of the client. Typically, the greater the quality, the greater the level of effort, and therefore, the greater will be the scope of the project. This knowledge area ensures that project deliverables meet the expectations of the client. Traditional quality management and quality assurance tools are found within this knowledge area.

1.8.6 HUMAN RESOURCE (RESOURCE MANAGEMENT)

Projects are carried out through the collective efforts of individuals. The human resource knowledge area provides guidance for the project manager with respect to acquiring team members to get the job done, and building, managing, and motivating the team. It is of interest that the human resource knowledge area is the one knowledge area with the most processes to be found within the executing process group. This strongly suggests that the fundamental work involved with getting the work of the project done is through the management of people using the processes and guidelines taken from the human resource knowledge area. Note also that project resources include more than people. Resources may also refer to funding or to capital equipment to name two additional categories. For this reason, the latest version of the PMBOK, PMBOK Version 6 has changed the name of the Project Human Resource knowledge area to the “Project Resource Management” knowledge area.

1.8.7 COMMUNICATION

It is often said that “90 percent of project management is communication.” Communication is truly a necessity in project management given that project management requires continuous interaction with the client, the team members, and the sponsoring organization as requirements, tasks, milestones, and deliverables are communicated throughout the project. The communication knowledge area provides process support for managing project communications during the life of the project.

1.8.8 RISK

Any event that has the potential to stand in the way of project success could be considered a project risk. The difficulty of managing project risks begins with the identification of risks. The risk knowledge area outlines tools and techniques for identifying, assessing, responding to, and finally controlling project risks.

1.8.9 PROCUREMENT

Few project teams do all of the work using only the members of the project team. Labor, components, and intellectual property are often combined together to form project deliverables. For this reason, procurement work plays an intensive role in modern project management. The procurement knowledge area provides a framework for undertaking activities such as tendering bids and managing contracts along with the required supporting management activities.

1.8.10 STAKEHOLDER

The final knowledge area in the PMBOK framework involves the management and engagement of anyone who has an interest in the outcome of a project. Stakeholders include clients, sponsors, team members, and members of the organization that spawned the project team—to name but a few. An understanding of who stakeholders are as well as how they should be addressed in terms of communication media and engagement activities goes a long way toward advancing the interest of a project.

1.9 PROCESS GROUPS AND KNOWLEDGE AREAS—HOW DO THEY GO TOGETHER?

The combination of knowledge areas and process groups appear together in the complete matrix of processes in the PMBOK (Table 1.7). It is this combined table of process groups and knowledge areas that is a source of anxiety for newcomers to the field. Although it is understood that process groups and knowledge areas “go together” somehow—it may not be immediately obvious where to start. A good “point of entry” to the PMBOK table is to think in terms of the sequence of events to be undertaken—followed by the carrying out of supporting activities. The beginning is where the work starts.

1.9.1 “START IT!” (INITIATING PROCESS GROUP)

What needs to be done when work is started? In the context of managing projects, formal authorization is required as a first step. This authorization is given by the project charter. The process for creating a project charter is found at the intersection of the initiating process group and the integration knowledge area (Table 1.1).

Table 1.1. Knowledge areas in the initiating process group

Knowledge areas	Initiating process group
Project integration management	Develop project charter
Project stakeholder management	Identify stakeholders

Once authorization is given, the next step in the sequence is to understand all of the “players” in the overall project. Who is working on the project? Who is paying for the deliverables? Who might want to be involved in some way? These are stakeholders—and stakeholder management processes are found at the intersection of the initiating process group and the stakeholder management knowledge area.

1.9.2 “*THINK ABOUT IT!*” (PLANNING PROCESS GROUP)

An inspection of the PMBOK table of processes reveals the planning-intensive nature of project management. What gets planned in a project? Everything! The overall project management plan is identified as a starting point to planning at the intersection of the initiating process group and the integration knowledge area. Integration is the act of tying things together—and the overall project plan does just this. The overall plan begins with the identification of what the project does and does not do (scope), how long it will take to complete (time or schedule), and finally, how much budget is required (cost). The three dimensions of the triple constraint are planned beginning with the basic approach taken to carry out the respective plan. This is seen in the first step identified in each element of the triple constraint—plan scope management, plan schedule management, and plan cost management. Common sense requires that scope, time, and cost are considered when completing work. Therefore, common-sense validates these important elements of the plan as a good start to an overall plan. When this portion of the overall project plan is completed, the project manager has a fully resourced schedule. The project manager at this phase of the development of the project plan could be expected to answer with specificity *what* will be delivered, *when* it will be delivered, and *how much* it will cost (Table 1.2).

Table 1.2. Knowledge areas in the planning process group

Knowledge areas	Planning process group
Project integration management	Develop project management plan

Project scope management	Plan scope management Collect requirements Define scope Create WBS (Work Breakdown Structure)
Project time management (schedule management, PMBOK 6)	Plan schedule management Define activities Sequence activities Estimate activity resources Estimate activity durations Develop schedule
Project cost management	Plan cost management Estimate Costs Determine Budget

1.10 WHAT’S NEXT TO THINK ABOUT? COMPLETE THE PLAN

The preferred approach to continuing the development of the overall project management plan is to step through each knowledge area within the planning process group. All knowledge areas intersect with the planning process group, and this fact creates a roadmap or checklist for planning each component of the project. Common sense continues to play a role in the elaboration of the plan. Each knowledge area acts as a subplan of the overall project. The subplans answer important questions for the project manager.

For example:

- What exactly do I need to deliver? (Plan scope management)
- When will I deliver it? (Plan schedule management)
- How much will I need to spend on this project? (Plan cost management)
- What is the plan for ensuring that the project deliverables meet the expectations of the client? (Plan quality management)
- Where are my resources coming from and how do I manage and develop them? (Plan human resource management)
- What will I communicate? To whom, how, and how often will I communicate? (Plan communications management)
- What could stand in the way of project success? How do I know and what should I do about it? (Plan risk management)
- How do I acquire labor, components, or intellectual property from outside the organization? (Plan procurement management)

What steps should I take to engage with project stakeholders?
(Plan stakeholder management)

Each knowledge area in the planning process group could be thought of as a segment of an overall, comprehensive project plan. Each subcomponent of the overall plan begins with the management approach and ends with the supporting detail. It is only after the plans are completed that the work is carried out. In project management, think in terms of “plan first, then do!” (Table 1.3).

Table 1.3. Knowledge areas included in the complete plan

Knowledge areas	Planning process group
Project quality management	Plan quality management
Project human resource management (Resource management, PMBOK 6)	Plan human resource management
Project communication management	Plan communications management
Project risk management	Plan risk management Identify risks Perform qualitative risk analysis Plan risk analysis
Project procurement management	Plan procurement management
Project stakeholder management	Plan stakeholder management

1.11 DO IT! (THE EXECUTING PROCESS GROUP)

Project execution, stated simply, is doing the work of the project as outlined in the subplans and overall project plan. The key to the executing process group is to follow the overall plan and the knowledge area subplans. Unlike *ad hoc* management methods that operate without the benefit of a formal plan, the project management process framework establishes a clear context and direction for all project action (Table 1.4).

Table 1.4. Knowledge areas in the executing process group

Knowledge area	Executing process group
Project integration management	Direct and manage work
Project scope management	

Project time management (Schedule management)	
Project cost management	
Project quality management	Perform quality assurance
Project human resource management (Resource management)	Acquire project team Develop project team Manage project team
Project communication management	Manage communications
Project risk management	
Project procurement management	Conduct procurement
Project stakeholder management	Manage stakeholder engagement

1.12 STAY ON TOP OF IT! (THE MONITORING AND CONTROLLING PROCESS GROUP)

The work of a project does not end with the carrying out of the plan. The project plan is completed by a project manager, a project team, and often an extended team. This means that work is assigned to others—and the project manager must therefore follow up to ensure that the assigned work gets done, and is on-target with respect to plan. “Staying on top of things” is therefore the work of the monitoring and controlling process group (Table 1.5).

Table 1.5. Knowledge areas in the monitoring and controlling process group

Knowledge area	Monitoring and controlling process group
Project integration management	Monitoring and controlling project work Perform integrated change control
Project scope management	Validate scope Control scope
Project time management (Schedule management)	Control schedule
Project cost management	Control cost
Project quality management	Perform quality control

(Continued)

Table 1.5. (Continued)

Knowledge area	Monitoring and controlling process group
Project human resource management (Resource management)	
Project communication management	Control communications
Project risk management	Control risk
Project procurement management	Control procurement
Project stakeholder management	Control stakeholder engagement

1.13 FINISH IT! (THE CLOSING PROCESS GROUP)

When is a project “over?” Since a project exists to produce deliverables, the receiving party (i.e., the client) must accept the deliverables and agree that they are complete. This is a major step in project completion—but it is not the only one. It is the first step in a series of many housekeeping activities that formally end the work of the project (Table 1.6).

Table 1.6. Knowledge areas in the closing process group

Knowledge area	Closing process group
Project integration management	Close project or phase
Project scope management	
Project time management (Schedule management)	
Project cost management	
Project quality management	
Project human resource management (Resource management)	
Project communication management	
Project risk management	
Project procurement management	
Project stakeholder management	

1.14 SEEING THE “BIG PICTURE”

It is observed that the PMBOK framework provides a natural sequence in getting the work of the project done from starting it, thinking about how to do it, to doing it, to staying on top of project activities, to finishing the project. An inspection of the PMBOK process framework illustrates that the main work of the project involves planning out what is to be done, and then ensuring that the work gets done and the project is on track. Making sense of the PMBOK framework is no more difficult than starting out at the upper left hand corner of the process table, and, as described, walking process group by process group through the knowledge areas. That being said, 47 process remains quite a bit of steps, actions, and activities to keep up with. How does a project manager keep up with it all? Instead of memorizing 47 processes, it is recommended to keep a “Big Picture” view of the PMBOK in mind so that it may be easily recreated on a whiteboard—perhaps in the context of leading a project team. This apparently difficult task is carried out by memorizing only two things. The first involves memorizing the five process groups, and then by using a mnemonic device to remember the knowledge areas.

1.15 THE FIVE PROCESS GROUPS

The five process groups are Initiating, Planning, Executing, Monitoring and Controlling, and Closing (or **IPECC**).

Remembering five things is not difficult given that the processes follow a natural and logical sequence. Chances are, most people follow these steps naturally in getting work done in daily life. But, how should a project manager keep up with the knowledge areas? The 10 knowledge areas are more numerous and do not follow a step-by-step sequence. A mnemonic device in the form of a single sentence is suggested as follows:

“I Saw The Customer Quote His Common Requirements Plan Systematically.”

By inspection, the first letter of each word in the sentence is the first letter of each process group (Table 1.7):

Table 1.7. The 10 knowledge areas

Knowledge areas
Integration
Scope

(Continued)

Table 1.7. (Continued)

Knowledge areas
Time (Schedule)
Cost
Quality
Human resources
Communications
Risk
Procurement
Stakeholder

With the five process groups and the one sentence memorized, it is not difficult to imagine writing out all major elements of the PMBOK in matrix form on a whiteboard and then sketching in the details (Table 1.8).

Table 1.8. Recreating the framework from memory

	Initiating	Planning	Executing	Monitoring and Controlling	Closing
Integration					
Scope					
Time					
Cost					
Quality					
Human Resources					
Communication					
Risk					
Procurement					
Stakeholder					

The stage is set to discuss the details of each process group–knowledge area intersection so that the overall framework emerges.

After this, take the project team and stakeholders on the walk through the process groups by simply discussing the type of activities that would likely need to be done within each process group and knowledge area intersection, and, voila! The big picture that the PMBOK framework attempts to communicate, emerges (Table 1.9).

The project manager uses the overall PMBOK framework by working through the framework knowledge area by knowledge area, and process by process. The framework may appear to be cumbersome when applied to small-scale projects or subprojects—but remember that each of the process groups and knowledge areas may be scaled appropriately depending upon the size of the job undertaken. The processes are always the same—

Table 1.9. Abbreviated view of the PMBOK framework

	Initiating	Planning	Executing	Monitoring and Controlling	Closing
Integration	Develop	Develop	Direct Manage	M and C Perform	Close
Scope		Plan Collect Define Create		Validate Control	
Time		Plan Define Estimate Develop		Control	
Cost		Plan Estimate Determine		Control	
Quality		Plan	Perform QA	Control	
Resources		Plan	Acquire Develop Manage	Control	
Communi- cation		Plan	Manage	Control	
Risk		Plan Identify Perform		Control	
Procure- ment		Plan	Conduct	Control	Close
Stakeholder		Plan	Manage	Control	

but the level of detail may differ. For example, it is possible to document processes for a backyard project on a single sheet of paper—whereas the processes for a space shuttle may require multiple warehouses full of documentation (Figure 1.3).

The flow of the 47 processes becomes clear in the schematic view of the framework as well as the diagram illustrating how each of the individual processes in the knowledge areas are connected to the process groups. Managing a project could be viewed as executing a checklist that flows in logical order from beginning the project, to developing the subplans for each of the project components, to actually doing it. As the plans are

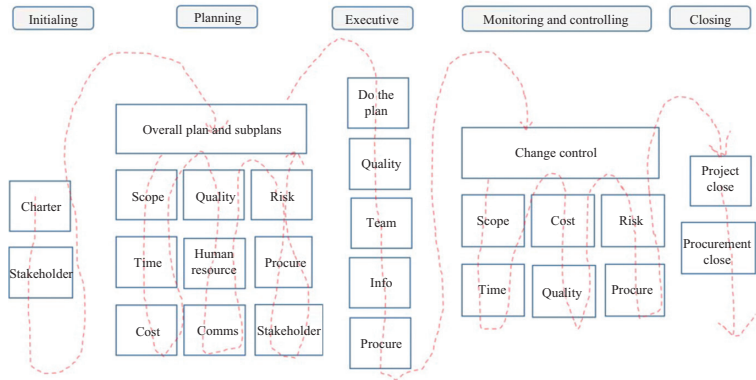


Figure 1.3. The flow of the PMBOK process groups.

carried out, problems arise, requirements change, and an infinite array of risks tend to get in the way. This is why monitoring and controlling is so important. The project manager stays on top of each of the subplans and requests and evaluates changes as needed. In fact, this is why the PMBOK framework is described as iterative. Plans are made, executed, and continually adjusted throughout the duration of the project. Finally, when the subplans are complete—the project is closed out—and all ongoing procurement activities are wrapped up and formally closed. This sequence of events follows regardless of the specific version of the PMBOK. PMBOK 4 has fewer process and knowledge areas, but follows the same logic of the five process groups and the sequencing through the knowledge areas to complete a project plan. Versions of the PMBOK beyond Version 5 of the PMBOK may have more processes—or have the processes positioned in a slightly different manner. Regardless of the differences, the basic approach to incorporating project management processes within a project remains the same.

1.16 THE PROCESS LOGIC IN THE PMBOK

The schematic view of the flow of the knowledge areas within each process group illustrates the hidden logic of the process approach to project management as communicated by the PMBOK. Each process requires inputs. For example, some of the inputs to the development of a project charter would include the policies, procedures, and strategy of the company. The inputs are transformed by the tools and techniques outlined by the process. Finally, once tools and techniques are applied, the process produces outputs. In shorthand, this is referred to as “ITTO” or, “Inputs,

Tools and Techniques, and Outputs.” The output of one process then becomes the input of a following process. This interlinking of processes forms an overall system that is used to execute the project. Although it is easy to get lost in a discussion of PMBOK processes and the underlying elements of process, it pays to step back and see the big picture of what the PMBOK is trying to communicate. Managing a project is simply a systematic approach to starting, planning, executing, controlling, and finishing work using an interlocking sequence of logical steps.

1.17 CHAPTER 1: IMPORTANT “TAKEAWAYS” FOR THE PROJECT MANAGER

- Project managers lead temporary organizations that produce deliverables.
- Deliverables are tangible outcomes that result from effort expended on a short-term time horizon.
- Managers of ongoing operations also produce deliverables, but the overall focus is on the long-term time horizon.
- Projects operate within a larger organizational context and their specialized focus and temporary nature require supporting processes, procedures, and guidelines.
- Project management is fundamentally a discrete or “digital” approach to managing work rather than the continuous or “analog” approach used in previous eras. Its focus is on increased control, efficiency, and flexibility in getting work done.
- The PMBOK framework is best understood by starting with the process groups.
- The process groups follow a sequence similar to that commonly used in completing work in daily life. (“Start it, think about it, do it, stay on top of it, and finish it.”)
- Project management provides efficiency gains and flexibility at the cost of additional complexity and management sophistication.
- The PMBOK knowledge areas clarify those things that a project manager will need to do within each of the process groups.
- The knowledge area breakdown could be considered a “content” view of the project as opposed the “process” view of the process groups.
- The process groups provide a natural and intuitive flow in the project from beginning to end.
- The knowledge areas of the PBOK framework provide the guidance for what the project manager should do within each process group.

CHAPTER 2

PROJECT SELECTION

2.1 WHAT SHOULD BE DONE? DECIDING UPON THE RIGHT PROJECT

When a project manager begins a project, it is assumed that the purpose of the project and the underlying rationale for the effort is clear. Unfortunately, this is not always the case—especially in companies that routinely commission projects to produce deliverables such as new products and services for the marketplace. With so many different project options from which to choose, how does a company select the best one? Making this decision is rarely easy—and this is why project selection is approached in a systematic way. Project selection is often visualized as a “funnel.” A funnel is very wide at one end, and very narrow at the other as is observed in Figure 2.1.

Likewise, the set of all possible projects that a company could undertake is potentially very large. However, the funding available to pay for projects is limited. The limited funding is what makes the funnel narrow rather than wide. The objective of an organization therefore is to vet the large population of potential projects so that only a very few projects are chartered. Those projects that survive the vetting process are those that are most likely to be successful. Selecting projects does not end at the project charter. As the project progresses through its life cycle it is vetted at each phase in order to ensure that the original assumptions about the project and its likelihood of success remain sound.

2.2 STRATEGY: KNOWING “WHY” COMES BEFORE WHAT

Projects produce deliverables—and companies that commission projects to produce these deliverables do so in order to contribute in some way, no

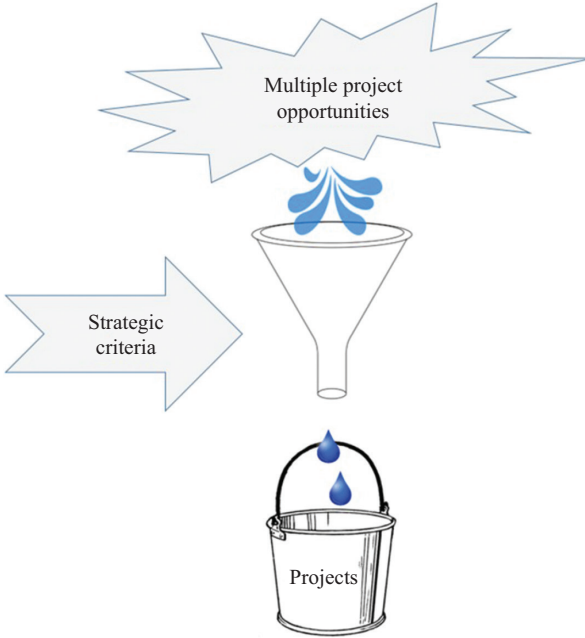


Figure 2.1. Project opportunity screening.

matter how small, to the overall mission and objectives of the company. A project is considered an investment in time, effort, and money. When a company invests money, it does so in pursuit of its mission to achieve and maintain a competitive advantage within the markets it serves. The term “competitive advantage” is a reference to competitive positioning. A company is better able to succeed when it is well positioned compared with those against whom it competes. A company is considered to be well positioned when it is able to set the price level for its products and maintain it—while at the same time—minimizing its costs. Michael Porter, a well-known strategist from the Harvard Business School, informs us that companies that are best able to do things such as minimize competition and rivalry, minimize the threat of substitutes, and keep new entrants out of the marketplace have the power to set their prices and minimize their costs. They do so because they are said to be well positioned in terms of Porter’s strategic model. To use an analogy drawn from the military, imagine a platoon preparing to engage with the enemy. The platoon leader will survey the surrounding environment to find the best position within the field of battle. A hill is a position that is likely to be preferred over a valley. A mediocre platoon may still have a strong chance of winning the battle if it fights from the hill rather than the valley. Fighting from a hill provides



Figure 2.2. Strong and weak strategic positions.

an almost “unfair advantage” that may be exploited. This is graphically illustrated in Figure 2.2.

Returning to the business arena and using an analogous example, during the housing crisis of 2007, a home buyer would be far better positioned strategically than a home seller. The individual trying to sell the home may well have an excellent product that includes many different upgrades. However, since the seller is poorly positioned, the seller has little power to obtain the desired price. The difference in power between buyer and seller seems unfair—in the same way that “fighting from a hill” is. However, this is simply a result of strategic positioning. A similar situation exists between consumer electronics manufacturers and electronics distributors. A large nationwide retailer has the choice of many electronics manufacturers from which to choose. Because of this, the retailer has more power to set prices than the manufacturer.

Every company therefore has a fundamental approach that it employs in order to seek the optimal position within its competitive landscape. All operations, products produced, and projects in which the company play a role in achieving the company’s competitive positioning strategy. The first rule therefore for selecting the optimal project for which to invest is to deeply understand the strategy of the company both in terms of what it is as well as how it works. Managers involved in project selection must therefore be able to readily answer the question of “Just what is it exactly are we trying to do here, and why?” If this question cannot be answered, it is not possible to choose an optimal project from a range of possibilities.

2.3 STRATEGIC ALIGNMENT

The term alignment suggests that elements put “in alignment” must be ordered so that they are all facing, or pointing to the same direction. Strategic alignment uses this concept—but in terms of activities carried out by the organization. All initiatives, tasks to be carried out, deliverables to be produced—as well as projects—must “point in the same direction” as that indicated by the strategy of the company. It follows then that when a company selects an optimal project for execution, it will be a project that is considered to be in alignment with the company mission. It further follows that the degree of alignment of a project with the mission of the company is obvious. This is not always the case—which is why tools are applied to make the degree of alignment clear.

2.4 HOW TO NARROW DOWN PROJECT CHOICES

The concept of alignment provides the project manager with only a starting point for deciding upon which projects to fund and execute, and which to discard. It is only a starting point because the degree of strategic alignment of each project proposal must be determined. There are many different ways to do this including the application of judgment using qualitative tools, as well as analytical techniques that apply quantitative measures to assess the degree to which the project fits the goals spelled out in the strategy of the company. Often the process begins with a qualitative approach by quickly weeding out projects that obviously do not fit well with the company mission. Eventually the vetting process leads to a small number of projects that on the face of it, all seem to satisfy company strategic requirements. It is at this point where the application of tools becomes more advantageous by making small but important differences clear for the purpose of decision making.

2.5 QUALITATIVE SELECTION TOOLS

An experienced project manager with a long career within a particular company is usually very familiar with the company strategy and culture. In this case, the application of judgment may be all that is needed to select projects that make sense to pursue and which do not. Not all project managers have this skill or background. As a result, the collective expertise and judgment of the company may be gathered together in the form of a

strategic checklist. Often a checklist used for this purpose is developed over a long period of time by successive project managers and executives who have selected and delivered successful projects. The checklist then forms part of the vetting process, and as such, becomes what the Guide to the Project Management Body of Knowledge (PMBOK) framework refers to as “Organizational Process Assets (OPA).” Further, how the checklist is used, who uses it, and when it is used may become part of the culture of the company. The PMBOK uses the term “Enterprise Environment Factors (EEF)” to describe the cultural and environmental dimension of the company. Project managers will recognize OPA and EEF as inputs to important PMBOK processes.

The purpose of the strategic checklist is to compare the goals of the project and its proposed results with the strategic goals of the company. When the checklist method is used, the more elements in the checklist that the project satisfies, the more that the project is said to be in alignment with company strategy. An example of a strategic project selection checklist is provided in Box 2.1.

