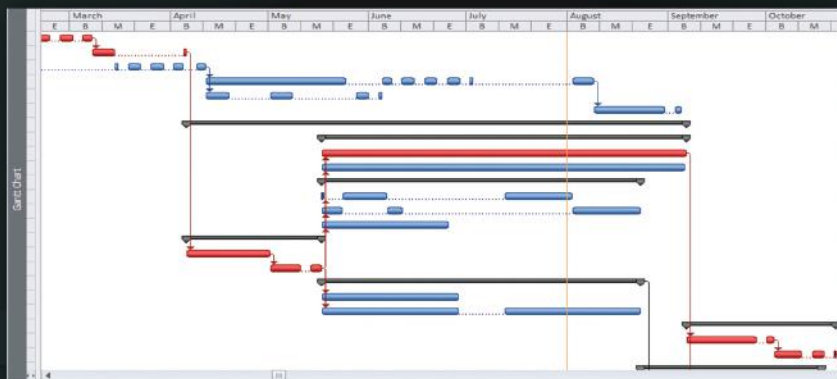


Project Management Tools and Techniques

A PRACTICAL GUIDE



Deborah Sater Carstens, PMP
Gary L. Richardson, PMP
Ronald B. Smith, PMP



CRC Press
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I dedicate this book to my family and friends. My children, Ryan and Lindsay, are the highlight of my life and have the ability to always brighten my day. My husband, Mark, would continuously listen to my ideas and support me in this endeavor. My parents, Stan and Norma Sater, have always provided me with a loving environment while teaching me the value of hard work and education. My brothers, Craig and Richard Sater, and longtime friend Jennifer Campbell Matejeck, along with their families always provide me with great assistance. I also greatly appreciate the dedicated mentoring and guidance provided from my coauthor Gary L. Richardson, as without him, this book would not have been possible.

Deborah Sater Carstens

I dedicate this book to the growing Richardson clan and hope that someday all of them will read this textbook and think that the topic is cool. Failing that goal, I am grateful for the health of this group. They have done more to support me than they will ever understand. Thanks to Shawn for her continued patience with my endless time in the man cave.

Gary L. Richardson

I dedicate this book to my family, which includes my daughter Julie Ann Wood and my son Michael Brian Smith and their families, which include their spouses and my grandchildren. They are my legacy in life. Also, I want to give special thanks to my wife, Janet L. Smith, for supporting my efforts in coauthoring this book, which included editing all my written materials and giving advice. Finally, I thank my friend and coauthor Dr. Gary L. Richardson for his coaching and continuous support.

Ronald B. Smith

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Preface

The topic of project management is truly an art seeking science involving the balancing of project objectives against restraints of time, budget, and quality. Achieving this balance requires skill, experience, and many tools and techniques, which are the focus of this textbook. There is no longer any doubt that this is a valid intellectual subject and one not well mastered in either our personal lives or the workplace. We would define this as an immature art form, but one that has now reached a critical mass. Over the past 40 years, this topic progressed from a defined life cycle to the current state where nine specific knowledge topics have been identified and described in some detail. Professional organizations such as the Project Management Institute (PMI) and others have added substance to our level of understanding. The PMI Project Management Body of Knowledge (PMBOK) documentation is continuously enhanced and this textbook is based heavily on the current definition of its core model.

It would not be fair to the reader to suggest that everything you will ever want to know about this topic is covered in this textbook. Hopefully, the topics described here will survive the test of time, and the reader will come away with a better understanding of this basic topic. Twenty more years of evolution in this area will surely expand many aspects regarding this subject. We also recognize that the supporting tools will iteratively be updated to new versions over time; however, the main concepts and value of the functionality discussed in this textbook are anticipated to remain in use to those in the field of project management. We also recognize that management of the human element is the real key to project success and not just a tool kit of techniques. Furthermore, we recognize that the techniques described here will cover much of the processes needed for planning and control of the model project.

One of the lesser understood aspects of project management is that our personal life also fits this model. That is, our lives go through phases, with various tasks required to reach the next point. We can move through this cycle either randomly or with some forethought similar to the model steps outlined here. Many humans do not manage their own life project well because the overall view is not well understood. For this basic reason,

we believe that this topic is relevant as a common body of knowledge that is relevant to all. It encompasses more than planning schedules and budgets, but certainly that is also a consideration in life as in all project environments.