Box 2.1. Strategic project selection checklist

1. Does this project meet the company objectives for financial return?
2. Does this project address markets that the company deems to be important?
3. Does this project make strategic use of company resources?
4. Is our company capable of developing and delivering this project?
5. Does the company have adequate funding to deliver this project?
6. Is this project consistent with the company mission, vision, and values?

One problem with using a strategic project selection checklist is that it weights all elements of the checklist equally. It is not often the case that all elements within a checklist would be considered to be equally important. A weighted checklist provides the project manager with the means for putting greater emphasis on some elements versus others. Instead of simply indicating the presence or absence of an important strategic factor, the project manager—and perhaps the project team and executive sponsors—may apply weights to each strategic factor. The weighting of each category is derived from the emphasis each category is given in the strategy of the company. Each score is then multiplied by the weight of each

Table 2.1. Weighted project selection checklist

Project (A, B, C)	Weight	Score	Total
Financial returns	0.3		
Markets	0.1		
Strategic resources	0.2		
Capabilities	0.2		
Funding	0.1		
Mission consistency	0.1		
Total	1		

element and total. Multiple projects are then compared against each other based upon the total weighted score for each. An example of a weighted project selection checklist is provided in Table 2.1.

Although the weighted selection checklist uses numbers—this does not necessarily mean that the method is considered to be a quantitative method. This is because the numbers used for scoring and weighting are based upon the collective subjective judgment of the management team. The numbers are therefore interpreted as relative measures of emphasis—rather than absolute quantitative measures.

2.6 QUANTITATIVE SELECTION TOOLS

Selecting a project that aligns with the strategy of the company is important—but it may be only a beginning. For example, companies often have multiple possible choices of projects from which to choose that each align with the strategy of the company. What should a project manager do if (and likely when) this happens? The next level of consideration usually involves determining if the project will result in financial rewards. There are a number of techniques that may be applied in order to make this determination—and different companies will likely use different methods. Each of the analysis techniques are designed to answer questions that lead to project selection decisions.

2.7 PROJECT SELECTION QUESTIONS AND ANALYSIS TECHNIQUES

The first question of interest from a project manager seeking to understand the viability of a possible project selection is:

If we do this project, how much money will we make?

The amount of money made is simply the total revenues generated by the project deliverables less the cost of the project (including overhead) as well as the costs of the deliverables. This may be easily expressed in the form of a formula:

$$\text{Total project revenues} - (\text{Total cost of project} + \text{Total cost of project deliverables}) = \text{Money made}$$

While it is true the project managers seek to make money, it is also true that they want to avoid losing money—and they seek to recover the initial project investment as soon as possible. This leads to the next important project evaluation question, which is:

When can we expect to recover the investment we made in this project?

Answering when (and possibly if) the project investment will be recovered is answered by means of the standard formula for the payback period. At a high level, the payback period formula is given as:

$$\text{Project payback period} = \text{Total project cost} \div (\text{Project deliverable revenues} - \text{Cost of project deliverables per period})$$

Although this is a rather simple formula, calculating the payback period may be complicated in practice. This is because the exact revenues and the cost of project deliverables may be difficult to project or even calculate depending upon the nature of the deliverables and the accounting system of the company.

The simple payback period is intended to be simple and because of this, it ignores the complexity of the time value of money (TVM). In projects with relatively low up-front costs and high sales and gross margins—the TVM may prove to have negligible impact since the recovery period of the investment will as a result be rather short. Longer-term projections that include a great deal of uncertainty of cash flows and gross margins may benefit from the use of TVM in the payback period calculation in order to obtain a more realistic picture.

2.8 THE TVM: WHAT DOES IT MEAN?

Understanding TVM in the project selection process is simple if you start from a familiar financial scenario. For example:

\$100 in your pocket today will be worth more tomorrow if you put it in the bank and it earns interest.

How much more? If we assume 5 percent interest, then \$100 in your pocket today (and put in the bank) will be worth, in one year:

$$\$100 * 1.05 = \$105.00$$

The difficulty of incorporating the time TVM in project selection scenarios is the understanding of this simple financial scenario in the reverse sense. For example:

What if you didn't have \$100.00 today, but someone promised to give you \$100.00 one year from now? The question now becomes:

How much is “\$100.00 promised in one year actually effectively worth today?”

Assuming that we could have earned 5 percent interest by putting it in the bank for a year, then the value of \$100.00 promised one year from now is effectively worth:

$$\$100.00 \div 1.05 = \$95.24$$

Said another way,

If I put \$95.24 in the bank today earning 5 percent, in one year it would equal \$100.00

As can be observed in the formula for “discounting” future cash to the present, the formula is reversed from that of banking \$100 and calculating the one-year interest. This simple scenario however ignores the fact that cash flows from projects typically continue beyond one or more years. Multiyear cash flows from project deliverables complicate the TVM calculation, but once the algorithm is understood, it is a simple process to discount multiple future cash flows to the present.

To begin with understanding multiyear TVM, we can start at the beginning and assume that we are putting \$100 in the bank at 5 percent interest for several years. In this case, we have the following:

$$\text{One year: } \$100 * 1.05 = \$105.00$$

$$\text{Two years: } \$100 * 1.05 * 1.05 = \$110.25$$

$$\text{Three years: } \$100 * 1.05 * 1.05 * 1.05 = \$115.75$$

In multiyear TVM, the principle that is invested, plus the interest it accrues, feeds the next period. Interest is therefore earned not only on principle, but on the interest of previous periods. This is the principle of “compounding” that naturally leads to significant growth of an initial monetary stake over time. In mathematical shorthand, these equations tell us that the money in your pocket today, multiplied by the discount rate raised to the power of the number of periods, equals the final value of your deposit. Expressing this mathematically leads to the following formula:

$$\text{Money} * \text{Rate}^{\text{Period } n}$$

For example, using the previous example for three years but employing the simpler formula, we have:

$$\text{Three years: } \$100 * 1.05^3 = \$115.75$$

To reverse the process, it could be asked, “What is the value today of \$100 promised three years from now?” The answer comes from reversing the process of calculating the value of a deposit within three years and “discounting to the present.” This is done as follows:

$$\$100.00 \div (1.05)^3 = \$100 \div 1.16 = \$86.38$$

What if the going rate of interest was not 5 percent—but instead—it was 10 percent? In this case we would have:

$$\$100.00 \div (1.10)^3 = \$100 \div 1.33 = \$75.13$$

There are some observations that can be made by comparing the value of \$100 promised three years from today versus one year from today, as follows:

1. The longer the waiting period for the promised money, the less it is worth today.
2. The higher the discount rate, the less the money is effectively worth today.
3. The higher the discount (or “hurdle”) rate, the more money the project will need to generate in order to compensate for the higher rate.

From these simple observations, it is clear that regardless of the project scenario being considered, “Early money is better than late money,” meaning, that it is preferred for projects to return money sooner rather than later—regardless of the TVM. Also, we observe that in times of high discount rates—or in times when the project is assigned a high discount rate due to its relative high risk—the project must “work harder” in order to prove its worthiness as an investment.

2.9 HOW IS TVM APPLIED TO THE PAYBACK PERIOD CALCULATION?

If TVM is taken into account when using the payback analysis, then the cash from project deliverables (less the cost of project deliverables) is simply discounted to the present. Again, this is useful for presenting a more accurate assessment of the payback when future cash flows are less certain and the initial investment is high. In simpler cases, TVM may be dispensed with when calculating TVM. What would constitute a “simpler case?” An example would be a project whose payback timeframe is short compared to its project life cycle. A project that produces deliverables that lead to profits that pay back the initial investment within one to two years need not be overly concerned with the TVM. However, projects that are not expected to pay back within 5 to 10 years, and include widely spaced and inconsistent cash flows would likely benefit from the incorporation of TVM within payback analysis.

2.10 RISK AND REWARD IN PROJECT SELECTION

An important question that is asked in the project selection goes beyond the payback period in order to consider if the project is worth doing in light of the risk. The question asked is:

Are the forthcoming rewards consistent with the risk undertaken?

Risk and reward in project selection is considered using TVM techniques with specific emphasis on the discount or hurdle rate. This is simply another way of expressing the fact that a project that has more at risk must produce more return. In life, we see the discount rate difference when we examine the cost of a mortgage loan (which guarantees the payback of the loan via the collateral of the house) versus a credit card charge that has no collateral backing. The default risk of the credit card loan is higher than the default risk of a mortgage loan. As a result, the interest rate charged in a credit card loan is much higher—often several times higher than a mortgage loan.

The same principle applies to project selection which is in effect a decision regarding the determination of which project to invest. A high-risk project must be judged using a higher return on investment (RoI) than a low risk project. What rate of return then should a project manager seek and how is this rate determined? This is a question that the company Chief Financial Officer (CFO) can play a role in answering. The CFO knows the rate that the company pays for its funding. This rate is derived from the weighted average of the mix of debt and equity financing used by the company. This rate, known as the WACC (Weighted Average Cost of Capital) will likely not be the same as the hurdle rate or return rate required for the project. The reason is that the project is likely to exhibit more risk than the company as a whole. Therefore, the required return rate for the project would necessarily need to be higher. Again, the specifics of this rate are derived from a consideration of the strategy of the company as communicated by senior management.

One of the most important questions to be asked in selecting projects is:

What is the return on the money invested in this project and how does it compare with the return on secure financial instruments?

There is both a simple as well as a complex answer to this question. The simple answer is to compare the total profit of the project deliverables to the expense of creating the deliverables. For example, if the project cost is \$100,000.00 and the resulting profits are \$110,000.00, then the ROI is 10 percent. Why does ROI matter? It matters because the more capital that is at stake, the greater the resulting return that is expected. This goes hand in hand with risk versus reward.

There is a more complex answer to this question and it involves considering TVM, and the comparison of the overall project return to the

return offered by a similar, but more secure, financial instrument. To put it in simple terms, the Net Present Value method (or NPV) not only considers the project return based on TVM, but it also answers the question:

Should I invest in this project, or should I just put my money in the bank?

The NPV project selection and evaluation procedure is a step-by-step process and works as follows:

1. Estimate the project cash outlays required to produce the project deliverables.
2. Estimate the future cash flows associated with the profits from the project deliverables.
3. Discount the future cash flows to the present (the Present Value (PV) portion of the NPV process).
4. Combine the present value of future cash flows with the estimate project outlay of the present (the N or Net portion of the NPV process).
5. Assess whether the result is positive, zero, or negative.
 - a. Positive: This means that the present value of future cash flows associated with project profit cash flows—discounted to the present—is greater than the amount invested. Also, it can be said to exceed the project’s discount rate. A positive NPV is therefore money well spent.
 - b. Zero: A zero NPV means that the present value of future cash flows associated with project profit cash flows—discounted to the present—is the same as the amount invested. Also, the returns can be said to equal the returns consistent with the project’s discount rate. A zero NPV infers that the project returns no more than the required discount rate. The implication of a zero NPV is that the return of the project is no more than that which could be earned in a secure financial instrument—for example—“putting it in the bank” to use the vernacular.
 - c. Negative: This means that the present value of future cash flows associated with project profit cash flows—discounted to the present—is less than the amount invested. Also, it can be said to produce returns less than the project’s discount rate. A negative NPV is therefore money not very well spent. The implication is that funds intended to be invested in this project would be better utilized in other projects.

What does it all mean? When a project manager selects from a number of projects—the optimal choice from a purely risk and reward perspective would be the project with the highest NPV. In simple terms, positive NPVs result from projects that produce returns above the required project discount rate. The higher the NPV, the greater the return exceeds the project discount rate. An NPV of zero indicates that the project returned profits sufficient to equal the required project discount rate. Although zero is considered acceptable—it may be a question mark for project selection. Because the project result is only an estimate—it is not difficult to imagine a scenario when the future expected cash flows are less than expected. In this case, the zero NPV could shift to a negative value depending on events and circumstances. Finally, a negative NPV is an indicator that the project returns less than the return targeted by the discount rate. In most cases—this is an indicator that the project should be rejected. However, negative NPV projects might be selected if some higher level strategic reason exists for pursuing the project. A project that is commissioned simply to produce a placeholder product in the market or to maintain market share may be one example of a strategic reason to pursue a project with a negative NPV.

2.10.1 AN NPV EXAMPLE...

Assume a project that cost \$100,000.00, but returns \$15,000, \$25,000, \$40,000, \$45,000, and \$50,000 in Years 1 to 5. What is the NPV given a 5 percent discount rate? Is the project “worth it?” An inspection of the NPV table shows that the project is very much “worth it.” The project returns \$47,712.87 more than its discount or hurdle rate of 5 percent (Table 2.2).

What if, however, the project projected the same cash flows—however—the case flows would occur later in Years 1 to 5. Should a project manager continue to select this project?

An inspection of Table 2.3 illustrates that, although the NPV is lower, it remains very high. Project managers would take note that as a principle, the longer that project sponsors have to wait for cash flows—the lower the NPV will be. This is because the longer investors have to wait for promises of cash in the future—the less that the money is valued today due to the exponential property of discounting.

Finally, what if the sponsors of the project are concerned about the lack of cash flows in Years 1 and 2, and as a result, request a higher discount rate? In Table 2.4, the rate of 15 percent is suggested given the risk concerns. By inspection, the NPV has gone marginally negative—thereby

Table 2.2. An NPV example

Cash outlay	Year 1	Year 2	Year 3	Year 4	Year 5
\$100,000	CF	\$25,000	\$40,000	\$45,000	\$50,000
Net	Discount	1.05	1.1025	1.2155	1.2763
\$47,712.87	PV	\$14,285.71	\$22,675.74	\$34,553.50	\$39,176.31

Table 2.3. Impact of delayed cash flows on the NPV

Cash outlay	Year 1	Year 2	Year 3	Year 4	Year 5
\$100,000	CF		\$55,000	\$55,000	\$65,000
Net	Discount	1.05	1.1576	1.2155	1.2763
\$43,688.90	PV		\$34,553.50	\$37,021.61	\$39,176.31

Table 2.4. Higher risk reflected in the NPV discount rate

Cash outlay	Year 1	Year 2	Year 3	Year 4	Year 5
\$100,000	CF		\$55,000	\$55,000	\$65,000
Net	Discount	1.15	1.3225	1.7490	2.0114
-\$73.69	PV		\$34,553.50	\$37,021.61	\$39,176.31

making the new series of cash flows and higher discount rate a question mark in terms of project selection.

2.11 ANOTHER VIEW OF RETURN—THE INTERNAL RATE OF RETURN (IRR)

The NPV returns three possible results—positive, zero, and negative. The NPV therefore is a comparative measure that examines how the project performs by comparison to a given target discount or hurdle rate. Another way to evaluate a project however is to determine its effective return rate known as the IRR. The formula for the IRR is rather complex—although the formula is embedded within Microsoft Excel and does produce the correct result when used correctly. However, a project manager who first performs an NPV may easily determine the IRR in a spreadsheet by adjusting the discount rate until the NPV becomes exactly (or at least very close to) zero. The discount rate at an NPV of zero is the IRR. Revisiting Table 2.4 shows a slightly negative NPV. This infers that the discount rate applied was in fact very close to the IRR rate since it is close to zero. Adjusting the discount rate to 14 percent returns a positive NPV of \$3,446.81. This informs the project manager that the IRR is between 14 and 15 percent—and likely very close to 15 percent. Granted, this is a ballpark IRR figure—but—project selections involve estimates and judgment including the estimation of the investment level, timing of cash flows, and choice of discount rate. Finding the IRR in this way makes it a simple process to work hand in hand with the NPV calculation in project selection.

2.12 RETURNING TO THE ORIGINAL QUESTION...

After carefully evaluating a number of possible projects using both qualitative and quantitative selection remains, “Which project should be selected?” Although the final answer may be difficult to answer with perfect clarity—the fact that the question is being asked is an important first step. In all things project management—anything to be done must be first planned. One of the objectives of the project selection process is to ensure that projects are not commissioned by the organization in an ad hoc manner. Instead, possible projects should be evaluated in terms of their alignment with company strategy and in terms of the potential for rewards consistent with the risk undertaken. Project selection techniques provide the means to make this assessment.

2.13 NUMBERS DO NOT ENSURE UNBIASED RESULTS

The use of financial techniques in project selection often gives the impression that the selection of the project is without bias and it is wholly scientific in its methodology. Nothing could be further from the truth. The project manager should be aware of the shortcomings associated with the use of financial selection methods. The shortcomings relate to the underlying assumptions made in the analysis. For example, it is easy to create a financial analysis that causes a poor project to be selected. This can be done by selecting an abnormally low discount rate. Recall that the higher the discount rate, the harder that the project must work (in terms of future cash flow generation) in order to demonstrate its merit. The reverse is also true. Set too low—the discount rate can make a bad idea look better than it actually is. Also, beware of a financial analysis that rejects a promising project due to the selection of a discount rate that is too high. An abnormally high discount rate effectively forces a project to work harder than it needs to in order to justify its existence. The lesson for project managers is that project selection is a time for asking questions. When financial selection techniques are used, the first question to be asked is “Where did that discount rate come from—and how was it derived?” Finally, regardless of the chosen discount rate—it pays to challenge future cash-flow assumptions. The future is always uncertain—so the project selection process would benefit from the use of conservative future cash flow estimates.

2.14 CHAPTER 2: IMPORTANT “TAKEAWAYS” FOR THE PROJECT MANAGER

- Understanding company strategy is an essential element of project selection.
- Project opportunities are many, but strategically aligned projects that are likely to be successful are few.
- Project selection involves both qualitative as well as quantitative methods.
- The checklist selection method compares projects against a list of strategic criteria.
- A weighted scoring model mirrors the project selection checklist method—but weights some strategic criteria higher than others.

- Multiple financial methods exist for selecting projects. These include, but are not limited to the ROI, the payback period, the NPV, and the IRR.
- Financial methods generally weigh the expense of the project compared to the promise of future cash flows.
- The discount rate is an important component of financial selection methods.
- High discount rates generally reflect project risk and force the project to produce higher returns in order to justify selection.
- Lower discount rates are a general indicator of lower project risks.
- The choice of discount rate highly influences the project selection result and should therefore be closely inspected to ensure the right balance of risk and reward is being applied.





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PART II

FROM PROJECT TO SCHEDULE



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CHAPTER 3

GETTING STARTED: ESTIMATES, STAKEHOLDERS, AND SCOPE

3.1 INITIAL PROJECT ESTIMATES

Project selection decisions rely on limited data regarding the proposed project. Since the project has not yet started, the data used for project selection comes from estimates of the overall cost and schedule. Once the project has been selected, it is useful to confirm the overall level of financial, time, and resource commitment that will be needed to complete the project. The difficulty with such a confirmation is that at the stage of the process after the project is selected—the project scope is not well known. A detailed estimate of the project requires significant time and effort to produce and requires a thorough analysis and determination of scope, resources, and timing in order to develop. The irony of project estimating is that project sponsors, such as senior management, desire to know the required level of commitment at the earliest stage of the project. Unfortunately, this is at the point in the project when the least amount of information is available. By the time all information is available—it is likely that the time window for an advance decision has passed. How should project managers address this conundrum?

3.2 THE ROM ESTIMATE

The Rough Order of Magnitude (or ROM) estimate is a path forward for estimating projects at the earliest stages of the process. Although it is true that all estimates are wrong (otherwise they would not be estimates!), ROM estimates are known to be more wrong than other methods of project estimates. In fact, ROM estimates may be in error by as much

as 50 to 100 percent. In spite of the lack of accuracy, ROM estimates are very useful for determining the scale of the overall effort. The term “order of magnitude” refers to powers of 10. For example, powers of 10 from 1 (10^1) through 6 (10^6) represent the numbers 10, 100, 1000, 10,000, 100,000, and 1,000,000. The scale of the estimate is that which proves useful to the project manager and the project sponsor in the earliest phases of the project life cycle. The scale of the project often stated in terms of order of magnitude informs sponsors and project team members alike whether the project is a commitment for \$100,000.00 a \$1,000,000. Even if the estimate produced by the ROM differs significantly from the actual result—the scale of the estimate is likely to be accurate. A ROM estimate therefore answers the question, “What level of investment are we really about to sign up to?” Based on the strategic direction of the company, the result of a ROM may trigger the start of the development of a project plan.

3.3 STARTING A PLAN WITH A PROJECT SCHEDULE

A complete project plan includes all knowledge areas within the planning process group. However, a schedule, in contrast to a complete plan, is focused on “what?” “when?” and “how much?” The schedule therefore is a useful start for beginning the development of a complete project plan. Once the schedule is in place—the rationale for the elements of the complete project plan begins to come into clear focus. Like the complete project plan, the schedule is developed using processes from the initiating and planning process group. However, the project schedule includes only a portion of the integration knowledge area as well as the complete scope, time, and cost knowledge areas. A completed schedule provides a reasonable checkpoint for making a “Go/No-Go” decision for spending the resources for developing a complete project plan thereby providing a sound rationale for starting first with a project schedule—then continuing on to a full project plan. A schedule requires more time and effort to develop than a high-level ROM estimate, but considerably less effort than a complete project plan. Also, it may be desirable to plan and complete only a phase of a project, learn more about the level of difficulty and cost, and then proceed further to develop a complete plan. In either case, laying out the what, who, and how much elements of a plan lays down a significant foundation to a complete planning effort.

3.4 START IT! GETTING WORK STARTED WITH THE INITIATION PROCESS GROUP

Starting a project is straightforward when the objective is known upfront. This is a likely occurrence in a contractual situation—for example—when a client agrees to pay a specific amount over a period of time for the delivery of a detailed SOW (Statement of Work). Unfortunately, this is a luxury that not all project teams enjoy. In the case of a project initiated for the purpose of creating and fleshing out a product concept for the ultimate launch to the marketplace, the initial objective or project scope may initially lack clarity. In these situations—one of the first activities assigned to the project team would be to develop the project scope. The scope and the charter therefore becomes a “chicken-and-egg” situation. In some cases, the scope is clear, in other cases, the scope at this stage is just an idea in need of a project team to fully develop. In either case, the project begins with the project charter.

3.4.1 WHAT IS A PROJECT CHARTER AND WHY IS IT NEEDED?

Projects, being temporary organizations, need special authorization in order to get the work of the project done. Projects acquire people from departments or from outside the organization, and they spend money as they develop deliverables. Since project teams are temporary organizations operating outside of the functional organization structure, they must be formally authorized. This then is the purpose of the project charter—to provide formal authorization for everything that the project will do. What would project manager expect to find on a project charter? Although the exact format of the charter is likely to vary from company to company, project charters will include, at minimum, one or more of the following elements:

1. **Scope:** Scope may not be known with specificity, but some mention of what the project will be doing will be found on the project charter. This is because there must be some clarity about what it is that the project is being authorized to do. If the scope is not yet known—as in the case of a new concept or product development—the project may first be chartered to develop the project scope.
2. **Timing parameters:** The charter identifies the high-level time-frame for which the project will be authorized. If the project exceeds

this timeframe, the project must be reauthorized. In some cases, a larger project may be broken into smaller phases and each phase is chartered separately. Later phases are chartered only if earlier phases are completed successfully.

3. **Team:** The project manager and the core project team members are identified. The term “core” team distinguishes between team members who remain assigned to the project throughout the project life cycle and those who are assigned temporarily in order to complete assigned project work packages.
4. **Cost parameters:** The project is authorized to operate within specific cost limits. As in the case of the overall timing parameters—if the cost parameters are exceeded, the project must be reauthorized.
5. **Constraints:** Any constraints that would impact the project are noted in this section. Constraints might include dependencies, time to market, or regulatory issues to name but a few.
6. **Sponsor:** The sponsor or authorizing authority of the project is identified.
7. **Business case or rationale:** A simple statement or paragraph identifying the purpose of the project is included in this section.
8. **Comments or notes:** Any special notes, observations, or requests by the sponsor or other interested parties are indicated here.
9. **Authorization signatures:** The sponsor and the project manager sign the project charter. Also, some companies may include space for acknowledgment signatures by members of the management team who may interact with or supply resources to the project team.

Although the project charter contains a number of important elements—note that the primary purpose of the charter is the authorization of the project. Some project details and parameters are necessary for project authorization—but the details do not constitute a complete elaboration of scope, schedule, nor a complete project plan. The details are produced by the project team after it is authorized to do so in the charter.

3.5 THE CHARTER AS CONTRACT

Another way to think of the project charter is to view it as a type of contract between the executive stakeholders of the company and the project team. In essence, the executive body funds a project team to do work within the bounds of performance, schedule, and budget constraints. This arrangement is similar to the contractual relationship set up between the

company and an outside vendor. Creating and managing the project charter as a contract has the further advantage of minimizing the management burden of the executive team. The project, under the authority of the project charter, is given full license to carry out its activities within the bounds of the constraints identified in the charter. If the project team violates one or more constraints—or recognizes the possibility that it will do so—the team calls for a formal review meeting with the executive committee in order to see reauthorization of the project and update of the charter. If the team remains within the bounds of the charter, the team needs no additional management oversight until the next contractual milestone. At each milestone—or special review called by the project team—the project charter is reaffirmed (and updated as necessary), or the project is redirected or terminated. The project charter from this point of view amounts to a means for implementing the delegation of authority in a structured and efficient manner. It also solves the problem of ensuring the result of the delegated effort meets the desired outcomes of the project sponsors.

3.6 STAKEHOLDERS: WHO ARE THEY, AND WHY THINK ABOUT THEM?

Once a project is formally authorized it is time for the project team to pause and consider who are the players involved in the project. It may be tempting for the project team to think in terms of only two sets of “players” (or, “stakeholders”) involved in the project—the project team and the client. However, this is far too narrow a view of the overall dynamics of the project. While the project team and the client both have an interest in the outcome of the project and are therefore considered stakeholders, it is important to consider other possible stakeholders such as:

Managers and employees in the company who are not a part of the project directly, managers and employees in the client’s company who are not a part of the project directly, the project sponsor, and members of the community outside of the community—to name but a few. Why should a project team think about individuals who are not directly involved in the project? The reasons for this are many. To begin with, the project team will likely need support from individuals who are not directly a part of the project team or the client. Support could range from simple cooperation, to occasional collaboration, to moral support. Also, stakeholders, who by definition have an interest in the outcome of the project, will desire

information updates on a periodic basis. Finally, some stakeholders or stakeholder groups may have the power to influence the outcome of a project—either positively or negatively. It is for these reasons that it is incumbent upon the project team to know who the project stakeholders are, to understand how they may interact with or influence the outcome of the project, and finally, to understand the overall level of potential impact. It is important to remember that not all stakeholders will want to see your project succeed. For instance, internal and external competitors for project funding or client business may well have a greater interest in the failure of the project rather than its success. The project team must be especially aware of this stakeholder group.

3.7 ANALYZING YOUR STAKEHOLDERS

The analysis of stakeholders is a relatively simple process that is carried out using the following steps:

1. Identify stakeholders: Project team brainstorming is recommended in order to ensure that all relevant stakeholders are captured and recorded.
2. Interest ranking: Rank all identified stakeholders in terms of the perceived level of interest of each stakeholder.
3. Power ranking: Rank all identified stakeholders in terms of the power to affect the outcome of (or otherwise interfere with) the project.

The power or interest ranking helps the project team understand at a glance which project stakeholders need most attention—and which may be addressed with routine communication and engagement efforts.

There are two practical outcomes of the stakeholder analysis process. The first output of the process is known as a stakeholder register. The stakeholder register is a list of stakeholders presented in order of importance with associated details that are of interest to the project team. Think of the stakeholder register as a table or spreadsheet that is maintained and updated as the project progresses. The stakeholder register is in essence a directory of project stakeholders. A simple example of a stakeholder register is provided in Table 3.1.

The second output of the stakeholder analysis process that is very useful for the project manager is the stakeholder “Power or Interest” grid. The

Table 3.1. Stakeholder register example

Name	Title	Role	Contact information	Concerns	Power	Interest
John Jones	GM	Sponsor	Jjon1@xyz.com	Budget	H	H
Bill Smith	VP	Client	Bsmit95@abc.com	Schedule	H	H
Jill Ong	IT Dir.	Support	Jo45@123.com	Network	L	H
Sue Huff	HR	Staffing	Sh100@456.com	Team	L	H
Ed Pkunk	Manager	Maintenance	EP85@xyz.com	Offices	L	L

“Y” grid axis ranges from low to high power. The “X” grid axis ranges from low to high interest. Stakeholders are placed onto this grid according to their respective rankings carried out in the initial stakeholder power or interest analysis. For example, a stakeholder with an “HH” ranking (High power, High interest), would appear in the upper right-hand corner of the grid. Likewise, a stakeholder with an “LL” (Low power, Low interest) ranking would appear in the lower left-hand corner of the grid. Intermediate rankings such as HL and LH would appear in the upper left-hand and lower right-hand of the grid, respectively (Table 3.2).

Table 3.2. Stakeholder power-interest grid

High power		John Jones Bill Smith
Low power	Ed Pkunk	Jill Ong Sue Huff
	Low interest	High interest

A new project manager may well ask the question, “Why go to all of this trouble—especially at the beginning of the project? After all, we have so much work to get started on!” Although stakeholder analysis does seem to be quite a bit of apparently nonessential work—the need for these efforts come into clear focus as the project progresses. Fundamentally, project managers must understand who the project serves and with whom

the project will interact. Also, stakeholders, by definition, have an interest in the outcome of the project. Because of this, they are likely to be interested to hear progress updates on a regular basis. This leads to the conclusion that stakeholder will be in need of communication and will need to be engaged. It takes resources to do this—so a good understanding of who the players are as well as their information needs is essential in planning out the overall project workload. Finally, tools such as the stakeholder register and the power or interest grid help ensure that the appropriate focus and attention of the project team is placed where it is most needed.

3.8 SCOPE, TIME, AND COST IN THE PLANNING PROCESS GROUP

The project is selected and authorized—and the key players are known. It is now time to think about what the project is going to deliver in detail, how the deliverables will be produced and in what order. Further, the specific resources required to produce the project deliverables must be understood. This is the fundamental building block of the larger project plan, and it begins with building a fully resourced schedule. It is important to understand though that while the plan is developed—the plan is not to be considered something that is “carved in stone.” A plan could be thought of as a “plan of attack.” Keeping this in mind helps the project manager appreciate that the project is dynamic and faces constant issues, changes, and barriers to success every day. The process of planning therefore does not end once the initial plan is developed. The plan is iterative—beginning with the original baseline—and modified over time as the project team manages through the dynamics of the project as it unfolds.

3.8.1 WHY PLAN?

If the plan is flexible and iterative, it raises the question of “why plan?” Planning is given high importance in the PMBOK—and this is evident by the number of processes in the planning process group. The philosophy behind the emphasis on planning is that of process maturity. Companies that rigorously follow process are said to be more mature—and have the potential to be more successful—than those who manage their respective businesses using *ad hoc* management methods. The emphasis on planning therefore helps ensure that the project team avoids jumping directly into project execution—and instead—carefully thinks through what needs to be done, why and how. Although the plan may change—and multiple

plans may be created over time—it is still preferred to acting before thinking or being in perpetual “reactive mode.” A project team that takes planning seriously is one that is said to be mature in its business management outlook.

3.8.2 THE ROLE OF ESTIMATES IN THE PROJECT PLAN

As the project team steps through each of the elements of the planning process group, there will be an ongoing need for cost, time, and resource estimates. Estimates are essential in planning in order to set expectations for timing and resource needs in addition to sequencing of activities and deliverables. After the project was selected, the entire project was estimated using a ROM estimate. When the actual work of the project begins, estimates are used for life cycle phases, for activity durations, for the cost of deliverables—in short—anything that needs to be planned. Finally, estimating is likely to be iterative in nature and repeated throughout the project in order to support iterative planning. Because of this, it is important to have a good understanding of practical estimating fundamentals.

3.8.3 ESTIMATING THE PROJECT: BEYOND THE ROM

Although many techniques exist for estimating project work, there are two primary approaches—top down and bottom up. The top-down approach begins with an assumption about overall cost, time, or effort, and then proceeds to apportion the top-level number among each of the lower level elements. As an example, in a home-building project, a budgetary number could be assumed for the overall cost of the house—and then the overall home cost could be apportioned among the components of the home such as the land, the foundation, the roof, the kitchen, and so on. An example of an apportioned estimate for a home is demonstrated in Figure 3.1.

3.9 TOP DOWN VERSUS BOTTOM UP

The strength of the top-down approach is its simplicity. It is logical, and it results in what amounts to budgetary targets for cost, duration, or effort. Its simplicity and its natural fit with existing budgets make the top-down approach appealing to senior management. The weakness of the top-down approach is that it begins with assumptions about total

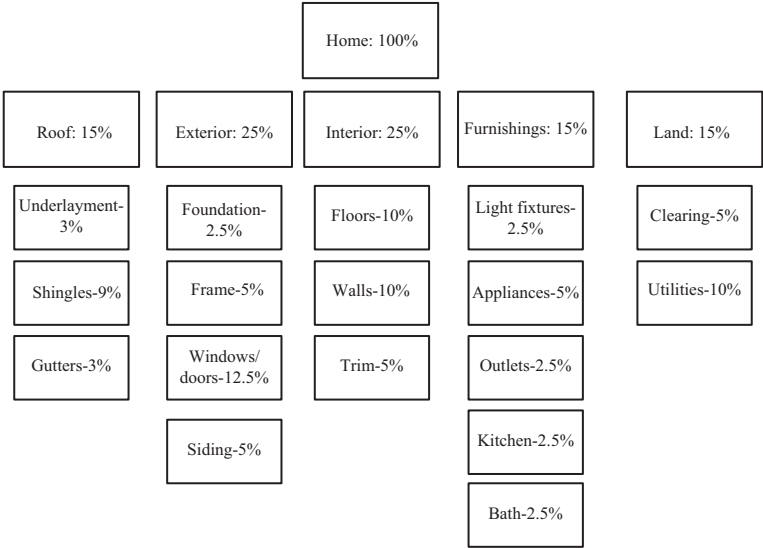


Figure 3.1. Apportioned estimate example.

costs that may or may not reflect reality. Top-down estimates are often spearheaded by management and project sponsors who seek to fit the project into business model constraints. The top-down budget has the potential therefore to represent what the project should cost rather than what it actually costs.

By way of contrast, a bottom-up approach to estimating is derived from an analysis of each step within each project activity. The cost of each low-level activity is estimated and combined with other activities until a top-level number is reached. The bottom up view is created by those who actually do the work. The bottom-up estimators therefore have a highly granular view of every step that needs to be completed in every activity along with its associated cost. Those who are estimating a project from the bottom up therefore often see details that managers who have the top-down view tend to miss. Since the bottom-up approach is closely grounded to the actual activities associated with each deliverable—the bottom-up number that results may be more accurate. The weakness of the bottom-up approach is that it is focused exclusive on the work itself rather and does not take into account possible budgetary constraints. Further, those who are actually doing the work have the motivation to ensure that funding and allotted time duration is sufficient for producing the agreed upon project deliverables. As a result, the bottom-up number that results is usually higher than the top-down number.

3.10 APPLYING EXPERTISE

Whether the top-down or the bottom-up approach is used in estimating—there are a number of different estimating practices that the project team may use. Such practices may be readily used without thinking of it as a specific estimating methodology—especially when highly skilled team members employ it. Estimating typically involves highly experienced professionals with expertise in completing similar project. It is this expert judgment that is applied by senior team members who have experience with the work being estimated. Expert judgment in estimating can save considerable time and effort. However, it is essential to ensure that the expertise truly applies to the work at hand. Some previous experience may be related—but not sufficiently related such that an accurate estimate is produced. This is especially true in software or intellectual property projects where a number of intangibles are involved. Technologies and standards are changing rapidly, so expertise garnered from a project that took place three to five years ago may no longer be applicable. Unfortunately, flaws in estimates that are related to out of date or not adequately applicable expertise may not be discovered until it is too late. The lesson for project managers is to ensure that those who apply expert judgment actually have the judgment that they claim to have.

3.11 USING ANALOGIES AND PARAMETRIC ESTIMATION

Another common estimating practice is to employ analogies. For example, an activity, a project phase, or a particular deliverable that is similar to something that was done within another project may be compared. The previous experience may form the basis of the current estimate. Also, the previous project experience could be scaled. As an example of this approach, the project manager's thought process might proceed as follows, "Last year we delivered this software subsystem—and what we are working on now seems to be similar—but about twice as much work." Finally, another estimating practice is the parametric approach. Parametric estimating is a time-saving device that is very simple to implement. As an example of parametric estimating, if one element of work is determined to cost \$10 and this work must be completed ten times throughout the project, then the total estimated amount is $10 \times \$10$ or \$100.

3.12 ESTIMATING AND TRADE-OFFS

The desired result of estimating—be it time, cost, or effort—is to arrive at a number that both works for planning purposes as well as for budgeting. It is one thing to have a number that reflects the likely actual outcome—but it is quite another to arrive at a number that the project sponsors and the client are willing to fund. For this reason, there is often considerable give and take as the estimates of the project unfold. Granted, bottom-up approaches may arrive at a number that is too high to be acceptable to management. A top-down number may be considered too small to be workable by the project team. In the end, the numbers agreed on for planning and budgetary purposes will be the result of ongoing negotiation—and trade-offs between the overall cost, schedule, and scope of the project.

3.13 PROJECT ESTIMATES AND “THE LEARNING CURVE”

The learning curve is a mathematical formula applied in operations management that describes how efficiency improves and effort declines as the output of production doubles. The learning curve is a powerful model for describing efficiencies that are observed within a manufacturing or mass production environment.

The formula for the learning curve is:

$$y = a * x^b$$

where y is the cumulative cost or outcome, a = the time or cost for the initial unit produced, x = the number of units produced, and b is the learning factor; $b = (\log \text{ learning rate} / \log 2)$ (Figure 3.2).

The mathematical expression produces a continuous curve that is characterized by the learning rate and the number of units produced. Although the term “learning curve” is often used, it is usually used informally and tied loosely to the original context of mass production.

The learning curve is also often referenced with respect to project management and estimates. The reason for this is that when estimates are generated for projects that involve work in which the project team is well experienced, it can be assumed that the effort required will diminish over time—and that this fact should be reflected in the project estimate. While it is generally true that effort tends to decrease as experience is gained, the learning curve formally generally does not apply in the project

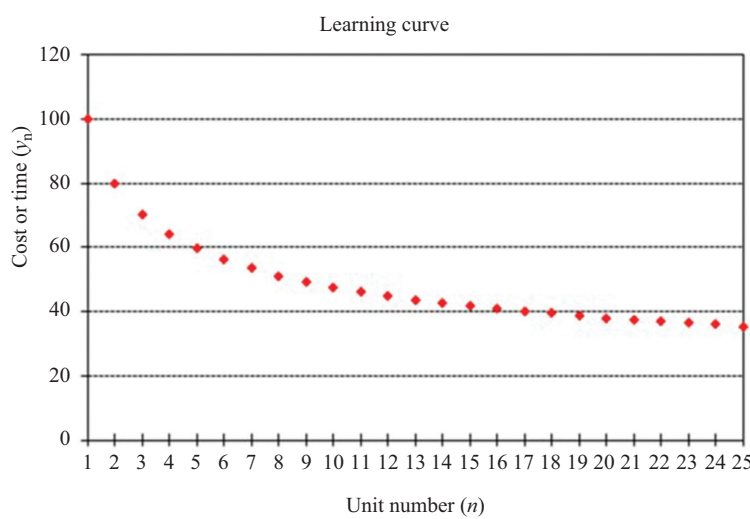


Figure 3.2. The learning curve.

context. Recall that every project is unique and has a clear beginning and ending. For this reason, projects generally do not exhibit long production runs associated with doubling of volumes. When estimating projects, it is therefore fair to take into account experience and recognize that the second and following times that a particular type of work is done—the experience of the project team will generally lead to increased efficiency and therefore lower cost estimates. For example, the second time a project team develops a particular type of information system or network—the less time and cost will be required—assuming minimal new technologies or configurations are encountered. However, it is the principle of the learning curve that is applied in estimates rather than the specific learning curve formally derived from manufacturing and operations management.

3.14 FROM HIGH-LEVEL ESTIMATES

Estimates take time, money, and resources to complete. Still, estimates are only estimates until the project details are laid down in project plans. Also, an actual plan can still be considered an estimate since it is never truly known how much something will cost nor how long it will take until the activities are executed. The first step however in moving from initial estimates into a project schedule or complete plan is the definition of project scope.

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3.15 PROJECT SCOPE-GETTING STARTED

Projects exist for a singular purpose—to produce deliverables. The project scope refers to *what* the project will deliver. Given that the objective of a project is limited to producing very specific things over a fixed period of time—the concept of project scope would appear to be straightforward. Unfortunately—it is not. Scope in project management has a tendency to grow over time for many reasons. To begin with, each time a problem is encountered in a project, the project scope grows. This is because additional work is required to solve the problem. Depending upon the exact nature of the problem, additional resources may be assigned and new plans generated. Also, scope can grow simply because a project takes time to deliver. Because of this, requirements, standards, markets, and so on may change—and this may require additions to the work that is already planned. Because of these and many other scope-impacting factors, the first step in the scope planning process is to step back and think about how you as project manager will approach managing it.

3.16 PLANNING TO PLAN: HOW TO APPROACH YOUR PROJECT SCHEDULE

The PMBOK provides guidance for what amounts to the development of a “plan for a plan” in the context of scope, time, and cost management. This may be observed in the “Plan Scope Management, Plan Cost Management, and Plan Schedule Management” processes. On the surface, this would appear to be yet another layer of planning—and perhaps more planning than is even necessary. There is another way to view this apparent additional and possibly unnecessary sequence of steps. This is to think of this step as a means to step back and consider the strategy to be taken when managing scope, time and cost. For example, with respect to project scope, it is useful to consider the basic approach employed for dealing with the most difficult challenges in scope management—scope identification and scope control. Each of these elements of scope management could conceivably be managed in different ways. Scope identification could be implemented by means of a team brainstorming session. It could also be carried out by use of an outside facilitator with both project team and client team members present. Further, there are different tools and techniques from which to choose in managing the requirements from which the project scope is developed. Finally, different strategies for controlling scope exist—such as the implementation of a change management

process or a CCB (Change Control Board). The “plan for a plan” approach as outlined in the PMBOK therefore provides project managers with the opportunity and the means to step back, think about the big picture, and establish in writing the basic strategy for managing the important elements of the project beginning with scope, time, and cost. Rather than being an unnecessary step, it is a step that once undertaken, can prevent additional planning work later in the project or the implementation of loosely defined *ad hoc* methods.

3.17 DESCRIBING SCOPE IN STAGES

Project scope starts small, and then is progressively elaborated until the entire project scope is fully understood. Projects that are fortunate enough to begin with an SOW associated with a contract, have a head start in the development of project scope. However, the SOW requires further interpretation, it requires translation into specific project deliverables, and finally, it may well require some additional negotiation. Prior to the activity of fully elaborating the project scope—it is highly recommended that the project team begins with the writing of a simple scope statement. The scope statement serves multiple purposes. It captures the essence of what the project will and (equally important in the context of scope management) will not do. Also, as the elaboration of scope and the overall management of the project progresses—the scope statement is a useful point of reference for decision making as well as dispute resolution among the project team and stakeholders. To make an analogy, the government of the United States is governed by its constitution. The constitution is a highly succinct document that serves as a foundation for the extremely large body of laws that exist at all levels of government. Likewise, the scope statement is a succinct document that underpins the often elaborate full documentation of project scope.

3.17.1 WHAT SHOULD BE INCLUDED IN THE SCOPE STATEMENT?

The scope statement is a challenge to write. There is an old saying that it is “difficult to be simple,” and this saying certainly applies to the writing of the scope statement. The effort to condense the essence of the project into a few succinct paragraphs can be simplified by asking the following questions:

1. “What specifically will this project deliver?”
2. “What is the primary objective of this project?”
3. “How will the success of this project be determined and measured?”
4. “What will not be included in this project?” (Stated differently, What should be considered “out of bounds” or “out of scope”?)
5. “What constraints should be considered in this project?”
6. “What specific assumptions should be specifically stated?”
7. “What are the acceptance criteria for the project deliverables?”

A simple statement no more than one or a few paragraphs—not to exceed a single page—is a good start to the development of the project scope.

3.18 THE WBS: WHAT’S THE POINT?

The scope statement is the beginning of the development of project scope. It is, however, only the beginning of the process of the elaboration of scope. Recalling that scope is about “*what*” is to be delivered by the project, the elaboration of scope is an exercise in identifying the deliverables of the project in fine detail. It is essential though to keep the activity of scope elaboration highly organized—and to ensure that no deliverable is overlooked. It is for this reason that the next phase in scope development is the creation of the Work Breakdown Structure (WBS). The WBS is a structured outline of deliverables that is both hierarchical as well as categorical. The term “hierarchical” refers to the multiple levels of a WBS. It is the vertical (or said another way, the “top to bottom”) description of the project deliverables. Using the example of a homebuilding project, the home itself is the highest level project deliverable. However, underneath the house in the WBS is the roof. The roof includes elements such as plywood, underlayment, shingles, and a gutter system. The sequence of house-roof-shingles-underlayment-plywood-gutter system illustrates the hierarchical view of the WBS. It is clear though that a home includes more than a roof. It also includes a foundation, exterior, interior, rooms—to name just a few. This list is an example of the horizontal or categorical view of the project that is presented in the WBS. The categories—or range of elements—that must be delivered by the project along with all levels and sublevels of deliverables include 100 percent of the scope of the project. Notice that the simple case of the “home” WBS, is identical to the top-down apportioned estimate—but in this case—it lacks the percentage breakdown (Figure 3.3).

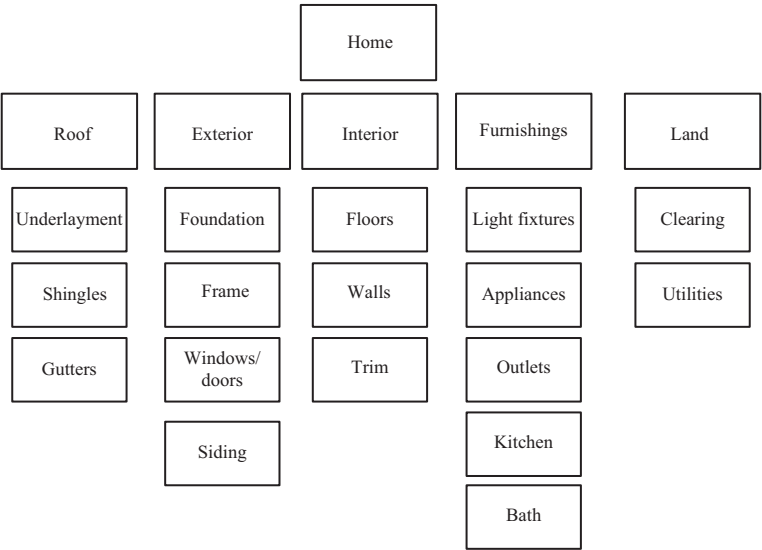


Figure 3.3. The Work Breakdown Structure (WBS).

3.19 SCOPE = DELIVERABLES

A description of the WBS includes frequent mention of deliverables. This is because deliverables are, in effect, the totality of the scope of the project. It is important to note what the WBS does *not* include. The WBS does not include:

- 1. Activities
- 2. Durations
- 3. Milestones
- 4. Resource assignments
- 5. Verbs (typically associated with activities)

It is recognized though that these items are important and part of the work involved in completing a project. Why then are they not included in the WBS? This is because the WBS is an elaboration of *what* will be delivered—not *who*, *how*, or *when*. This information comes later in the project schedule. The WBS therefore is not a project schedule—and it is not a task list. It is only an outline of deliverables. However, an outline of deliverables is required in order to fully describe the project scope.