Think about the universal aspect of this project model as you review each of the major segments of this textbook. Also, it is important to stay in touch with the evolving literature to see how the model is being morphed and interpreted. Certainly, future project managers must learn how to plan and execute their initiatives quicker and more effectively. A static life cycle would not accomplish that goal, but the future must be built from a solid foundation, and the current model therefore is that springboard into the next iteration. We ask that the reader try to understand the fundamental components described here as it will make them more prepared to move to that next level as it is defined.

Dr. Deborah Sater Carstens
Dr. Gary L. Richardson

Prologue

The field of project management uses a significant number of custom tools and techniques in its planning and control processes. A major goal of this textbook is to provide the reader with mechanical examples of these project decision support artifacts. The level of background theory described will be kept to a minimum, and the book will instead focus on illustrating the topic mechanics and examples. Each of the authors has extensive real-world experience in her or his respective professional areas, and the topics selected for inclusion were made based on the authors' experience-based valuation of the tool about the project management value. There is an attempt to not slant the text material toward any particular project type with the belief that maximum value is obtained in viewing a project as a management model that can be adjusted to fit any project. This suggests that there is a base philosophy that all projects have a great deal of similarity, and the tools selected here reflect that. Gary Richardson previously wrote *Project Management Theory and Practice* as the theory source for this topic, and this textbook is more focused on the mechanics.

Microsoft Project and Excel are two of the most used computer-based project management support tools in practice, so they are used extensively here in the various aspects of the text tool discussions. In addition, there is a bias that other software utilities are now entering the commercial market to aid in this very complex activity. A sample of these will also be used to illustrate selected areas where the basic tool set has functional gaps. Primary examples of these are

1. Microsoft Visio—a work breakdown structure (WBS) graphic generator add-in to MS Project
2. WBS Chart Pro—a WBS graphics generator add-in to MS Project (see www.criticaltools.com)
3. Full Monte—a project model simulation utility add-in for MS Project (www.barbecana.com/fullmonteacademicdownload)

Appendix D provides more specifics outlining how the reader can access this software. In addition to the commercial utilities outlined above,

two other author-produced computer-based support resources are utilized. Detailed access to these support items is outlined in Appendix F. These sources are

1. ProjectNMOtion (www.tech.uh.edu/projectnmotion.com)—an MS Project video tutorial support library
2. Publisher website (www.crcpress.com/product/isbn/9781466515628)—a set of support files described in the textbook that can be utilized by the reader to practice the techniques described in the textbook

ProjectNMOtion was developed by one of the authors, Gary L. Richardson, to support teaching project management, and over the past few years the site has grown into a broad overview of various project management and MS Project tutorial topics. Each major section of the website contains an introduction to that aspect of the project life cycle. Each major section contains a set of audiovisual tutorials to explain the various lower-level planning and control components related to that knowledge area. The Taylor & Francis website contains sample raw data files used to support various chapter problems referenced in the textbook. These files are designed to save the reader keystrokes and help provide further practice for the various problem types.

This collective software tool set constitutes the working utilities that will be used to produce the various textbook sample artifacts.

The examples developed in this textbook are designed to be very simple in structure and are intended to highlight the mechanics of that section. Obviously, these toy examples do not necessitate the use of computer software, but real-world problems would be much larger than these, and the modern project manager must be computer literate to perform the class of analysis outlined in this textbook.

Most of the chapters will supply sample questions and exercises to help with a review of that material. A common sample project topic is used frequently throughout for this purpose and is titled “car project.” Although this bears some resemblance to the actual car development project, its real role is to supply a common example and provide sufficient size to help illustrate the chapter area. Various project management scenarios will be used with this common plan to provide a platform to practice various techniques. These case scenarios deal with schedule, budget, status tracking, capacity management, variable time scheduling, risk, earned value, and others. In addition to the standard model mechanics, various decision-oriented worksheets are used to demonstrate how this form of checklist-type problem structuring can help evaluate certain problem domains. This latter class of tools represents decision support artifacts that can be utilized for various project-related actions.