3.19.1 WHY CONSTRAIN THE WBS?

Given that activities, durations, and milestones are very important in projects—why should project teams be constrained to focus on only deliverables rather than activities at the early stages of scope development? There are several reasons for this. First, activities and milestones are not a part of the project scope—they are components of the project schedule. It follows then that these elements of the project plan should not be included in the WBS—which is the elaboration of scope. There is another important reason however for focusing solely on deliverables first in project planning. A project exists for a limited period of time and as a result, has limited resources as authorized by the project charter. Therefore, it is important to ensure that every activity undertaken by the project must be directly linked to the deliverables that the project is expected to produce. The project must not engage in any activities that are not associated with the work of the project. The approach to project planning that first begins with the elaboration of scope as outlined in the WBS forces the project team to focus first on what needs to be delivered. Once this is complete the project team may then focus on identifying the activities required to produce the project deliverables. In this way, no extraneous or unnecessary activities end up in the final project plan.

3.19.2 THE WORK PACKAGE: WBS OR SCHEDULE?

The WBS includes multiple levels—typically at least three. As the top-level project is broken down into the lowest level of deliverables, eventually the deliverables become of sufficient scope and scale that they could be assigned to one or more individuals for completion. The assignment of the lowest level of deliverables to project team members is typically done in the form of the work package. The work package is a management tool for assigning and tracking of work. Deliverables are included in a work package—but the work package—unlike the WBS—includes more than deliverables. The work package includes deliverables—including a description or specifications, resource assignments, duration, and budget estimates. The data that is included in the work package is administrative in nature and is designed to both assign as well as track the work that is assigned to individuals and team. Although it is often said that the work package forms the lowest level of the WBS. This is not entirely correct. The work package includes the deliverables that are specified within the lowest level of the WBS. However, the work package also includes other

Project Name:	Project manager:	Date required:
WBS code:	Activity/summary description:	Actual finish date:
Responsible team member:	Cost variance:	Time variance:
Completion comments/notes:		
Approvals/signoffs	Team lead signature/date:	Project manager signature/date:

Figure 3.4. Work package example.

information that is not part of the WBS—but is a part of the schedule (such as resource assignments and task durations). Because of this, the work package should be viewed as a work assignment and administration tool that represents a transition from the development and elaboration of scope, to the creation of the project schedule (Figure 3.4).

3.20 CHAPTER 3: IMPORTANT “TAKEWAYS” FOR THE PROJECT MANAGER

- Stakeholders are those who have an interest in the outcome of the project.
- Stakeholders include clients, sponsors, team members, and members of the community in which the project operates.
- Stakeholders directly or indirectly determine project deliverables.
- Stakeholders require management and engagement by the project team as they constrain the overall operation of the project.
- The project charter authorizes a project to acquire resources, do work, and spend money associated with producing deliverables.
- The project charter includes a brief summary of the project scope and project constraints to the degree that they are known at project initiation.

- Early project estimates generally involve high-level estimates of the project scale.
- Multiple estimation methodologies exist and are used at different points in the project and for different reasons.
- Top-down estimates are typically driven by budgetary and business model constraints and often originate from senior management.
- Bottom-up estimates are created by team members who actually perform the work of the project. For this reason, bottom-up estimates tend to be accompanied by significant detail and numbers that often exceed top-down estimates.
- Final project estimates may result from negotiation between the project sponsor and the project team and characterized by a number of trade-offs between budget, schedule, and deliverables.
- The scope statement is a highly abbreviated, condensed description of the project scope. The scope statement could be envisioned what the project will and will not deliver.
- The WBS is a structured outline of what the project will deliver.
- Since the WBS is deliverable-oriented, it will not contain activities, milestones, resources, costs, or even verbs.
- The work package is the administrative device for assigning a bundle of deliverables and related activities and costs to one or more team members.
- The work package should be scoped not exceed two weeks in duration.
- The deliverables assigned in the work package are found at the lowest level of the WBS.

CHAPTER 4

How Long, AND How Much?

4.1 TIME: ACTIVITIES AND DELIVERABLES

The Work Breakdown Structure or WBS identifies all project deliverables. Once the project deliverables are determined, the scope is defined and the project team next begins the development of the schedule. What should the project team include in the project schedule? The activities that are required to produce the project deliverables are that which is placed in the project schedule. This requires then that the project team systematically examine the deliverables as identified in the WBS, and then identify all activities required to produce them. A test of a valid WBS is to confirm that it contains only nouns since only deliverables should be included. By way of contrast, the list of project activities that is used to populate the project schedule includes only verbs—since activities are actions that are taken to produce the deliverables outlined in the project scope. The rigorous focus on deliverables first, followed by activities helps ensure that no extraneous activities are included within the project schedule. This is a reasonable approach since the only work that is carried out within a project is that which is done in order to complete the fundamental mission of the project—which is to produce the project deliverables.

4.2 PUTTING THINGS IN ORDER

This shift in focus from project deliverables to project activities signals the shift from the project scope development (project scope management knowledge area), to the development of the project schedule (the project time management knowledge area). The project schedule describes how much time it takes to produce the deliverables of the project. The challenge in doing this is that the schedule requires more analysis than simply

adding together the duration of each deliverable in order to arrive at a total time. The reason for this is that not all activities within a project schedule will follow in sequence one after another. Some activities will follow each other while others will unfold in parallel with each other. A good way to think of the series and parallel nature of project activities is to think of making a pot of coffee as a project. Several of the activities associated with making coffee must be carried out in sequence. For example, coffee may not be added to the pot until the filter is installed. Also, the brewing cycle may not start until both the water is poured and the coffee is put into the coffee maker. These activities are sequential and one must be done before the other. Once the brewing starts—several activities may be carried out in parallel. For example, during coffee brewing—this is a good time to retrieve the cup, the spoon, the sugar, and the cream. For some who prefer this—it is also possible to add cream and sugar to the cup during the brewing cycle.

To further examine the simple example of brewing coffee, it is possible to estimate the total time, in seconds, required to brew coffee (Figure 4.1).

	Activity	Seconds
A	Get coffee grounds	10
B	Get pitcher of water	10
C	Get coffee filter	5
D	Get cup	5
E	Get cream	10
F	Get sugar	5
G	Get spoon	5
H	Pour water	15
I	Put in filter	5
J	Put in coffee grounds	20
K	Turn on coffee maker	5
L	Brew coffee	500
M	Pour coffee	15
N	Add cream	5
O	Add sugar	5
P	Stir	10
	Total	630

Figure 4.1. Coffee brewing activities.

In this example, the time required for all coffee-brewing activities are added together. The total time required to brew the pot of coffee is determined to be 630 seconds. As mentioned previously, this time is clearly not correct due to the fact that some activities fall in sequence one after the other—whereas some are in parallel. Once the parallel activities are identified—the actual time required to brew the coffee comes into clearer focus, as follows in Figure 4.2.

From inspection of the highlighted activities in the coffee example, the total brewing time becomes 605 rather than 630 seconds since Activities D, E, F, and G are carried out during the time that Activity L, “Brew

	Activity	Seconds
A	Get coffee grounds	10
B	Get pitcher of water	10
C	Get coffee filter	5
D	Get cup	5
E	Get cream	10
F	Get sugar	5
G	Get spoon	5
H	Pour water	15
I	Put in filter	5
J	Put in coffee grounds	20
K	Turn on coffee maker	5
L	Brew coffee	500
M	Pour coffee	15
N	Add cream	5
O	Add sugar	5
P	Stir	10
	Total	630

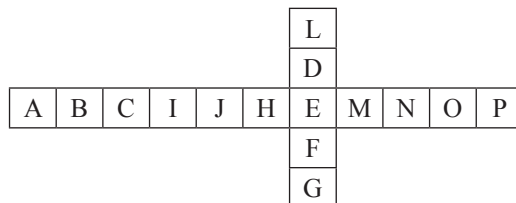


Figure 4.2. Coffee brewing with activities in parallel.

Coffee” is carried out. In fact, Activities D, E, F, and G may be delayed for a significant period of time without delaying the overall coffee preparation time. For example, Activity D, “Get cup” requires 5 seconds. Activity L, “Brew coffee” requires 500 seconds. Because of this, it is possible to delay “Get cup” for 495 seconds and the cup will still be ready for use at exactly the right moment when the coffee brewing ends. Activity D is therefore said to have 495 seconds of “slack” or “float” in the overall coffee brewing “project.”

In addition to overall project timing and slack, another important principle may be gained from inspecting the sequence of events associated with coffee brewing. Since Activities D, E, F, and G are in parallel with a much longer activity (Activity L, Brew coffee), it is observed that these activities are not on the longest path or sequence of project events. The sequence of events leading up to, including, and following Activity L make up the longest path of the project. The longest path in the project is the shortest possible period of time in which the brewing of coffee may be completed. The longest path in a project is referred to as the project “critical path.” It is referred to as critical because a delay of any activity on the critical path will cause a delay in the overall project. This does not infer that other activities are not important. It simply means that activities that are not on the critical path may be delayed—by the amount of slack in the activity—without delaying the overall project.

4.3 FROM SIMPLE, TO COMPLEX

Brewing coffee is a relatively simple endeavor and therefore does not represent the complexity observed in most projects managed by project managers and project teams. However, the same scheduling principles are applied to all projects—regardless of complexity. They are as follows:

1. List all activities required to produce the project deliverables.
2. Order them in such a way that sequential and parallel activities are identified.
3. Identify the longest path in the project (the sequence of project activities that do not have slack—or “those activities that cannot be moved without delaying the overall project”).

After Steps 1 to 3 are completed, the project manager and project team are now able to determine how much time it will take to complete all project activities, and as well, identify which activities may not be delayed without delaying the overall project. In the case of brewing coffee, these

steps may be completed by inspection. A more complex and more typical project will require the use of a structured methodology that makes use of network diagrams.

4.3.1 WHAT IS A NETWORK DIAGRAM?

A network diagram is a method for recording and analyzing the sequence of project activities and their relationships to each other. The type of network diagram most frequently employed by project managements and project management software is known as the “Activity on Node” or AON method. In this type of diagram, activities are identified by a series of boxes that are connected to each other with lines. The nodes, or boxes, contain information about the activity including the activity identifier, the duration of the activity, the amount of slack associated with the activity (SL)—as well as the earliest and latest start (ES and LS) and finish (EF and LF) time of the activity (Figure 4.3).

ES		EF
SL	L	
LS	500	LF

Figure 4.3. Network diagram node example for Activity “L” in coffee-brewing example.

The information contained in each node is extensive, but it is there for a specific purpose. Each node in a network diagram contains the information required to determine the project critical path using the “Forward and Backward pass” algorithm. This analysis is known as CPM, or the “Critical Path Method.” It is also sometimes referred to as PDM or the “Precedence Diagramming Method.” Both labels describe the basic function of network diagrams in terms of putting the activities in order, and determining the critical path.

4.4 ACTIVITY ON ARROW: A DIFFERENT TYPE OF NETWORK DIAGRAM

The AON network with its connecting boxes complete with activity information is most commonly observed in project management software

packages. It is also the most intuitive method to use when project networks are developed and analyzed manually. However, Activity on Arrow (AOA) networks are sometimes seen in projects and they are useful for software optimization packages that seek to optimize projects for minimum duration and costs. AOA networks include activity labels on the arrows themselves instead of on the network nodes. Unlike the AON method, the nodes act simply as connectors for the arrows and may contain node labels (Figure 4.4).

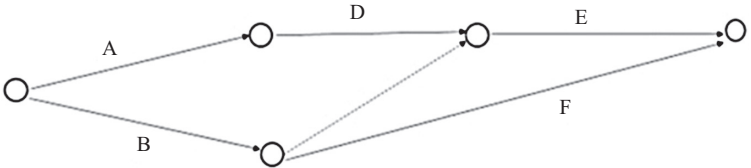


Figure 4.4. Activity on Arrow (AOA) network diagram.

One reason that AOA diagrams are not frequently used (unless for specialized mathematical optimization applications) is the presence of “dummy” activities. In AOA, since each arrow includes both activity and duration information, there may be situations where the project manager needs to indicate a sequence of events that end at the same time—but not all previous activities are predecessors. In the earlier example, Activity E follows both B and D—but only D is an activity predecessor. Project managers should be aware of AOA networks even though as a practical matter, such project networks are developed only for specialized applications by those who understand and can interpret them. It might be asked, “If AOA networks can be misinterpreted—why use them?” The rationale behind the AOA network is simply that the connector nodes used in an AOA network make it easy to include constraint equations into an optimization package such as a spreadsheet solver (Figure 4.5).

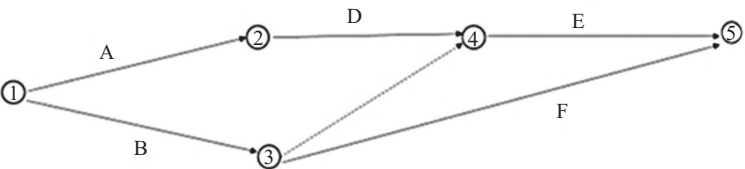


Figure 4.5. AOA network diagram with dummy activity.

As a simple example, the Connector Node “5” could be represented with the expression:

$$“5” \leq E + F$$

4.5 ANALYZING PROJECT DURATION USING A NETWORK DIAGRAM

The benefits of using network diagrams to determine the critical path become clear when the critical path is not easily determined by simple inspection. A typical project scenario using CPM illustrates this.

4.5.1 CPM SCENARIO

Assume that you are a project manager within a small computer system and networking and installation company. Your company has been awarded a contract to upgrade a network of computers in a call center environment. The upgrades in the contract consist of updating the operating system and call center application residing in each of each of the computers, performing memory upgrades to those desktops that require it, and converting to a wireless LAN network. Once the contract has been analyzed and the scope statement and the WBS for the project have been created, the high-level activities required to produce the deliverables are identified and listed. The first step therefore in creating the network diagram for CPM analysis begins with the list of activities.

4.5.1.1 Activity List

1. Desktop PC evaluation.
2. Call center bandwidth estimation.
3. Upgrade plan.
4. Procure computer memory.
5. Procure wireless access equipment.
6. Procure system software.
7. Install wireless access equipment.
8. Install PC memory and wireless cards.
9. Install OS and Applications.
10. Develop training materials and user guide.



- 11. Train end users and administrator.
- 12. Launch new system.

4.5.1.2 Activity Precedence

The task list is then prepared for the development of the network diagram by establishing the order of precedence of all tasks. Establishing precedence simply involves determining what activities come before, after, or in parallel with another activity. Stated another way, this step in the processes identifies the logical progression of project activities. Each activity is labeled with an identifier as well as a predecessor (if applicable) in a corresponding table (Table 4.1).

Table 4.1. Task list for call center scenario

Identifier	Task description	Predecessor
1	Desktop PC evaluation	-
2	Call center bandwidth estimation	-
3	Upgrade plan	1
4	Procure computer memory	3
5	Procure wireless access equipment	2,3
6	Procure system software	3
7	Install wireless access equipment	5
8	Install PC memory and wireless cards	4,5
9	Install OS and Applications	6,8
10	Develop training materials and user guide	6
11	Training	7,9,10
12	Launch new system	11

4.5.1.3 The Network Diagram

The precedence table is then employed to create a network diagram. Each activity forms a node in the network, and the nodes are connected together using lines in order to indicate graphically the logical flow of task (Figure 4.6).

As anticipated, a typical “real world” schedule is considerably more difficult to analyze than the simple coffee-brewing project example. From inspection of the network diagram, the logical progression of activities is clear. A number of activities follow in sequence one after another, while

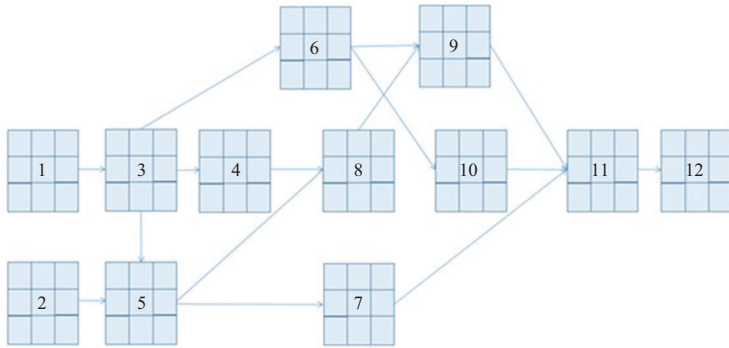


Figure 4.6. Network diagram for call center scenario.

some activities are carried out in parallel. However, the longest, or critical path in the project is by no means obvious. To continue with the CPM analysis, now that the activities are in logical order, the next step is to include the duration of each activity on the diagram. The duration of each activity was not previously stated—but is first added to the project activity list using a series of estimated durations using the expert judgment of the project manager and project team (Table 4.2).

Table 4.2. Call center activities and durations

Identifier	Task description	Predecessor	Duration
1	Desktop PC evaluation	-	10
2	Call center bandwidth estimation	-	5
3	Upgrade plan	1	7
4	Procure computer memory	3	3
5	Procure wireless access equipment	2,3	4
6	Procure system software	3	3
7	Install wireless access equipment	5	10
8	Install PC memory and wireless cards	4,5	10
9	Install OS and Applications	6,8	7
10	Develop training materials and user guide	6	15
11	Training	7,9,10	7
12	Launch new system	11	1

The network diagram is then updated with the duration of each activity (Figure 4.7).

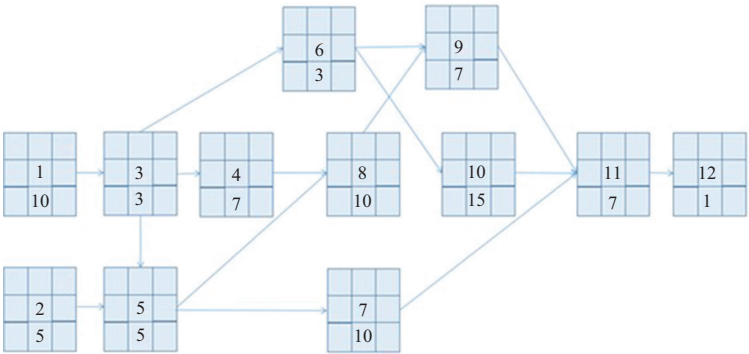


Figure 4.7. Call center network diagram with activity durations.

With the duration of each activity in place, it is observed that some activities take more time than others, but the project critical path remains hidden. The CPM “Forward and Backward Pass” algorithm is the necessary next step required to reveal which activities include slack and which do not.

4.6 THE FORWARD PASS

The forward pass calculation begins by populating the early start (or ES) box in the first node, adding the duration, and inputting the total (ES + Duration) into the early finish (or EF) box (Figure 4.8).

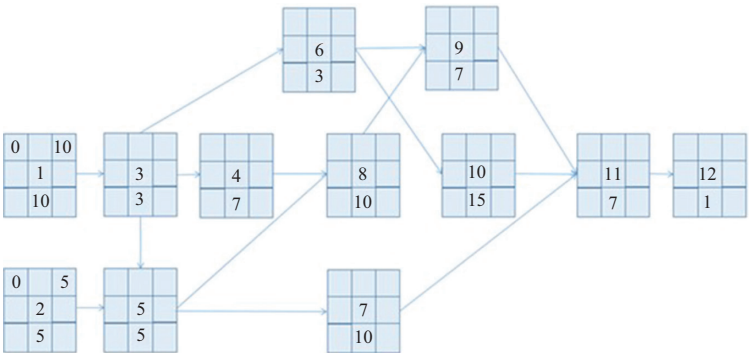


Figure 4.8. Beginning the forward pass calculation.

In the case of this sample project, Activities 1 and 2 do not have predecessors. Because of this, they both begin at time “0”. To complete a forward pass for each element, take the ES or early start time, add the duration, and place the total into the EF or early finish box. The general formula for the forward pass for each element is:

$$EF = ES + \text{Activity Duration}$$

This formula has been completed for Activities 1 and 2 in Figure 4.9.

The next step of the forward pass is carried out by moving the early finish (EF) from the completed nodes, and using this number as the early start of the immediately following node (Figure 4.9).

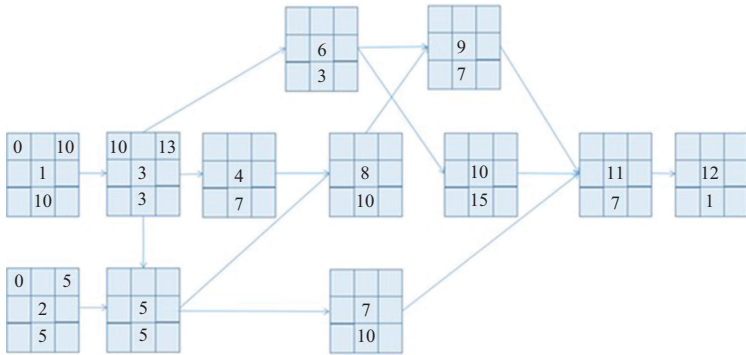


Figure 4.9. Continuing the forward pass calculation.

This process continues throughout the network diagram until any node is reached that is connected to two predecessors. This occurs first in Activity 5.

4.7 FORWARD PASS WITH MERGING ACTIVITIES

In activities in which more than one predecessor merges (such as Activity 8), the ES or early start date is no longer a simple matter of “carrying over” the EF or early finish date of the previous node. There is however, a common-sense approach to determining the early start date. This is done by asking the following question, “According to the diagram, when is the earliest that Activity 5 may start?” The simple answer is that “Activity 5 begins when *both* Activity 3 *and* Activity 2 are completed.” At what time are both Activities 3 and 2 complete? At time 13 (the EF or early finish

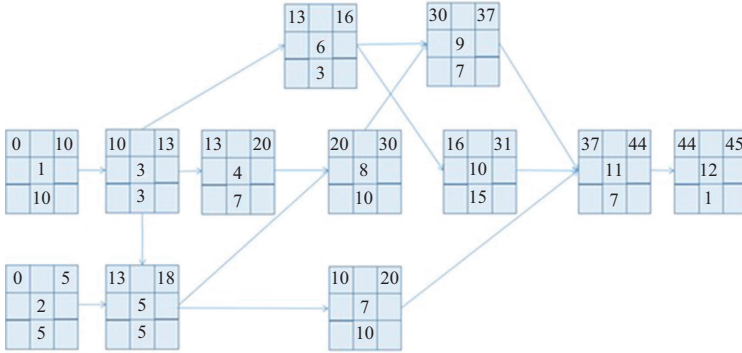


Figure 4.10. Forward pass with merge activities.

for Activity 3). Prior to this time, Activity 2 may be complete—but not both Activities 2 and 3. This leads to a general rule for calculating the forward pass early start times for activities with more than one predecessor (Figure 4.10):

When more than one activity precedes an activity in the forward pass calculation, the highest early finish date is used as the early start for the successor activity.

Using these two rules, the forward pass is completed for the network (Figure 4.11).

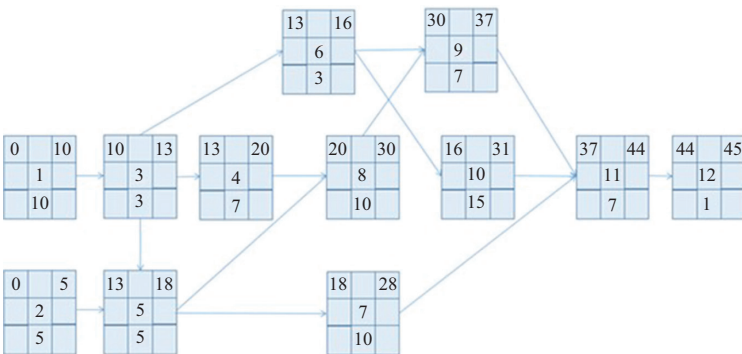


Figure 4.11. Completed forward pass calculation.

4.8 THE BACKWARD PASS

The backward pass begins at the end of the network diagram, and works forward toward the beginning of the schedule by taking successive Late

Finish (LF) times, subtracting the duration, and arriving at the Late Start (LS) time. As a first step, the EF time of the final activity is moved “down” to the LF square in the final activity node. The rationale for doing this is that when the final activity has ended, the activity can finish no later than when the project is completed. For this reason, in the final project activity, the LF equals the EF (Early Finish). For activities directly in sequence, the backward pass process is straightforward. This process is completed for Activities 11 and 12 (Figure 4.12).

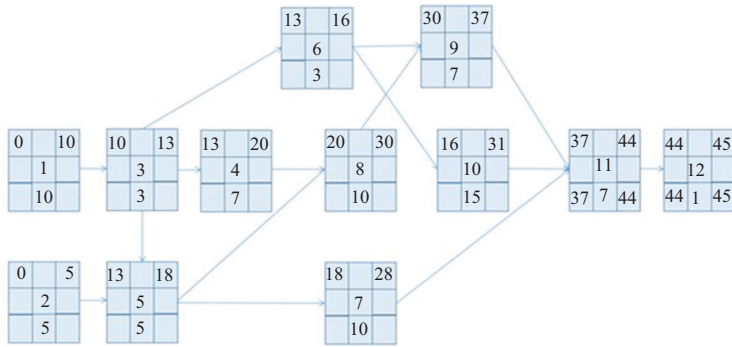


Figure 4.12. Backward pass for Activities 11 and 12.

In Figure 4.13, it is observed that Activity 11 connects to Activities 7, 9, and 10 when moving from the end of the schedule to the beginning. The LS date of 37 time units is then moved forward to the LF finish date of Activities 7 through 10 as indicated in Figure 4.13.

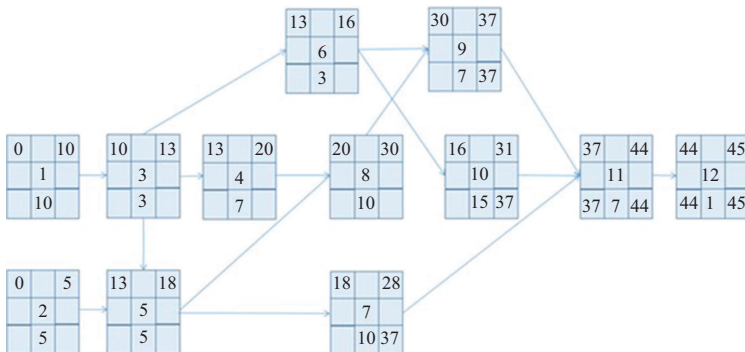


Figure 4.13. Backward pass calculation with merge activities.

Once again, the duration is subtracted from the LF date—in this case 37—in order to arrive at the LS for Activities 7 to 10 (Figure 4.14).

The backward pass is completed in Figure 4.16.

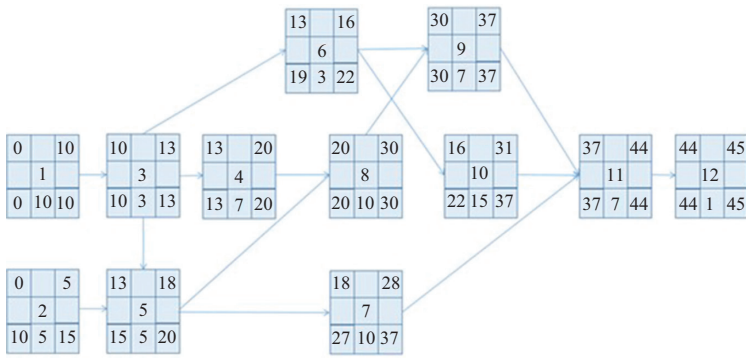


Figure 4.16. Completed backward pass calculation.

The purpose of this exercise becomes clear when the difference between the ES and the LS is determined via subtraction. If there is no difference—that is—a difference of zero, then the activity is said to be on the project critical path. Why should this be so? Consider that a property of activities found on the project critical path is that any delay of that activity would delay the overall project end date. An activity with a difference of zero between the ES and LS indicates that the LS is the same as the Early Start. Said another way—there is no room to maneuver and the activity cannot be delayed without delaying the overall project. To find the project critical path, simply identify all activities where the difference between the ES and LS is zero. This is completed in Figure 4.17 with the critical path highlighted in red.

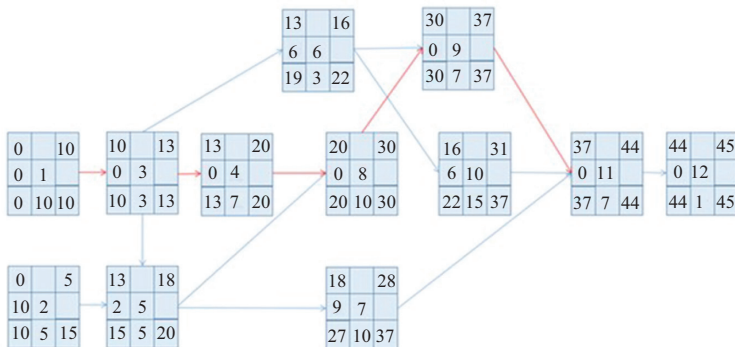


Figure 4.17. Critical path identified.

4.9 ACTIVITY SLACK

The term “slack” or float is used to describe the difference between the ES and LS. It is observed that activities with zero slack may not be delayed. How then should activities with positive slack be interpreted? The amount of slack indicates the period of time by which the particular activity may be delayed without delaying the overall project. Slack is found in activities that are in parallel with activities that are on the critical path. As an example, Activities 2 and 5 are in parallel with Activities 1, 3, and 4. If Activities 2 and 5 are delayed by the amount of slack in each activity, then Activity 5 would finish at the LF of time 20. Since Activity 4 on the critical path also finishes at time 20, then the delay equal to the amount of slack in Activities 2 and 5 does not delay the overall schedule (Figure 4.18).

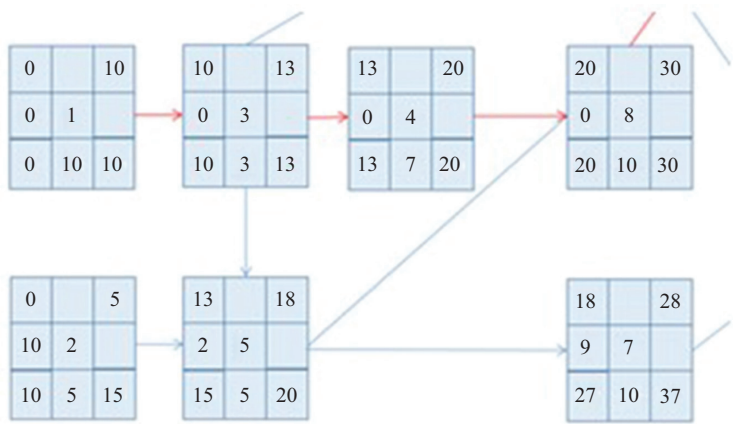


Figure 4.18. Slack in parallel activities.

If Activities 2 and 5 did exceed the slack for both activities, the sequence would finish later than 20 units of time and would then delay Activity 8. Since Activity 8 is on the critical path, this delay would then delay the overall project. Slack therefore allows for delays in activities corresponding to the amount of slack—but—exceeding the amount of available slack delays the entire project.

The critical path activities are now highlighted in tabular form along with the total project duration equating to the duration of all activities on the critical path (Table 4.3).

Table 4.3. Critical path in tabular form

Identifier	Task description	Predecessor	Duration
1	Desktop PC evaluation	-	10
2	Call center bandwidth estimation	-	5
3	Upgrade plan	1	7
4	Procure computer memory	3	3
5	Procure wireless access equipment	2,3	4
6	Procure system software	3	3
7	Install wireless access equipment	5	10
8	Install PC memory and wireless cards	4,5	10
9	Install OS and Applications	6,8	7
10	Develop training materials and user guide	6	15
11	Training	7,9,10	7
12	Launch new system	11	1
Total		45	

4.10 CPM AND SENSITIVITY

The term “sensitivity” refers to the critical path and its propensity to “wander” as the project moves from planning and into project execution. As each activity in the project is carried out, some activities take longer than planned—while others may take less time than initially envisioned. Because of the natural fluctuation in project execution, the path that was initially identified as the critical path may no longer be the critical path. A different path may have taken the place of the original critical path. The degree to which this is more or less likely to occur is referred to as the project sensitivity. Generally speaking, if the duration of the project critical path is close to the duration of a noncritical path, the project is said to be highly sensitive. If the critical path is significantly different in duration from other paths in the project, then the project network is not sensitive.

4.10.1 OVERALL OBSERVATIONS ON THE CRITICAL PATH METHOD

The purpose of the network diagram within the CPM is to organize all activities in the logical order of activity precedence so that the project critical path—the longest path in the project—may be determined. Knowing which specific sequence of activities in the network that may not be delayed is important for management purposes—but it also definitively determines the overall project duration. Without the analysis of the critical path, the overall project duration would not be obvious. For instance, the multiple parallel paths along with the two activities in parallel at the beginning of the network diagram in this example illustrate the difficulty of assessing the project duration by simple inspection of a list of activities and predecessors. The CPM also informs the project manager regarding how much room to maneuver exists when scheduling activities that are not on the critical path. Finally, it should be noted that the forward and backward pass algorithm is a manual process that is completed automatically in project management software packages—providing that the activities, duration, and activity precedence is entered correctly. When project schedules are developed manually, the CPM using the forward and backward pass algorithm is the most straightforward approach.

4.10.2 GOING BEYOND CPM: THE PERT METHOD

An implicit assumption throughout the development of a schedule using the CPM is that the duration of all activities in the project are well understood. Another way to say this is that CPM is “deterministic”—the activity of each duration is known and it is fixed. Unfortunately, this is not an ideal model for developing project schedules in the real world. Real projects consist of activities with durations that are estimated rather than certain and are not fixed. This is true for many reasons including normal variation, unanticipated difficulty in completing the activity, or unexpected work interruption. The Program Evaluation and Review Technique, or PERT methodology provides tools for taking into account the expected variation in the duration of project activities. Additionally, PERT provides statistical techniques for calculating the probability of achieving a specific target schedule duration. Finally, the PERT method of using estimates instead of fixed activity durations is ideal for garnering support and buy-in from sponsors, clients, and other senior-level stakeholders. For example, a project manager is free to poll senior management for PERT estimates instead of being the sole source of project duration estimates.

4.10.3 DIFFERENT, YET SIMILAR

PERT analysis does differ from the CPM by virtue of its statistical approach including three-point estimates that are combined using a type of weighted average. However, PERT analysis follows the same approach that is employed by CPM. Both methods use network diagrams, and both use the forward and backward pass algorithm in order to identify the project critical path. Since in most cases project durations are not known with certainty, and so much is common to both CPM and PERT analysis, many project managers will often use the two terms interchangeably.

4.10.4 BEGINNING A PERT ANALYSIS

The first step in PERT analysis is the same as the CPM. The list of activities required to produce deliverables in the WBS along with the accompanying logical predecessors is collected in a list or table. The PERT methodology can be illustrated using the CPM scenario described earlier and beginning with the activity and predecessor list (Table 4.4).

Table 4.4. Activity list for PERT analysis

Identifier	Task description	Predecessor
1	Desktop PC evaluation	-
2	Call center bandwidth estimation	-
3	Upgrade plan	1
4	Procure computer memory	3
5	Procure wireless access equipment	2,3
6	Procure system software	3
7	Install wireless access equipment	5
8	Install PC memory and wireless cards	4,5
9	Install OS and Applications	6,8
10	Develop training materials and user guide	6
11	Training	7,9,10
12	Launch new system	11

Unlike CPM, the duration of each activity is not assumed to be known with certainty. Instead of fixed durations, PERT incorporates three estimates including the best-case estimate (BC), the worst-case estimate

(WC), and finally, the most-likely (ML) estimate for each project activity. The three estimates are combined using a form of weighted average. The weighted average formula used for these estimates is:

$$\frac{BC + 4 * ML + WC}{6}$$

Why use this specific formula for the weighted average? This formula is derived from a special statistical distribution known as the “Beta Distribution.” It is useful in PERT analysis for its ability to incorporate both BC and WC estimates while weighting the ML estimate more strongly. Knowledge of this distribution as well as other statistical distributions that might be employed are necessary only for the most advanced analysis. Therefore, the implementation of the simple formula is all that is needed to use PERT in practice.

4.10.5 FROM WHERE ARE THE ESTIMATES OBTAINED?

Estimates often flow naturally from the application of expert judgment of project team members. On the other hand, the PERT estimating process provides an avenue for senior level stakeholders to become directly involved in estimating the project duration. This can be important for project managers since in most cases, the target schedule results from a negotiation between the project team, the client, and project sponsors. One means for doing this is to bring together senior stakeholders by holding a high-level schedule estimation meeting. When high-level activity duration input is collected from senior stakeholders within the setting of a schedule development workshop meeting, the risks and implications of the agreed on final project schedule dates may become more obvious. The ability of the PERT methodology to quickly provide probability calculations for achieving a schedule on a particular date offers feedback to senior sponsors on the schedule risk that often would not be otherwise forthcoming.

4.11 BUILDING THE ESTIMATED PERT SCHEDULE

Once the PERT estimates are acquired—either through project team member expert judgment—or in the ideal case of a stakeholder schedule development workshop—the BC, WC, and ML estimates are collected in tabular form in the same way as the CPM. For the sake of simplicity, the ML durations are taken from the fixed durations used in the CPM scenario (Table 4.5).

Table 4.5. PERT activity estimates

Identifier	Task description	Predecessor	BC	ML	WC
1	Desktop PC evaluation	-	7	10	14
2	Call center bandwidth estimation	-	3	5	10
3	Upgrade plan	1	4	7	10
4	Procure computer memory	3	2	3	7
5	Procure wireless access equipment	2,3	3	4	8
6	Procure system software	3	2	3	7
7	Install wireless access equipment	5	7	10	14
8	Install PC memory and wireless cards	4,5	7	10	14
9	Install OS and Applications	6,8	3	7	10
10	Develop training materials and user guide	6	10	15	21
11	Training	7,9,10	4	7	14
12	Launch new system	11	1	1	3



As a next step, the three estimates for each activity are combined using the PERT weighted average formula (Table 4.6).

Table 4.6. PERT weighted average of activity estimates

Identifier	Task description	Predecessor	Duration
1	Desktop PC evaluation	-	10.2
2	Call center bandwidth estimation	-	5.5
3	Upgrade plan	1	7.0
4	Procure computer memory	3	3.5
5	Procure wireless access equipment	2,3	4.5
6	Procure system software	3	3.5
7	Install wireless access equipment	5	10.2
8	Install PC memory and wireless cards	4,5	10.2
9	Install OS and Applications	6,8	6.8
10	Develop training materials and user guide	6	15.2
11	Training	7,9,10	7.7
12	Launch new system	11	1.3

It is observed that the calculation of the weighted average results in fractional time periods. What do fractional time durations mean to a project manager? This will depend upon what units of time are being used in the project. However, in PERT analysis, it is recommended that fractional durations be evaluated once the final analysis is complete. If the fractional unit of time is sufficiently important to the project—it may be retained in the project schedule. Alternatively, the fractional time units might be rounded up to the next period. When PERT analysis is carried out using a spreadsheet (and it often is), fractional durations are easily managed.

4.12 THE PERT NETWORK DIAGRAM

Once the durations are calculated, the network diagram may be analyzed in the same manner as the CPM by means of the forward and backward

pass algorithm. The network diagram is initially constructed using the PERT weighted average durations (Figure 4.19).

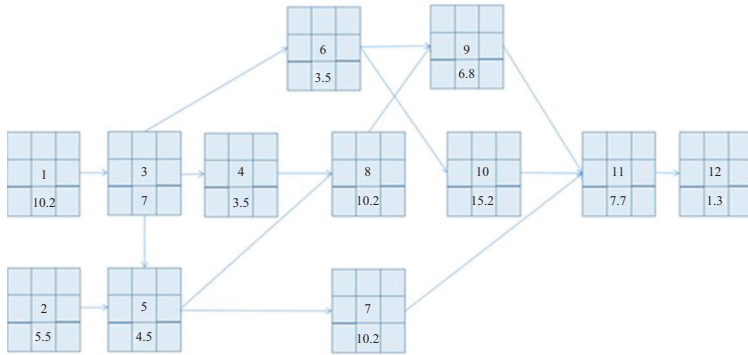


Figure 4.19. PERT network diagram.

Once the initial network diagram with PERT durations is constructed, the forward pass algorithm is applied (Figure 4.20).

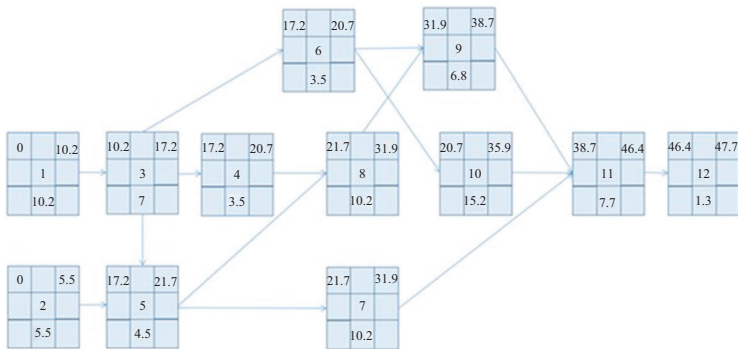


Figure 4.20. PERT forward pass calculation.

The backward pass algorithm is applied in the same manner as the CPM method. It is important to remember, for correct analysis, the two rules of thumb for the forward and backward pass algorithm (Figure 4.21).

Forward pass: The largest EF duration for multiple activities converging into a single activity is “carried over” to become the ES of the succeeding activity.

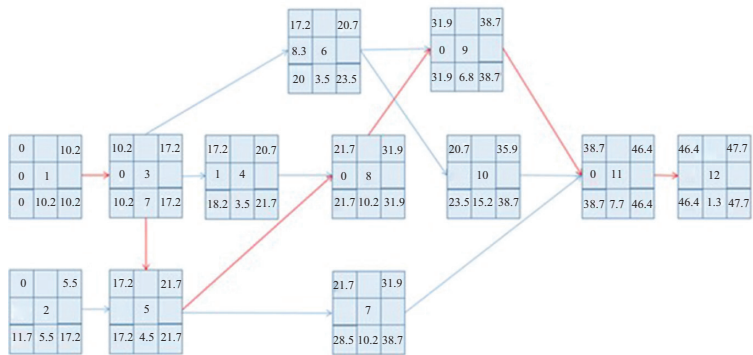


Figure 4.21. PERT backward pass calculation.

Backward pass: The smallest LS duration for multiple activities converging into a single activity is “carried over” to become the LF of the preceding activity.

The project critical path is then identified by taking the difference between the ES and the LS. The project critical path based on the PERT activity estimates is shown in Figure 4.22.

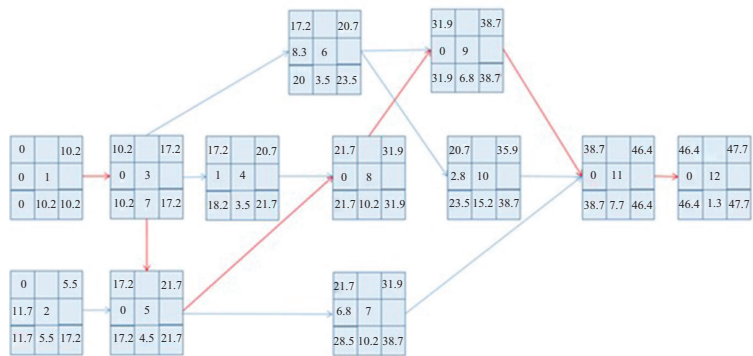


Figure 4.22. PERT critical path identification.

The PERT critical path is highlighted in a tabular view of the project activities. The critical path analysis using the PERT estimates changed many of the overall activity durations and also changed the critical path sequence. Further, the overall project length was extended by almost three units of time (Table 4.7).

Table 4.7. PERT critical path in tabular form

Identifier	Task description	Predecessor	Duration
1	Desktop PC evaluation	-	10.2
2	Call center bandwidth estimation	-	5.5
3	Upgrade plan	1	7.0
4	Procure computer memory	3	3.5
5	Procure wireless access equipment	2,3	4.5
6	Procure system software	3	3.5
7	Install wireless access equipment	5	10.2
8	Install PC memory and wireless cards	4,5	10.2
9	Install OS and Applications	6,8	6.8
10	Develop training materials and user guide	6	15.2
11	Training	7,9,10	7.7
12	Launch new system	11	1.3
Total		47.7	

At this stage of the PERT analysis process, it would appear that PERT has accomplished only three things:

1. Provided a means for collecting and using estimates from key stakeholders.
2. Created a schedule with a more realistic overall duration.
3. The sensitivity of the critical path to changes in activity durations for noncritical path activities was uncovered. (This is evident given the shift of the critical path observed once the project activity durations were changed based upon the weighted average of duration estimates.)

Although the PERT estimated schedule is an improvement—the most important benefits of applying this form of analysis is the ability to predict the probability of achieving a specific project target date. Using these features of PERT analysis however requires some familiarity with basic statistics.

4.13 THE WEIGHTED AVERAGE AND THE PROJECT AVERAGE

The important benefits of PERT analysis derive from the fact that activity duration estimates are formed using weighted averages. Although the weighted averages of the activities individually use the beta distribution rather than the normal distribution—known as “the normal curve”—the collection of all weighted averages of activities found on the critical path do approximate the normal distribution, and when summed, form an overall project mean. The reasons for this are theoretical and go beyond the topic of project probability estimation. What is important is that the PERT estimated weighted averages of critical path activities lead to a project mean that corresponds with the common normal curve. This is significant in project duration estimating due to the link between the normal curve and probability estimation.

4.14 THE NORMAL CURVE AND PROBABILITY

Properties that are sampled in nature often follow the normal curve. For example, demographic characteristics such as height, age, and income are normally distributed (Figure 4.23).



Figure 4.23. The normal curve.

This is because when measuring such characteristics, the probability of falling near the center of the curve (average or mean), is higher than falling far from the center. Samples that occur far from the center are often referred to as outliers. This phenomenon may be observed in the distribution formed by dropping marbles through a series of pegs. As can be



Figure 4.24. Marble distribution normal curve.

seen in Figure 4.24, most marbles tend to gather around the center of the distribution (Figure 4.24).

It is less likely, or probable, for marbles to fall far from the center of the distribution. The property of being near or far from the mean can be viewed as a measure of its probability. An inspection of the marble game illustrates how the area of the curve (i.e., sections that contain more versus less marbles) relates to the likelihood of marbles being found in each individual slot. Calculating probability however requires some method of measuring the distance from the center of the normal curve. Distance in terms of the normal curve is given by a measure known as the standard deviation. The standard deviation is referred to by the Greek letter sigma (σ). Project managers may be familiar with the term “Six Sigma” commonly used in industry. This refers to “six standard deviations from the mean”—or, from the center of the normal curve—since the mean is located at the center of the normal curve. Six standard deviations are distant from the mean and would be representative of values that are associated with a very low probability of occurrence. This is the point of six sigma quality management—to achieve an extremely small number of defects.

4.15 UNITS OF PROJECT TIME AND PROBABILITY

Project management makes use of the center of the normal curve and the standard deviation in PERT analysis in order to determine if the units of time established for the target schedule duration are likely or unlikely to be achieved. The probability of the project duration being achieved is based upon their distance from the center, or mean of the normal curve. The essence then of PERT probability analysis is to convert project units of time into “number of standard deviations” so that project target dates may be envisioned in terms of standard deviations from the mean. Once this is done, the probability associated with that distance from the mean may be calculated. If the project mean (“average”) and standard deviation (“how wide the project normal curve is in terms of time units”) is known, the probability of achieving the project schedule target date may then be calculated.

4.16 MEASURING STANDARD DEVIATIONS

The exact measure of probability associated with the number of standard deviations is provided by a reference known as a “Z table.” The “Z” in the Z table is interpreted as “number of standard deviations”—and typically “number of standard deviations from the mean.” The number associated with each Z value within a Z table corresponds to the probability value associated with a particular Z value. Another way to think of the Z value in this case is that it answers the question, “What is the probability that a marble will be found ‘Z’ number of standard deviations from the center, or mean of the distribution?” For example, a Z value of “1.5” refers to “1.5 standard deviations above the mean.” Likewise, a Z value of -1.5 refers to “1.5 standard deviations below the mean.” Referring back to the marble game, the greater the distance from the center, the less likely it is that marbles will be found. Likewise, when measuring properties in nature such as height, once the mean height and standard deviation of the population is known, it is possible to calculate the probability of having a height measurement that exist in standard deviation multiples (such as ± 1.5 Z) above or below the population mean.

4.17 USING THE Z TABLE

A Z table consists of rows and columns each beginning with zero and increasing in decimal increments. To use a Z table, the Z probability is

found by combining the first two Z digits in the column to the far left with the last two Z digits in the row across the top of the table. Then, the probability is found at the intersection of row and column. For example, a Z value of 1.000 (Row value of 1.0 plus column value of .00) corresponds with a probability of approximately 34 percent (.3413). Likewise, a Z value of 1.55 (Row value of 1.5 plus column value of .05) equates to a probability of approximately 44 percent (.4394), and finally, a Z value of 2.000 (Row value of 2.0 plus column value of .00) corresponds to a probability of approximately 48 percent (.4772) (Figure 4.25).

	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09

Figure 4.25. Z table.

4.18 APPROXIMATING PROBABILITIES

While a Z table provides exact probabilities, it is not typical for project managers or team members to have a Z table readily available. Probabilities however may be estimated directly from the normal curve. This is because there are simple rules of thumb that may be used in order to approximate normal curve, and therefore, schedule probabilities. Referring back to the Z table, note that a Z value of 1, or +1 SD is associated with

a probability of approximately 34 percent. Taken together with -1 SD, it may be observed that ± 1 SD corresponds with (2×34) or 68 percent of the area of the curve. Stated another way, “there is a 68 percent chance in the marble game for a marble to be found between ± 1 SD of the center” or “there is a 68 percent chance that an individual will have a height measurement falling between ± 1 SD of the population mean (Figure 4.26).”

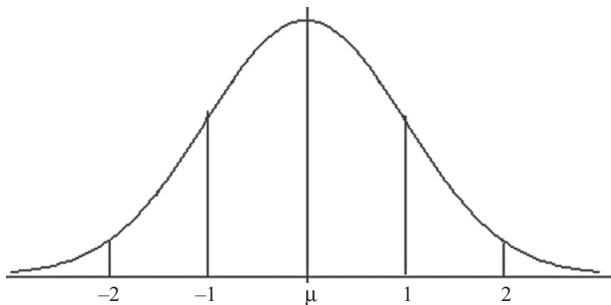


Figure 4.26. Normal curve with “rules of thumb.”

Likewise, it is observed that a Z value of 2.000 corresponds to a probability of approximately 45 percent (.4772). Taken together with -2 SD, it can be seen that ± 2 SD corresponds with approximately 95 percent of the area of the curve. Finally, by inspection of the normal curve, ± 3 SD corresponds with approximately 99 percent of the area of the normal curve (Table 4.8).

Table 4.8. The normal curve rules of thumb

Standard deviation	Probability
± 1 SD	$\approx 68\%$
± 2 SD	$\approx 95\%$
± 3 SD	$\approx 99\%$

4.19 THE “50 PERCENT RULE”

The “68-95-99” rule of thumb is used to approximate project schedule probability by using this in conjunction with the “50 percent rule” for the mean. The mean falls in the center of the normal curve. It is therefore at the 50 percent point of the area of the curve being one-half of the area of the curve when starting from zero. Using this property of the normal curve,

a point of +1 SD from the beginning of the normal curve is found to correspond with a probability of approximately 84 percent. This is because from zero to the mean or midpoint of the curve is 50 percent of the area, and from the mean to +1 SD equates to 34 percent of the area of the normal curve. Therefore, 50 percent plus 34 percent is 84 percent of the area of the curve. Likewise, a point corresponding to -1 SD is equivalent to 50 percent (the distance from 0 to the mean) minus 1 SD—or minus 34 percent of the area of the normal curve. As a result, 50 percent minus 34 percent corresponds with a probability of approximately 16 percent. Using these properties of the normal curve, and extrapolating between points on the normal curve, the schedule probability may be estimated for any number of project standard deviations calculated in PERT analysis (Figure 4.27).

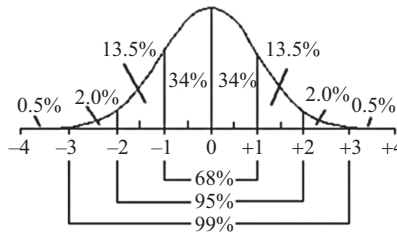


Figure 4.27. Rules of thumb illustrated.

4.20 CONVERTING SCHEDULE TIME UNITS TO STANDARD DEVIATIONS

Returning to the PERT call center schedule scenario, observe that the PERT process progressed through the following steps:

1. Identify project activities (activities required to produce the deliverables in the work breakdown structure).
2. Identify the logical sequence of activities (activity predecessors and successors).
3. Determine the PERT weighted average estimates of each activity by:
 - a. Obtaining an estimate for the BC, ML, and WC duration for each activity.
 - b. Calculating the weighted average for each estimate using the Beta Distribution (carried out in practice by the formula):

$$\frac{BC + 4 * ML + WC}{6}$$

4. Create a network diagram using the logical sequence of activities and PERT durations.
5. Determine the critical path using the forward and backward pass algorithm.

The only difference observed between CPM and PERT analysis is Step 3, the duration calculation. Other than this difference, PERT is approached in exactly the same way as CPM.

4.21 THE SIGNIFICANCE OF THE PROJECT MEAN

Once Step 5 in the PERT analysis process is complete, the estimated schedule duration is known. This is as a result of the summing of the three-point duration estimates of the critical path activities. It is of interest to note that the duration of the PERT estimated schedule corresponds with a 50 percent probability. This is because the duration is a mean resulting from the summation of the weighted averages (i.e., means) of the critical path activity durations. The mean resides at the midpoint of the normal curve, and as observed in the analysis of the normal curve rules of thumb, corresponds to a 50 percent area under the curve—or probability. Project managers would be prudent to highlight this fact when using a team of stakeholders to derive project estimates (Figure 4.28).

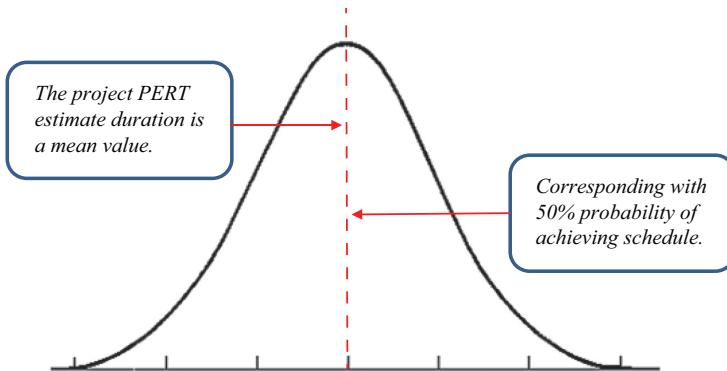


Figure 4.28. Project mean significance.

The result of the best guesses of the project duration has only a 50-50 chance of being realized. A project with only a 50 percent chance of successfully meeting its duration estimate is no better than the flip of a coin

and is generally too risky to undertake for most projects. Further, it is clear that the duration should not be reduced. A proposed schedule reduction would guarantee a project date achievement probability of less than 50 percent. This is because a proposed schedule reduction results in a duration that is less than the project mean. Moving from the project mean toward the origin of the normal curve moves the schedule probability from 50 percent to a value that quickly approaches zero. The project manager is in a good position therefore to suggest that the probability of schedule completion be increased. How would the probability be increased? It could be increased by adding additional time to the schedule. Doing so increases the project schedule probability from 50 percent to a value that quickly approaches 100 percent. Adding time to a schedule is best done systematically—with a typical target probability of achievement in mind. A typical target achievement probability used in project management is 95 percent. When the project manager seeks to achieve a specific schedule duration probability, this requires that the project manager and team be able to associate project units of time with normal curve standard deviations. Then, a target duration such as 95 percent is accomplished by adding time to the project consistent with the right standard deviation multiplier.

4.22 DETERMINING THE PROJECT STANDARD DEVIATION

The first step in finding the project standard deviation is taken by finding the variance of each activity on the critical path. Although this may appear to be a rather daunting prospect, the variance of each critical path activity is determined by using a very simple formula:

$$\left(\frac{WC - BC}{6} \right)^2$$

The variances of each critical path activity are then added together:

$$\sum \left(\frac{WC - BC}{6} \right)^2$$

Then, the square root is taken of the sum of the variances:

$$\sqrt{\sum \left(\frac{WC - BC}{6} \right)^2}$$

Notice that only the variances for the critical path activities are calculated. The critical path determines the overall project duration—so the

variances of additional activities are not required. This is why the critical path is identified prior to the variance and standard deviation calculation work is performed. By focusing on the only path that counts—the critical path—unnecessary work is avoided.

4.23 VARIANCE CALCULATIONS

The variance calculations for the call center scenario are given in Table 4.9. It is evident that the simple “square root of the sum of the variances” formula lends itself to spreadsheet formulas (Table 4.9).

The project SD is 2.82, and, referring again to the duration of the call center project, the project mean, or PERT estimated time is 47.7 units of time (Table 4.10).

Given the understanding of the rules of thumb for calculating probability from the normal curve, the following immediate observations arise from the project standard deviation calculation:

Observation 1: The project has a 50-50 chance of completion by 47.7 units of time.

Observation 2: The project has an approximately 68 percent chance of being completed between 50.52 and 44.88 units of time. (± 1 SD, or, as determined by the project PERT calculations, ± 2.82 days).

Observation 3: The project has a 95 percent chance of being completed between 53.35 and 42.05 units of time. (± 2 SD, or, as determined by the project PERT calculations, $2 * (\pm 2.82)$ units of time).

4.24 PRACTICAL USE OF PERT ANALYSIS

Although this is interesting information produced by PERT analysis, what is more useful is to understand the impact of reducing the schedule from the PERT estimate and to know the project duration associated with a 95 percent probability target date. Often after working with stakeholders to obtain PERT estimates and arriving at the mean, or “50 percent probability schedule,” the first request from senior stakeholders is to reduce the project by a certain number of days or time units. The project manager can address such a request by:

1. Converting the units of time into “number of project standard deviations;” and
2. Subtracting the resulting probability from 50 percent—since 50 percent is the starting point for PERT schedule probability.

Table 4.9. Variance calculations

Identifier	Task description	Predecessor	BC	ML	WC	Var
1	Desktop PC evaluation	-	7	10	14	1.36
2	Call center bandwidth estimation	-	3	5	10	
3	Upgrade plan	1	4	7	10	1.00
4	Procure computer memory	3	2	3	7	
5	Procure wireless access equipment	2,3	3	4	8	
6	Procure system software	3	2	3	7	
7	Install wireless access equipment	5	7	10	14	
8	Install PC memory and wireless cards	4,5	7	10	14	1.36
9	Install OS and Applications	6,8	3	7	10	1.36
10	Develop training materials and user guide	6	10	15	21	
11	Training	7,9,10	4	7	14	2.78
12	Launch new system	11	1	1	3	0.11
Sum						7.97
SD						2.82



Table 4.10. PERT duration estimate

Identifier	Task description	Predecessor	Duration
1	Desktop PC evaluation	-	10.2
2	Call center bandwidth estimation	-	5.5
3	Upgrade plan	1	7.0
4	Procure computer memory	3	3.5
5	Procure wireless access equipment	2,3	4.5
6	Procure system software	3	3.5
7	Install wireless access equipment	5	10.2
8	Install PC memory and wireless cards	4,5	10.2
9	Install OS and Applications	6,8	6.8
10	Develop training materials and user guide	6	15.2
11	Training	7,9,10	7.7
12	Launch new system	11	1.3
Total		47.7	

Using the call center schedule example, assume that stakeholders have requested that the project team commit to finishing the schedule five days—or five units of time—early. Five units is a round number and typical of a schedule reduction request. Since the project SD was determined to be 2.82 units, reducing the schedule by five units of time is equivalent to reducing the schedule by:

$$\frac{5}{2.82} = 1.77 SD$$

This is almost 2 SD. Referring back to the 68-95-99 rules of thumb for the normal curve, it is observed that -1 SD is approximately equal to 16 percent probability, and -2 SD is associated with an approximately 2.5 percent probability. Using the rules of thumb does not lead to exact probabilities—but in the context of schedule negotiation—the point is clearly made in this context that reducing the schedule by five days leads to a schedule that has only a very limited probability of successfully achieving the reduced schedule (in this case, between 2.5 and 16 percent by observation of the normal curve rules of thumb).

4.24.1 WHAT IS AN ACCEPTABLE DURATION?

Once stakeholders are informed of the reduced schedule probability, the question arises, “What project duration would we be certain to achieve?” While no project duration may be guaranteed with complete certainty—a 95 percent probability is considered desirable for planning purposes. The challenge for the project manager is to point out to stakeholders what project duration would lead to a 95 percent probability. This may be done by finding the number of standard deviations on a Z Table that corresponds with a 95 percent probability. From inspection of the Z table, a Z value of 1.65 leads is associated with an approximate 95 percent probability (Figure 4.29).

	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09

Figure 4.29. Z table with 95 percent probability.

This is determined by cross-referencing Row 1.6 with Column .05 and noting the intersection of .4505. By inspection, this appears to be only 45 percent. However, recall that this percentage represents the area between the mean and 1.65 SD above the mean. When the area between

0 and the mean is included, .5 is added to .4505 thereby resulting in 95.05 percent. The 1.65 number is a good one for project managers to remember given the desirability of a 95 percent schedule probability. However, the 95 percent target can also be approximated from the normal curve rules of thumb. Recalling that +1 SD equates to an 84 percent (50 percent +34 percent) probability, and the +2 SD point equates to a probability of 97.5 percent (50 percent + 47.5 percent), it is clear that the SD multiple for a 95 percent schedule is somewhere between +1 and +2 SDs.

It should be noted that not all Z tables provides the probability figure in the same way. Some for example provide Z values assuming “0” as the starting point rather than the mean. This type of Z table is a useful shortcut. In this type of table format, one would be able to read .9505 directly at 1.65 SD instead of .4505. Project managers would benefit from being familiar with both Z table formats—but when in doubt—remember the 68-95-99 rule.

4.25 AN ADDITIONAL NUMBER TO REMEMBER

The 1.65 value is therefore another rule of thumb to remember, and it is multiplied by the duration of time associated with the project SD, and then added to the project duration estimate. For the call center project scenario, the 95 percent probability duration is found to be:

$$47.7 + (1.65 * 2.82) = 52.35$$

The general formula for the 95 percent probability calculation is therefore:

$$\text{Project PERT Duration} + (1.65 * \text{Project SD})$$

4.26 RECALLING THE PERT ANALYSIS SEQUENCE

There are many steps involved in developing the project PERT estimates. But, remembering and applying the steps to determine the project estimated duration as well as the probability of achieving given schedules is a powerful technique for both schedule estimating as well as managing the expectations of project stakeholders.

The PERT sequence previously described is repeated in a concise series of steps.

1. Find durations for all high-level project tasks using estimates from key stakeholders.
2. Find the weighted average (“Beta Distribution”) duration for each activity using the following formula:

$$\text{Activity Weighted Average Estimate} = \frac{\text{Best Case} + (4 * \text{Most Likely}) + \text{Worst Case}}{6}$$

3. Create the network diagram using the PERT activity estimates.
4. Find the project critical path and determine the overall estimated PERT duration.
5. Find the variance for all tasks on the project critical path using the following formula:

$$\left(\frac{WC - BC}{6} \right)^2$$

6. Find project standard deviation using the following formula:

$$\sqrt{\sum \left(\frac{WC - BC}{6} \right)^2}$$

7. The project duration is sum of the durations on the critical path—and the probability of achieving this is 50 percent.
8. Find the 95 percent probability duration. This probability is found at the project duration associated with 1.65 standard deviations.
9. Find other project duration probabilities using the normal curve “rules of thumb” (68–95–99 percent) rule, or by consulting a Z table to cross reference Z values and probability values.

Finally—this series of steps may be easily carried out by setting up a spreadsheet with formulas to carry out statistical operations such as finding the weighted average of activity durations as well as the project standard deviation. Once the formulas are input into a spreadsheet, it can be reused in future projects as a project probability calculation tool. In this way, the project team can focus on the data and the result rather than the associated statistics.

4.27 PERT VERSUS MONTE CARLO ANALYSIS

The term “Monte Carlo” may evoke images of a roulette wheel—and this is not far off from the meaning of Monte Carlo analysis. Unlike PERT

analysis, Monte Carlo analysis does not compute weighted averages of each critical path activity, and compute the PERT expected time and standard deviation. Instead, Monte Carlo analysis uses computerized “brute force” methods to simulate thousands of project schedule trial runs in order to develop a statistical profile of the expected project duration. For example, in Monte Carlo analysis, the project manager may assign a three-point duration estimate for every activity in the project schedule. When Monte Carlo analysis is run, the software carrying out the simulation will use, at random, one of the three-point estimates for each activity in the project for each trial run. Over thousands of iterations—and thousands of random selections of three-point estimates—the Monte Carlo software builds up a statistical distribution of duration outcomes. Monte Carlo analysis has become more popular with the advent of power applications that may be added on to popular project management software tools.

4.27.1 IS MONTE CARLO BETTER?

The project manager may well ask, “Does Monte Carlo analysis produce different results than PERT analysis?” The answer is, like many things in project management, “maybe.” Since Monte Carlo incorporates all project paths in its analysis—rather than just the critical path as is the case in PERT analysis—results may differ when the critical path is considered “sensitive.” Recall that the critical path is said to be sensitive when other paths in the project are very close to the critical path in duration. When this is the case, the random selection of three-point estimate values may produce many project durations that exhibit a critical path that is different from the original plan. PERT analysis would not necessarily capture these dynamics since PERT focuses only on the critical path. Finally, it should be considered that both PERT and CPM have their place in project management. Whether to use PERT or Monte Carlo analysis could well depend upon what the project team is attempting to achieve. PERT works well in negotiating high-level project schedules within a schedule workshop environment. This is in part due to its simplicity and its focus on the project critical path. Monte Carlo analysis might be preferred for large complex projects where using manual PERT calculations would neither be realistic nor feasible. Also, Monte Carlo analysis would be useful when the project team and project stakeholders are able to understand and interpret the statistical distributions that Monte Carlo analysis produces.

4.27.2 HOW LONG DOES THE PROJECT “REALLY” TAKE?

Both CPM and PERT implicitly assume that the resources required to get the work of the project completed will be available. When determining the logical order of events and the critical path, resources are therefore not taken into consideration. However, in practice, resources, which may involve people, equipment, and even funding have practical limits. For example, project activities include work that requires unique skill sets. The rarer the skill set, the more challenging it is to schedule. Project teams often find that multiple activities that need to occur at the same time must be performed by the same resource. What happens then to the project schedule when resources are found to be lacking? In most cases, this will result in the schedule being delayed beyond the original plan. It is essential then for project managers to analyze resources are considered so that the final schedule is executable and is realistic in duration.

4.28 THE SCHEDULE DURATION AND RESOURCE LIMITATIONS

In the same way as CPM and PERT analysis, factoring in the impact of resources into the schedule is carried out using a series of steps. As a first step, the task list table with duration and predecessors is expanded to include the resources that are to be used for carrying out each activity. This is presented in Table 4.11 using the call center scenario developed for the PERT analysis.

Step 1: Activity and resource table with assigned resources.

Step 2: Determine possible resource overlaps.

When resources are constrained—as is usually the case in project management—the overlap in resource assignment may be observed by plotting the resource needed at every given unit of time using the logical sequence of activities presented in the project network diagram. By comparing the activities and assigned resources from Table 4.11 with the PERT network diagram repeated in Figure 4.30, the resources are plotted over units of project time in the correct units (Figure 4.31).

From inspection of the resources versus project units of time chart, it is observed that resource bottlenecks exist in purchasing as well as in the desktop technician resource.

Step 3: Resolve the resource overlaps using workaround strategies.

Project managers may employ different strategies for resolving resource bottlenecks depending upon the priorities of the project and the overall

Table 4.11. Activities with resources assigned

Identifier	Task description	Predecessor	Duration	Resource
1	Desktop PC evaluation	-	10.2	Desktop Tech
2	Call center bandwidth estimation	-	5.5	System Engineer
3	Upgrade plan	1	7.0	System Engineer
4	Procure computer memory	3	3.5	Purchasing Rep
5	Procure wireless access equipment	2,3	4.5	Purchasing Rep
6	Procure system software	3	3.5	Purchasing Rep
7	Install wireless access equipment	5	10.2	Desktop Tech
8	Install PC memory and wireless cards	4,5	10.2	Desktop Tech
9	Install OS and Applications	6,8	6.8	Desktop Tech
10	Develop training materials and user guide	6	15.2	Trainer
11	Training	7,9,10	7.7	Trainer
12	Launch new system	11	1.3	System Engineer
Total			47.7	



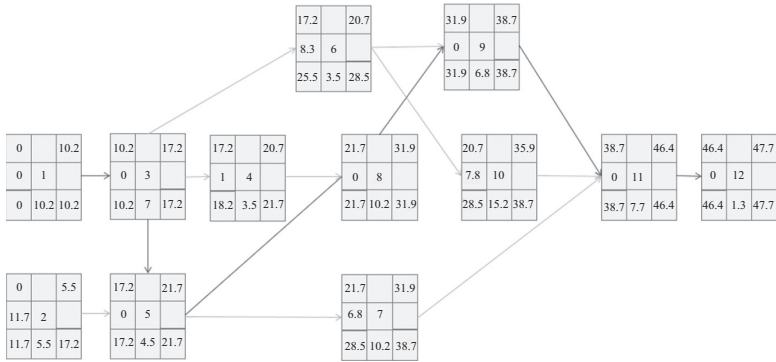


Figure 4.30. PERT network diagram.

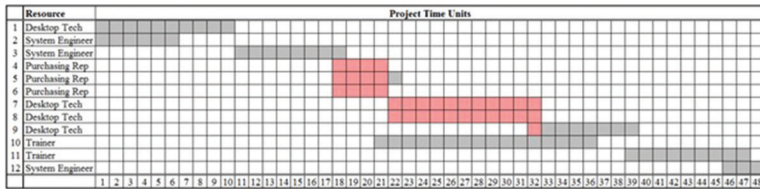


Figure 4.31. Resources plotted per unit of time.

strategy of the company. For example, if the goal of the project manager is to achieve the schedule and to avoid delays to the greatest extent possible, then the possible options for the project manager include:

1. Increasing the available project resources.
2. More fully utilize existing resources.
3. “Fast Track” by carrying out activities in parallel that are designed to be completed in sequence.
4. Scope reduction: Negotiate the reduction of scope for project deliverables.

Each of these options along with their relative merits and associated risks are outlined as follows:

4.28.1 INCREASING RESOURCES

Increasing resources requires bringing in new people and often additional equipment to the project. This requires possible training as well as

additional management oversight. Further, complex projects benefit from team members who are intimately aware of the context of the project—and resources joining the project late in the schedule tend to lack such awareness. Because of this, it is natural to expect a lag time between the addition of a new resource and the resource's ability to make a positive contribution to the project schedule. Last minute newcomers need time to understand how the project deliverables fit together. In practice—adding significant numbers of resources late in the project may not improve the schedule. This raises the question of initial resource numbers. If additional resources are found to be needed—why then aren't they included at the beginning of the schedule? The typical answer is that resources are not usually included because the initial project did not allow for it. The only reason that they should be considered late in the game is due to the attempt to maintain the commitment to the project schedule given few desirable alternatives.

4.28.2 UTILIZING RESOURCES

In lieu of adding resources, project managers seeking to stay on schedule when faced with constrained resources may push the team to take on longer hours and extended work schedules. When resources are utilized beyond the standard schedule, project managers may expect diminishing returns. Occasional overtime and weekend work may be assigned in exceptional circumstances—but overscheduling resources may lead to mistakes, additional rework, and poor team morale. As a practical matter in highly complex projects, increasing work hours is commonplace. There is risk of morale and potential quality problems—but this must be balanced against other limited alternatives that exhibit equal if not more risk.

4.28.3 FAST-TRACKING

Fast-tracking activities are possible means for working around the need to additional resources—or additional utilization of existing resources. It is however a less than ideal solution. Fast-tracking assumes that activities that were originally scheduled in sequence be instead executed in parallel—or at the least—a somewhat overlapping sequence. The problem is that activities originally scheduled in sequence were arranged that way for a reason. As an example, consider the development of a user manual for a software application. Such a manual would typically be developed after the application development was finished. Conceivably the manual could

be “fast-tracked” and started prior to the completion of the development of the application. Additionally, software testing might be started prior to the completion of the development. This strategy might work—and if it does—the schedule will be expedited. On the other hand, fast-tracking could lead to rework of both the software and the manual should. This is likely to occur if the application under development changes unexpectedly. Also, problems revealed in testing could also lead to changes required in both the software as well as the user manual. As in nearly all attempts at reducing the project schedule by working around resource constraints, the possibility exists that the project could experience further delays instead of being reduced (Figure 4.32).

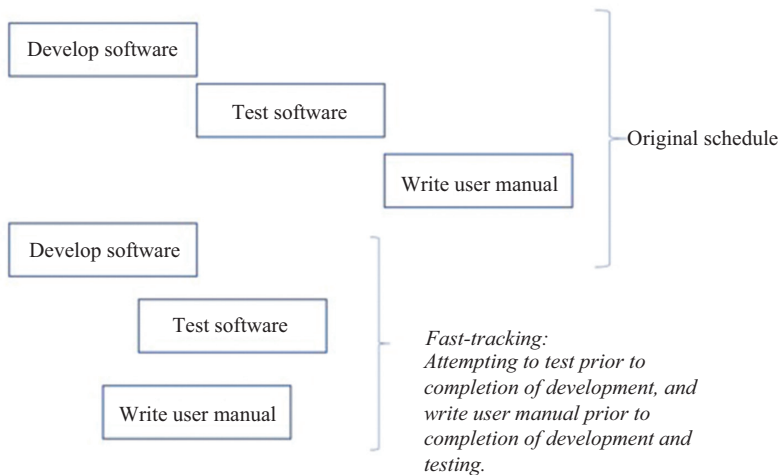


Figure 4.32. Fast-tracking illustration.

4.28.4 SCOPE REDUCTION

One possible response to resource constraints is to seek to reduce the overall number of deliverables—or the level of performance of some of the scheduled deliverables. This is only possible if the client agrees to it and typically involves significant negotiations. Further, if the project is producing a product for sale in the market—a reduction of features could lead to problems with product acceptance. In the case of the software development fast-tracking example, the development of the application could be terminated early by removing key features. This would result in a lower development, testing, and documentation burden. The combined effect of

reducing the project scope in this example would be to reduce the overall project duration regardless of the constrained resources. The danger is that the client fails to agree to scope reduction—or that sales in the marketplace collapse due to feature reductions. Regardless of the observed drawbacks—scope reduction is often done in the market—particularly when software is involved. It is not uncommon for example to purchase a software application only to receive repeated feature updates long after the initial launch.

4.28.5 SCHEDULE DELAY

It is evident that each of the possible strategies for working around resource constraints correspond with significant management risks. Further, even if the risks are managed—it is entirely possible that the project may be delayed—even with significant management efforts. Also, the delay comes at the expense of additional resources and possible goodwill in the marketplace, stakeholders, and finally, the client. Because of this, the project manager will have no choice at times but to eliminate resource overlaps by means of delaying the overall schedule. This final undesirable alternative may be carried out in a systematic manner. In fact, the schedule delay option is planned and efficiently executed as a series of tasks that could be considered a subproject. The project manager will employ guidelines or rules of thumb to minimize schedule delays while rearranging activities in such a way as to eliminate the resource bottlenecks.

Step 4: Resolving resource overlaps by delaying activities.

Referring again to Figure 4.32, Activities 4–6 as well as 7–9 are highlighted in red due to resource conflicts with the purchasing representative (4–6), and the desktop technician (7–9) resource. Since these resources are scheduled to carry out multiple activities at once, and additional resources or alternative solutions are not available, a resolution of the conflict requires that one or more activities be moved. The question for the project manager is, “Which one(s)?” Fortunately, common sense can be applied to this problem. Recall that the project critical path determines the overall duration of the project. All activities on the critical path have zero slack since they cannot be delayed without delaying the overall project. The first rule therefore for resolving resource conflict is to move activities that are not on the critical path by applying available resources first to those activities that *are* on the critical path. This rule may be generalized as:

Apply available resources first to those activities with the least available slack.

Beginning with Activities 4–6 and referring again to Figure 4.32, it is observed that, of the three activities, only Activity 5 is on the critical path. Therefore, this is the activity that should be first in line for resource assignments. If this activity is resourced, then the two parallel activities requiring the same resource must be moved out. As can be seen in the revised resource plot, the movement of these activities creates a ripple effect in which other resources come into conflict. In this case, Activities 7, 8, and 9 as well as the desktop technician resource remain in conflict. Further, the purchasing representative resource associated with Activities 4 and 6 continue to be in conflict (Figure 4.33).

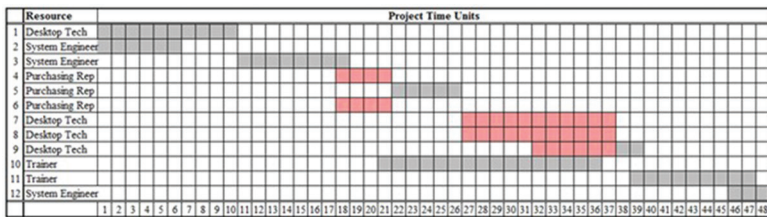


Figure 4.33. The ripple effect of resource conflict resolution.

The call center resourcing example illustrates how incomplete a project schedule is without consideration of resources. A single movement of an activity to address a resource conflict reveals several other underlying conflicts. This is not always immediately obvious since, during the first step in resolving resource conflict, only the initial conflict is the point of focus. To fully appreciate the impact, the network diagram is revised to include the new starts for each activity (Figure 4.34).

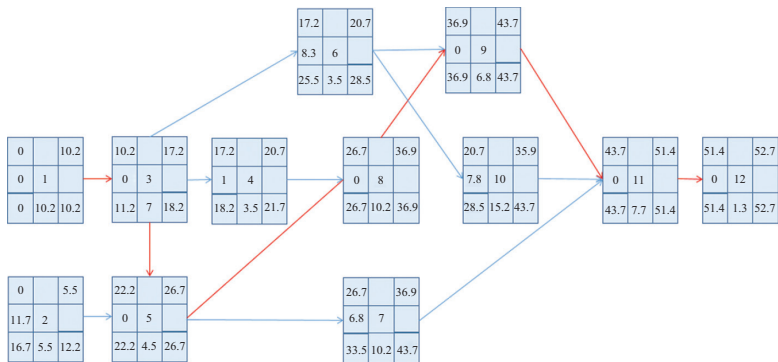


Figure 4.34. The revised critical path.

4.29 THE CRITICAL CHAIN

The problem of resource conflict and the resulting “ripple effect” as initial resource conflicts are resolved reveals resources to be a bottleneck within the process of project schedule development. The term “bottleneck” suggests the applicability of the Theory of Constraints in project management schedule development. The theory of constraints, in general terms, observes that the system can never proceed faster than the speed of its slowest element. Said in another way, systems are governed by their constraints—and in project management—resources are often the most impactful constraint. Applying the theory of constraints requires that bottlenecks first be identified, and then exploited or widened to increase the overall capacity of the bottleneck—thereby increasing the capacity of the overall system. In the case of constrained resources in project scheduling, it has already been determined that additional resources are not available. Because of this, the bottleneck is resolved by pushing out activities so that the resource is not overloaded. As observed, this in turn creates new bottlenecks. This is expected in theory of constraints system optimization. Opening-up one bottleneck—for example—increasing the capacity of a workstation in a factory assembly line—creates new bottlenecks. The manager then proceeds to resolve these one by one until the overall system is performing in an optimal way. Likewise, in a project schedule, resolving one resource bottleneck inevitably leads to another. This situation should come as no surprise to the project manager. As one resource conflict (or bottleneck) is resolved, the project manager and team should step through remaining conflicts one by one until a schedule is produced that balances available resources with project activities.

4.30 FURTHER CONFLICTS AND ADDITIONAL DELAYS

At this stage of the resource conflict resolution process, the critical path remains the same—however, the schedule is delayed to 52.7 units of time. However, since conflicts continue to exist in the purchasing representative resource, Activities 4 and 6 must be resourced. Once again, the project manager must decide which activity to apply resources to first. Neither Activities 4 nor 6 is on the project critical path. However, Activity 4 has much less room to maneuver (i.e., slack), and as well, is a predecessor to Activity 8 which is located on the project critical path. The best approach to resourcing these activities therefore is to move Activity 4 to the end

of Activity 5, followed by moving Activity 6 to the end of Activity 4 (Figure 4.35).

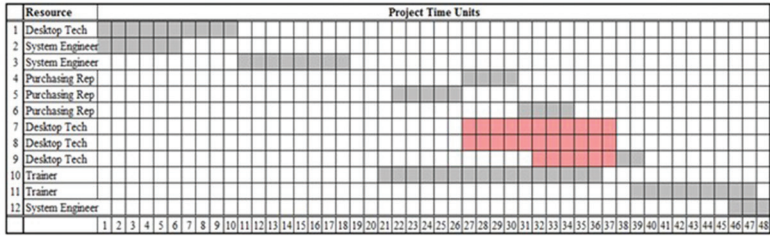


Figure 4.35. Schedule delay due to resource conflict resolution.

Although the conflict in the purchasing representative resource is now resolved, the desktop technician resource continues to be in conflict across Activities 7, 8, and 9. Further, Activities 7, 8, and 9 have not been adjusted so that the activity predecessors are maintained. This is an additional complexity for which project managers must be aware. When activities begin to move, predecessor and successor relationships must be maintained. Activities 4 and 5 are predecessors for Activities 7 and 8, and Activity 8 is a predecessor for Activity 9. Prior to resolving the desktop technician conflict, the activities are adjusted to reflect their predecessor activities. Further, Activities 10, 11, and 12 are also moved to reflect their respective predecessor relationships (Figure 4.36).

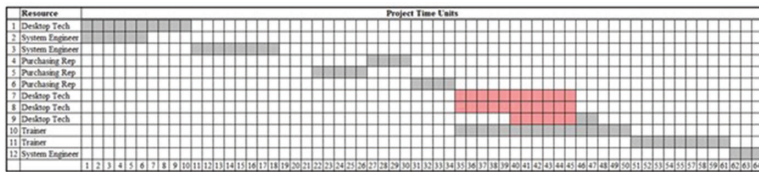


Figure 4.36. Adjusting schedule to maintain predecessor relationships.

Although the predecessor relationships are now reflected in the resources over units of project time diagram, the desktop technician resources remain in conflict. It is observed by reference to the network diagram that Activity 8 is on the critical path (Figure 4.37).

Activity 9 is a successor to Activity 8 and is also on the critical path. Activity 7 is not only the critical path, but it is, along with Activity 9, a predecessor to Activity 11. Since both must be completed, and Activity 9 is shorter in duration as well as being on the critical path, Activity 9 is

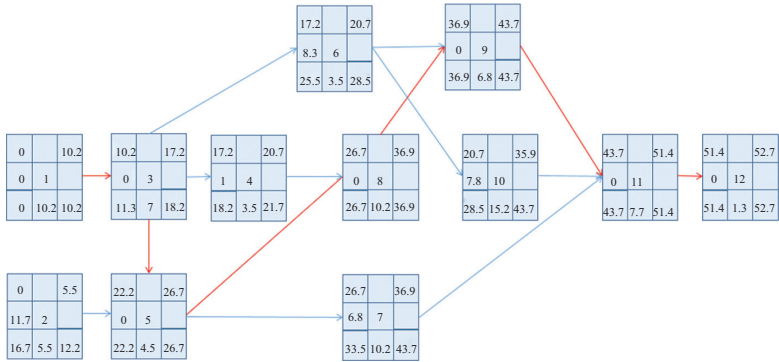


Figure 4.37. Critical path revised due to resource conflict resolution.

moved so that it begins once Activity 8 is completed. Activity 7 is likewise moved to begin after Activity 9 thereby resolving the conflict. The resources over units of time chart are updated to reflect the correct predecessor relationships for Activities 11 and 12 (Figure 4.38).

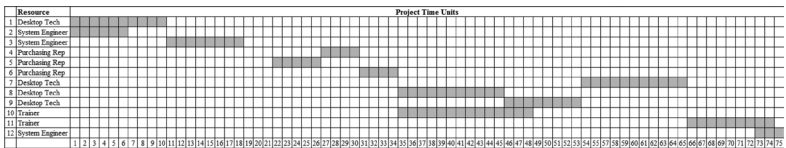


Figure 4.38. Revised resources over units of time chart.

4.31 IMPACT OF CONFLICT RESOLUTION

No resource conflicts now exist in the project schedule. However, the project has increased in duration from about 48 to 75 time units. This dramatic increase in the overall schedule duration is a testament to the impact of resource constraints on a project. This is also why the theory of constraints view on project management—known as “Critical Chain Project Management” (or CCPM) suggests that resources be considered at the earliest stage of or project schedule development—rather than after the creation of the network diagram. There is merit in this view in that it has the potential to foresee resource bottlenecks prior to the apparent collapse of an otherwise desirable schedule duration. On the other hand, since the resources applied to a project schedule are assigned based upon the activities that are required to produce the project deliverables, it is

unclear how resources could be assigned to the project schedule prior to identifying and sequencing the project activities. CCPM therefore remains an important principle to consider when assigning resources to a project schedule, but its full application to project management remains to be further operationalized.

4.32 SCHEDULE OPTIMIZATION

The project manager would naturally seek to optimize and compress the resulting schedule where possible without violating resource constraints or predecessor relationships. One such opportunity appears in the activities associated with the purchasing representative resource. When Activities 4 and 6 were moved beyond Activity 5 to preserve the critical path, a gap of three time units was created in the schedule. Although Activities 4 and 6 cannot be carried out until Activity 5 is completed, Activity 5 may be started immediately following Activity 3. The schedule is adjusted to eliminate the time gap—resulting in a 71-day schedule (Figure 4.39).

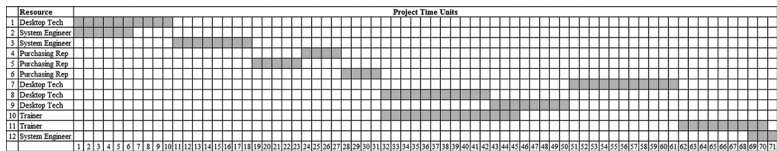


Figure 4.39. Schedule optimized to remove gaps due to conflict resolution.

Although this series of measures does improve the schedule—it does not improve it significantly. Because of this, it is at this point that the project team will likely face significant scrutiny from the project sponsor and the client alike to further optimize the schedule. What other options are possible? Although schedule reduction techniques such as adding resources, fast-tracking, and scope reduction have been evaluated—and presumably discarded at this point—often schedule negotiations will return to the application of a combination of these techniques. Sponsors and clients also have a way of forcing the issue, and pressing for schedule reduction by increasing the funding for and addition of resources to critical project activities. This schedule optimization discussion is referred to as “project crashing.” The term “crashing” is an appropriate one since adding resources to activities—especially late in the project—can be a complicated and messy prospect. Although project crashing seeks to

reduce the schedule by applying additional funding for resources, funding is never unlimited. For this reason, project managers proceed to apply funding and resources to the least expensive activities that, by the increase of resources, will result in the reduction of the overall schedule duration. Also, even though additional resources add cost to the project, the reduction of the project schedule has the potential to reduce some costs—for example, equipment rental and facility occupancy. As the project team applies resources to least expensive to most expensive activities and the schedule duration is observed to improve, the team eventually arrives at a project “crash point” which is the optimal mix of additional resource funding per unit of schedule duration reduction. This point is the recommended additional investment that is presented to project stakeholders. Recall however that adding resources and using advanced management techniques such as fast-tracking increase project risk. The “improved” schedule should therefore be considered a proposed solution for schedule reduction. The benefits of the additional costs and resources may or may not be forthcoming in the actual project execution.

4.33 SCHEDULE PRECEDENCE IMPACT

The rearrangement of the activities due to resource constraints has implications for the remaining activities as well as the overall schedule. This is illustrated by revising the network diagram to include the activities that have been moved. The new start and finish times are indicated, and the revised critical path is calculated using the forward and backward pass (Figure 4.40).

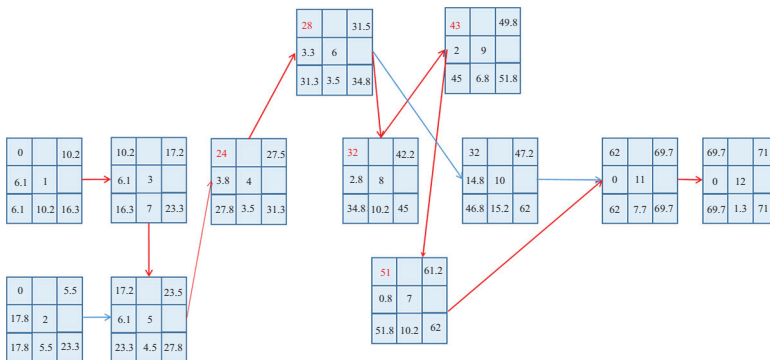


Figure 4.40. Revise network diagram with resource conflicts removed.

It is of interest to note the important results:

1. The project critical path has changed.
2. The critical path is no longer the path with “zero slack.” Rather, it is the path with the least overall slack in each activity. This is because the start of Activities 4, 6, 7, 8, and 9 are fixed as highlighted in red due to the resource constraints.

4.33.1 WHAT JUST HAPPENED?

The original project schedule as created using CPM and PERT changed significantly both in duration as well as logical sequence once resources were added to the schedule. This illustrates that a schedule is not a true schedule until resources are applied. It is therefore important that project managers avoid committing to a project schedule until resources are applied and the conflicts are resolved. The good news is that most project management software tools will detect and correct resource conflicts automatically or with no more than a few clicks. Software tools use the same principles as the manual steps by seeking to minimize delays where possible by assigning resources to activities with the least slack first. However, schedule days are inevitable when resources are constrained. As soon as project manager software is directed to resolve resource conflicts—the schedule will move out depending upon the severity of the resource constraints.

4.34 COST: WHAT FUNDING WILL BE REQUIRED TO COMPLETE THE PROJECT?

Although projects are estimated early in the schedule development process, costs are not known with certainty until resources are applied to the project activities. One way of thinking of the cost of a project is to visualize costs as being attached to the resources. When resources are added to the project, the costs of the resources follow. This can be visualized by imagining walking through a freshly painted hallway and occasionally brushing against the wall or touching the wall along the way. Every time the wall is touched or brushed against, by way of analogy, the more that wet paint gets absorbed by the person walking down the hall. Also, the more extensive the duration of the contact with the wet paint—the more that the individual is increasingly covered with paint. Costs in project

management follow a similar pattern. Every time a project “touches” or utilizes a resource—be it a team member or a piece of equipment—the more that cost is absorbed by the project. Also, the greater the length of time that a resource is employed in a project, the higher the resulting cost that is absorbed. This leads in turn to a higher resulting budget. The utilization of resources over the length of the project corresponds to the flow of cash associated with the cost of the assigned resources as they are used.

4.35 CATEGORIZING COSTS

4.35.1 *DIRECT AND VARIABLE COSTS*

The costs that are of primary importance to the project manager are the direct cost of the project that varies with the level of the resource used—or “direct and variable” costs. For example, assigning an individual to the project brings direct cost to the project budget. This cost is also variable because it increases according to the use of the resource and by the number of resources added. For example, when two individuals are assigned instead of one, the cost is doubled (assuming that the rate for both individuals is the same). Variable costs also increase according to the length of the project. Direct and variable costs are directly under the control and management of the project manager. Direct and variable costs may also be incurred by the project when the project employs capital equipment in the project. Recall that a resource may be people—but it also may involve equipment, funding, or anything used for the purpose of completing project deliverables.

4.35.2 *PROJECT ABSORPTION OF CAPITAL COSTS*

Determining the cost associated with using capital equipment is slightly more complicated than calculating the cost of employed human resources. If the capital equipment is rented or leased by the project team during the period of the project, then the project is assigned the rental or lease expense of the equipment. Cash flows associated with rental or lease payments are then included in the overall project budget. If on the other hand the capital equipment is owned by the company, then the project is typically charged a cost associated with the amount of use during the project. This charge is calculated by taking the portion of the equipment monthly depreciation cost for the period of time that the equipment is used in the project. To illustrate this point, assume that the project uses test equipment for 10 days during a month of project work. Assume further that the company

originally paid \$10,000 for the capital purchase, and that the company uses three-year straight-line depreciation. Depreciation is the charge that a company takes against its income statement to recognize the expense of the capital equipment, and to build a fund for its eventual replacement. A three-year straight-line depreciation would charge \$3,333.33 per year, or \$277.78 per month when assessed monthly. Assuming that the project used the equipment for 10 working days (roughly 2 weeks out of a 4-week month), then the expense incurred by the project by using the capital equipment for 10 days would be \$138.89. This figure equates to $\frac{1}{2}$ of one month's depreciation charge for use of the capital equipment.

4.35.3 DIRECT FIXED COSTS

A fixed cost by definition does not change. One common category of fixed cost that is absorbed directly by the project is known as NRE or “Non-Recurring Engineering.” NRE fees are often paid to companies who design custom hardware, software, or intellectual property components for a project. After the project produces its deliverables, and ongoing licensing or royalty fee may be incurred by the company—but the project fixed costs is linked only to the one-time charge. Any one-time expense paid by the project would be categorized as fixed cost.

4.35.4 INDIRECT COSTS

Indirect cost includes costs such as the facility in which the project is carried out as well as the expenses associated with the facility. Indirect cost may also include an allocation of the management overhead of the company. Some companies automatically allocate a portion of indirect costs to resources. Such “fully absorbed” costing will automatically push indirect costs into the overall project budget as resources are added. In other accounting systems, the indirect costs are managed separately. In either case, the longer that it takes to complete the project, the greater the amount of indirect costs will be absorbed by the project (Table 4.12).

Table 4.12. Cost categories

	Fixed	Variable
Direct	NRE Consultant fee License fee	Human Resources Capital Equipment
Indirect		Facilities Management Overhead

4.35.5 HOW DOES THE SCHEDULE BECOME A BUDGET?

Upon resolving all resource conflicts in the project, what results is a sequence of activities that are linked to the resources assigned to perform each activity. Given that the project absorbs the cost of each resource used, the cost of resources for each period of project time can be captured using the resource versus project units of time chart that was created for allocating resources and analyzing resource conflict. The combined costs from the use of all resources for any given project unit of time are summed, and then the cumulative cost is captured. The budget creation process begins with assigning the cost of the resources used in the project (Table 4.13).

Table 4.13. Costs associated with project resources

Resource	Salary	O/H	Total
Desktop tech	\$50	\$15	\$65
System engineer	\$75	\$20	\$95
Purchasing rep	\$65	\$20	\$85
Trainer	\$85	\$20	\$105

The costs are then accrued for each unit of time that they are utilized. Then, the accrued unit of time costs for all resources used during each period is combined to produce a cumulative total. The call center project is broken into blocks of 10 units of time for the sake of simplicity and to enable an at a glance view of the relationship between resource assignments, resource costs per unit of time, and finally, cumulative costs (Figures 4.41 to 4.47).

	Resource	Project time units									
1	Desktop tech										
2	System engineer										
3	System engineer										
4	Purchasing rep										
5	Purchasing rep										
6	Purchasing rep										
7	Desktop tech										
8	Desktop tech										
9	Desktop tech										
10	Trainer										
11	Trainer										
12	System engineer										
		1	2	3	4	5	6	7	8	9	10
	Total	\$160	\$160	\$160	\$160	\$160	\$160	\$65	\$65	\$65	\$65
	Cumulative	\$160	\$320	\$480	\$640	\$800	\$960	\$1,025	\$1,090	\$1,155	\$1,220

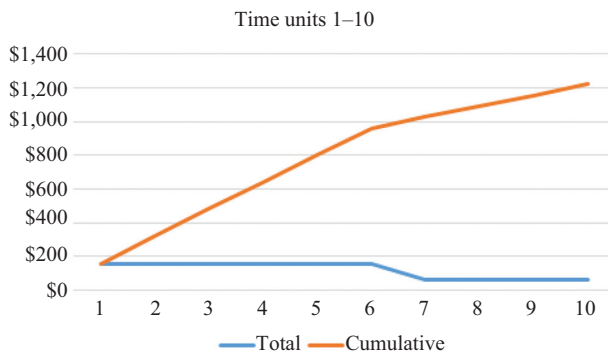


Figure 4.41. Time units 1–10.

Resource		Project time units									
1	Desktop tech										
2	System engineer										
3	System engineer										
4	Purchasing rep										
5	Purchasing rep										
6	Purchasing rep										
7	Desktop tech										
8	Desktop tech										
9	Desktop tech										
10	Trainer										
11	Trainer										
12	System engineer										
		11	12	13	14	15	16	17	18	19	20
	Total	\$95	\$95	\$95	\$95	\$95	\$95	\$95	\$95	\$85	\$85
	Cumulative	\$1,315	\$1,410	\$1,505	\$1,600	\$1,695	\$1,790	\$1,885	\$1,980	\$2,065	\$2,150

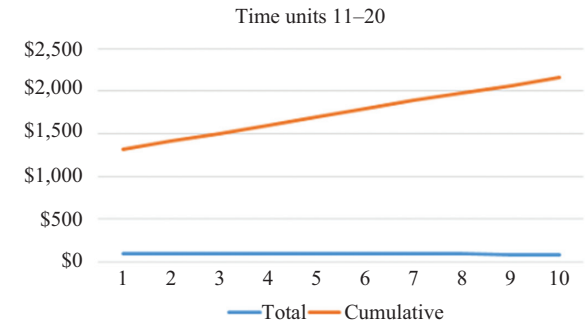


Figure 4.42. Time units 11–20.

	Resource	Project time units									
1	Desktop tech										
2	System engineer										
3	System engineer										
4	Purchasing rep										
5	Purchasing rep										
6	Purchasing rep										
7	Desktop tech										
8	Desktop tech										
9	Desktop tech										
10	Trainer										
11	Trainer										
12	System engineer										
		21	22	23	24	25	26	27	28	29	30
	Total	\$85	\$85	\$85	\$85	\$85	\$85	\$85	\$85	\$85	\$85
	Cumulative	\$2,235	\$2,320	\$2,405	\$2,490	\$2,575	\$2,660	\$2,745	\$2,830	\$2,915	\$3,000

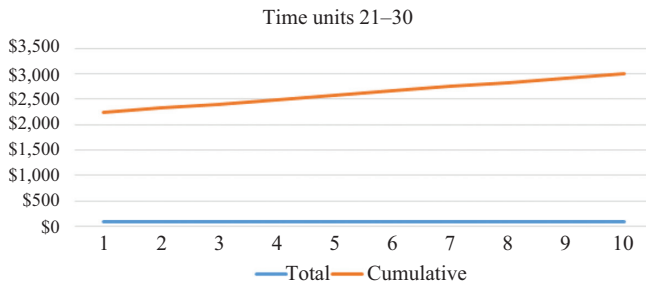


Figure 4.43. Time units 21–30.

	Resource	Project time units									
1	Desktop tech										
2	System engineer										
3	System engineer										
4	Purchasing rep										
5	Purchasing rep										
6	Purchasing rep										
7	Desktop tech										
8	Desktop tech										
9	Desktop tech										
10	Trainer										
11	Trainer										
12	System engineer										
		31	32	33	34	35	36	37	38	39	40
	Total	\$85	\$170	\$65	\$65	\$65	\$65	\$65	\$65	\$65	\$65
	Cumulative	\$3,085	\$3,255	\$3,320	\$3,385	\$3,450	\$3,515	\$3,580	\$3,645	\$3,710	\$3,775

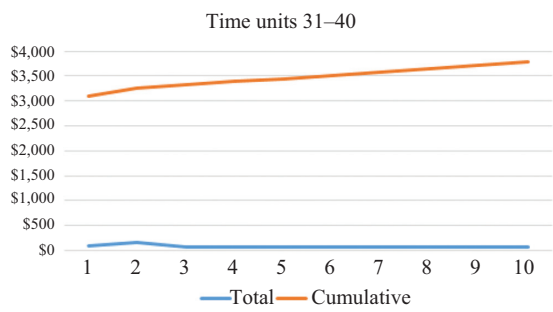


Figure 4.44. Time units 31–40.

Resource		Project time units									
1	Desktop tech										
2	System engineer										
3	System engineer										
4	Purchasing rep										
5	Purchasing rep										
6	Purchasing rep										
7	Desktop tech										
8	Desktop tech										
9	Desktop tech										
10	Trainer										
11	Trainer										
12	System engineer										
		41	42	43	44	45	46	47	48	49	50
Total		\$65	\$65	\$170	\$65	\$65	\$65	\$65	\$65	\$65	\$65
Cumulative		\$3,840	\$3,905	\$4,075	\$4,140	\$4,205	\$4,270	\$4,335	\$4,400	\$4,465	\$4,530

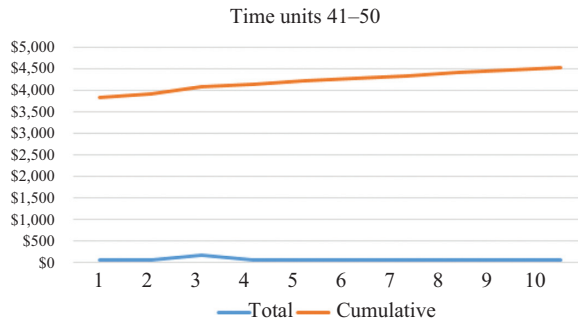


Figure 4.45. Time units 41–50.

	Resource	Project time units									
1	Desktop tech										
2	System engineer										
3	System engineer										
4	Purchasing rep										
5	Purchasing rep										
6	Purchasing rep										
7	Desktop tech										
8	Desktop tech										
9	Desktop tech										
10	Trainer										
11	Trainer										
12	System engineer										
		51	52	53	54	55	56	57	58	59	60
	Total	\$65	\$65	\$65	\$65	\$65	\$65	\$65	\$65	\$65	\$65
	Cumulative	\$4,595	\$4,660	\$4,725	\$4,790	\$4,855	\$4,920	\$4,985	\$5,050	\$5,115	\$5,180

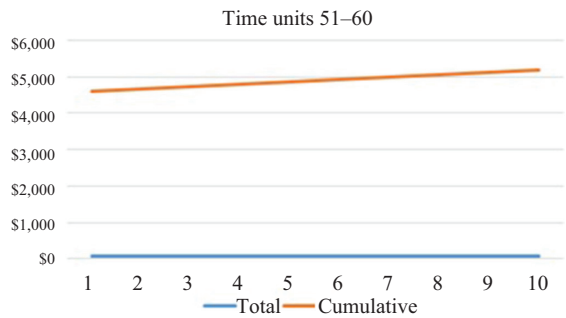


Figure 4.46. Time units 51–60.

	Resource	Project time units										
1	Desktop tech											
2	System engineer											
3	System engineer											
4	Purchasing rep											
5	Purchasing rep											
6	Purchasing rep											
7	Desktop tech											
8	Desktop tech											
9	Desktop tech											
10	Trainer											
11	Trainer											
12	System engineer											
		61	62	63	64	65	66	67	68	69	70	71
	Total	\$65	\$105	\$105	\$105	\$105	\$105	\$105	\$105	\$200	\$105	\$95
	Cumulative	\$5,245	\$5,350	\$5,455	\$5,560	\$5,665	\$5,770	\$5,875	\$5,980	\$6,180	\$6,285	\$6,380

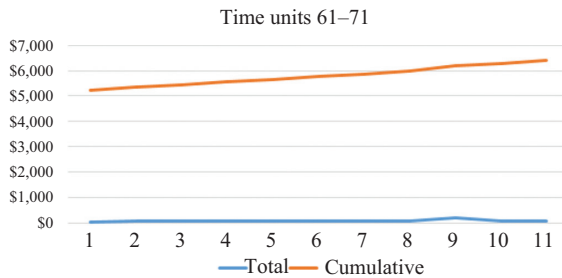


Figure 4.47. Time units 61–71.

4.36 BUDGET PLOT (“S CURVE OR PV”)

The cumulative cost of resources used throughout all time period may be plotted in order to view the spending pattern over the life of the project. This plot is often referred to as an “S” curve. This is because project costs (and resulting spending patterns) tend to start small, then increase, and finally trail off at the end—resulting in an “S” pattern. Although the project budget line is referred to as an S curve, this does not mean that all projects necessarily follow this pattern. The project budget is also referred to as the “PV” or planned value. This is because the planned value is the amount that the project intends to spend over the life of the project in the course of developing and completing project deliverables. The planned value is also a term used in the EVM (Earned Value Management) system used for monitoring and controlling project progress. In this system, the actual spending as well as the monetary value of the work completed are plotted together with the project PV curve to provide a realistic view of project progress (Figure 4.48).

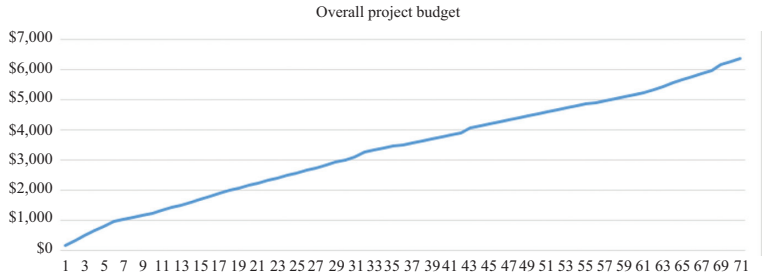


Figure 4.48. Overall project budget “S-Curve.”

4.37 FROM BUDGET TO GANTT

Many project managers are readily familiar with the Gantt chart. The Gantt chart provides a list of project activities in order and these are accompanied by activity durations and critical project milestones. Unlike the network diagram, the Gantt chart functions primarily as a communications tool. The important project dates may be observed at a glance. The “project resources over time” (Figure 4.50) chart has an appearance that is very similar to a Gantt chart. The difference is that project resources are plotted over time instead of project activities. The Gantt chart is in effect a “project activities” over time chart. The Gantt chart may be developed easily from inspection of the network diagram and while using the framework of the project resources over time table. Referring again to the final network diagram (Figure 4.49), the Gantt chart is developed using the following steps (Figure 4.49):

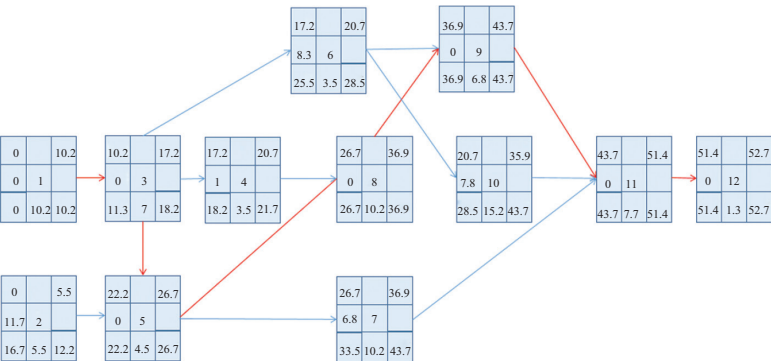


Figure 4.49. Final network diagram.

1. Refer to the table populated with dates created for the “project resources over time” chart (Figure 4.50).

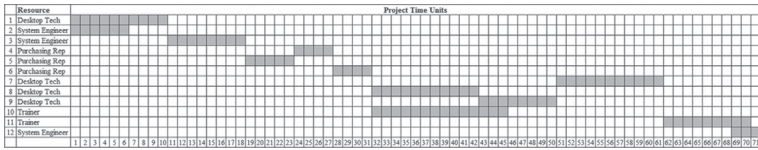


Figure 4.50. Project resources over time chart.

2. List each activity in order of appearance in the network diagram and use these activities to populate the table.
3. In the same manner as the “project resources over time” table, darken in each date that is occupied by an activity.
4. Highlight each date that corresponds to a critical path element.
5. Connect predecessor and successor activities according to the relationships observed in the network diagram.
6. Identify critical milestones with a triangular marker (Figure 4.51).

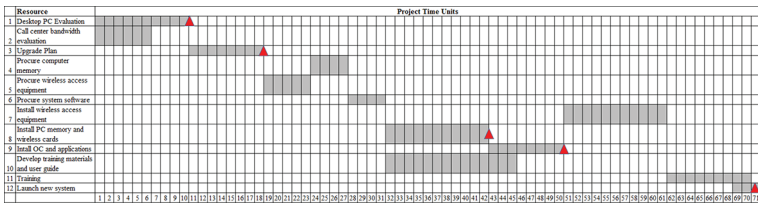


Figure 4.51. Simple Gantt chart.

With the creation of the Gantt chart project duration and milestone communication tool, the project manager now has a complete schedule that includes activities, the logical order of precedence in the form of a network diagram, PERT analysis with probability estimation, resource assignments, and project budget. The project team now has enough schedule information in place to either begin the project, or, to use the schedule that is developed to seek executive approval and funding.

4.38 CHAPTER 4: IMPORTANT “TAKEWAYS” FOR THE PROJECT MANAGER

- Activities required to produce the WBS deliverables are identified as the first step in the schedule development sequence.

- Activities are placed in order of logical sequence in order to determine the overall project duration.
- The network diagram is the analysis tool used to analyze activity sequence and determine the longest path in the project.
- The longest path of activities in a project is known as the project critical path. This is the longest sequence of activities in the project, and the shortest possible time in which the overall project can be completed.
- The critical path is located by using the forward and backward pass algorithm. The forward and backward pass algorithm identifies all activities that have no slack.
- Activities within the critical path cannot be delayed without delaying the overall project.
- A project that has a critical path that is similar in duration to other paths within the network is said to be sensitive.
- CPM is the term used for network diagram project critical path analysis.
- PERT is similar to CPM except for the fact that PERT assumes that activity durations are not known with certainty.
- PERT analysis makes probabilistic predictions of project schedule achievement by virtue of the fact that durations are estimated using weighted averages along with the project mean and project standard deviation.
- Resources are assigned to project activities to execute the work of the project.
- Project resources are limited. Because of this, resource conflicts often arise in project scheduling.
- When resource conflicts are resolved in project schedules, this often results in the delay of a project.
- Costs are associated with resources. When resources are assigned to activities, the project absorbs the cost of the resources.
- The cumulative costs of the resources applied over units of project time become the project budget.
- Project activities plotted over units of project time, along with important milestones, are observed in the Gantt chart.
- The Gantt chart is an important tool for communicating project activity durations and important milestones.

CHAPTER 5

THE SCHEDULE IS NOT A PLAN

It is not uncommon to think of a project schedule as a plan. After all, a schedule outlines what needs to be done, when the work will get done, how much the project will cost, and what resources will be assigned to the work. This sounds very much like a plan. The project schedule however focuses specifically on the “iron triangle” or, said another way, the intended trade-off between scope, cost, and schedule using the priority derived from the strategy of the company. Is the plan sufficient for the purpose of producing project deliverables? There is some appeal for the project manager in approaching the project in this manner. It avoids most of the process groups and therefore leads the project manager to focus on only a few “important” things rather than the totality of the “47 processes.” Given that the schedule would appear to fill the most pressing needs of a project manager—what then would a project manager lack if the project moved forward with only a schedule rather than a complete plan? Here are five missing pieces that a novice project manager may want to consider:

1. *Something unexpected happens!* Unfortunately, something unexpected happens in every project. If it were expected, then it would be part of the schedule. The “something unexpected” is defined as risk. A project schedule, unlike a plan, does not include the risk knowledge area along with supporting processes for identifying, assessing, and responding to those unexpected matters that pop up.
2. *The project team?* A project schedule includes resource assignments, but says nothing about from where the resources originate, how they are selected, and how they are led and managed. It pays to remember that the project manager does not execute the schedule in isolation. Projects are executed by people—typically a team of people. A project schedule does not include the holistic guidelines for team acquisition and management that a complete plan offers.

3. *Who gets informed and how?* A schedule may be communicated with a Gantt chart. A Gantt chart provides schedule activities, milestones, durations, and resource assignments. A schedule and a Gantt chart however does not provide ongoing progress reports tailored to specific stakeholders using specific information and delivered with custom media. Further, the schedule does not include forward-looking consideration for what specifically needs to be reported, when and to whom. The resource assignments in the project schedule typically are focused on project deliverables rather than communication and report generation assignments. The lack of detailed communication planning therefore will require the project manager to proceed using *ad hoc* reporting methods.
4. *What if we need to outsource?* Few companies that commission projects intend to do everything in-house. Project typically procure hardware and software components, systems and subsystems, labor, and support services. A schedule may provide some indication of outsourced resources, but no support is included for significant management issues such as vendor selection and contact negotiation. Additionally, outsourced work is often similar to in-house developed work—with the exception that communication is much more formal and intensive. Change control is an essential aspect of communication to suppliers. Finally, the level of required performance along with testing and acceptance criteria for supplier deliverables will need to be documented in a structured and legally binding manner. In short, a project will likely involve some amount of outsourcing—and this is something that is best not left to chance. In a project schedule—it is. A project plan, however, will include this supporting guidance, information, and documentation.
5. *What level of performance is sufficient?* A project schedule implicitly contains the quality level of the project deliverables within the description of what will be delivered and when. What is less clear in a project schedule is the means for deriving the requirements that drive project deliverables, the means for ensuring that the deliverables meet the specifications, and finally, the means for ensuring that the specifications for the project deliverables actually match what the client requires. What should be explicitly documented remains either implicitly stated, or not stated at all. A project schedule may therefore be carried out on time, on budget, and with the stated scope. However, whether or not the deliverables meet an acceptable level of quality, as well as how this is assessed by the client is missing.

5.1 ANSWERING THE UNANSWERED QUESTIONS

The sheer number of processes associated with the planning process group illustrates the weight given to planning before doing. A project schedule can be viewed as an incomplete plan that appears on the face of it—especially for novice project managers in a hurry—sufficient. Close inspection of what is clearly missing from a project schedule has revealed why there are 10 knowledge areas (rather than 3), and why project managers should take the trouble to complete a full project plan rather than jump into the execution of a project schedule. There is the old saying that “an ounce of prevention is worth a pound of cure.” The truth of this statement is revealed in the inspection of the project life cycle. At the very beginning of the life cycle—the uncertainty is highest, but the expense of making course corrections is lowest. The reverse is true at the end of the project. The more forethought that is put into a complete project plan to create a solid beginning, the better the chances of a successful project ending.

5.2 FINAL THOUGHTS ON THE PMBOK FRAMEWORK

The PMBOK is not the disconnected collection of boxes and processes for which it may first appear. Instead, it is a schematic depiction of the continuous flow of a project from its starting point to its finish, with each step in the planning and executing mapped out in sequence. When the number of steps or processes seems overwhelming—consider the simple example of comparing a project to a schedule. A schedule is simple, tangible, and focused. It makes perfect sense to use it as a template for carrying out work and producing deliverables...that it...until some tough questions are asked of the project manager. It is those “tough questions” that the PMBOK anticipated by presenting process support and guidelines at the right point in the sequence of events from project start to finish.

5.3 PMBOK 6 AND AGILE

In addition to changes in nomenclature of two knowledge areas and some relocation of some processes among knowledge areas, PMBOK Version 6 emphasizes Agile methods. What is the difference between Agile methods and traditional project management processes? To begin with, it is important to recognize that Agile is a methodology born out of software

development processes. In software development, requirements often change quickly. Further, when traditional project management methods are used, the end result of the software development is not obvious until the very end. For this reason, it is not uncommon to end up with a final “big bang” software integration that does not initially work and is riddled with significant defects. By way of contrast, Agile methodology focuses on completing a project in small increments that are characterized by tangible deliverables that the client can evaluate. One of the benefits of Agile is the ability to incorporate changes in requirements and to react to technical difficulties and scope changes as they arise. Further, progress measurement is considerably improved when the project produces deliverables along the road to completion. Agile represents a significant change in culture. Its very name evokes the ability to move quickly and flexibly with minimal process overhead. The inclusion of Agile methods in the PMBOK reflects the significant incorporation and popularity of this methodology. Project managers are advised to be aware of Agile nomenclature and to understand its fundamental operating principles. Finally, note that no matter what overall processes are employed, they all must be initiated, planned, executed, monitored and controlled, and closed—so the common-sense pattern of the PMBOK process groups will always be present.

5.4 CHAPTER 5: IMPORTANT “TAKEWAYS” FOR THE PROJECT MANAGER

- A project plan differs from a project schedule in many ways.
- Project schedules do not address risk, communications, resources, quality, and procurement to the same degree as an overall project plan.
- The missing elements in the project schedule are supported by the additional PMBOK knowledge areas that are employed in an overall project plan.
- PMBOK Version 6 includes support for Agile methodology.
- Agile is intended to provide the means for quickly and flexibly providing incremental project deliverables with a minimum of process overhead.

ADDITIONAL READINGS

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Project Management

A Common Sense Guide to the PMBOK, Part One—Framework and Schedule

James W. Marion

The Guide to the Project Management Body of Knowledge published by the Project Management Institute provides a roadmap of 47 processes designed to support project managers in all phases of project management. The sheer number of processes and their allocation across process groups and knowledge areas may leave project managers in a quandary about where to start and how to apply the many components of project management processes.

What is lacking is a simple explanatory guide for the layman that clarifies the "big picture" of the Project Management Body of Knowledge (PMBOK). This explains where a project manager should begin when managing projects, and how the project manager can easily make use of the PMBOK framework to progress from an initial idea to a project schedule.

Dr. James W. Marion, PMP is an assistant professor with Embry-Riddle Aeronautical University Worldwide. He is currently the discipline chair and assistant professor of project management and the program chair of the MS in engineering management program. His experience includes leading large organizations in multiple product launches in the United States, Europe, and Asia, as well as significant experience with Japanese companies including NEC and Panasonic. Dr. Marion has a PhD in organization and management with a specialization in information technology management (Capella University). He holds an MS in engineering (University of Wisconsin-Platteville), and a MSc and an MBA in strategic planning as well as a postgraduate certificate in business research methods (The Edinburgh Business School of Heriot-Watt University). Dr. Marion is a certified Project Management Professional (PMP).



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