The first five major sections of the textbook are organized around a project life cycle view and begin with an introduction to project management in terms of the role it plays in the organization and how a business case drives the process. From this starting point, the various planning and control-oriented techniques described evolve this process through the life cycle from scope development to completion. Section VI closes the discussion with a group of more contemporary topics labeled “advanced.” These are essential tools that need to be in wide use but are still evolving in practice. For this reason, this final grouping is judged to be important and certainly worthy of inclusion.

As indicated earlier, the focus of this book is more on how to perform the defined tool area rather than describing extensive theory behind the topic. The logic for this approach is couched in the belief that reasonable project management theory documentation is readily available from many other sources. However, practical mechanics for the topics shown here is generally lacking, especially when linked to a modern computer-based approach similar to those in real-world organizations. The one overriding theme followed throughout is that project management practice requires an understanding of a tested project process model. This model defines that all projects deal with scope, time, cost, tracking, scope change, risk, procurement, and human teams. Within each of these topics, there are defined planning and control processes and related decision support tools used to help manage each of these.

The resulting textbook material is reasonably easy to follow, and only minimal reader background is assumed. Once this material is mastered, the reader will have a good overview regarding the basic planning and control actions required by a project manager. We hope that the reader will find this to be the case, and we wish you success in your future project ventures.

The authors teach this material in their respective university project management programs, which are accredited by the Project Management Institute Global Accreditation Center. Because of this background, the material generally fits into that model view.

Deborah Sater Carstens

Florida Institute of Technology

Gary L. Richardson

University of Houston

Ronald B. Smith

IBM Global Services and University of Houston

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We have collectively identified all organizations and individuals whom we wish to thank for providing support toward our textbook development. We begin with special thanks to the institutions that we are affiliated with—the Florida Institute of Technology, Nathan M. Bisk College of Business, and the University of Houston College of Technology—for supporting us in our endeavor. In our journey, we have utilized various software that were provided to us by Full Monte™ Software, Barbecana, Inc. (Tony Welsh), and WBS Chart Pro. We also utilized the Microsoft Project User Group® (MPUG®) to assist us with the use of Microsoft® technologies. Our coauthor Ronald B. Smith had a number of project management templates published in *Baseline Magazine*, and they provided us with the permissions to reuse them. Throughout the book, we followed the Project Management Body of Knowledge® (PMBOK®) model by the Project Management Institute. We also acknowledge Ramanpreet Johar for her assistance with the instructor guide.

Authors



Dr. Deborah Sater Carstens, PMP, joined the Florida Institute of Technology in the fall of 2003, where she instructs both on-campus and online courses. She is an associate professor in information systems and the academic chair for the Project Management Track in the Online MBA Program. Previously, she worked for NASA's Kennedy Space Center (KSC) from 1992 to 2003. In her career both at Florida Tech and at NASA KSC, she has been the principal investigator of over a million dollars of funded research. She instructs undergraduate and graduate courses

in MIS, human-computer interaction, and project management. She has had an opportunity to work on funded research grants from the Small Business Administration, Florida Department of Education, Department of Health and Human Services, NASA, and other locally funded studies in task analysis, human error, patient safety, usability, learning effectiveness, and government accountability. She received her PhD in industrial engineering and BS in business administration from the University of Central Florida. She also holds an MBA from the Florida Institute of Technology. She has over 40 publications focusing in the areas of project management, human factors engineering, and technology.



Dr. Gary L. Richardson, PMP, currently serves as the coordinator for the University of Houston graduate-level project management program. His more than 30-year professional career has provided a broad industrial and academic background.

During the early part of his career, he worked for Texas Instruments as a manufacturing engineer, followed by consulting assignments at the

Defense Communications Agency, Department of Labor, and the U.S. Air Force in Washington, DC. The latter segment of his nonacademic career was spent with Texaco, Star Enterprise (Texaco/Aramco), and Service Corporation International in various senior IT and CIO-level positions.

Interspersed through the commercial stints were academic stints at the University of North Texas, the University of South Florida, the University of Dallas, Texas A&M University, and the University of Houston, plus serving as an adjunct professor at two other universities. Dr. Richardson has published five IT and technical management-related texts and many technical articles. Through these various experiences, he has observed the technical and human side of management from involvement in more than 100 significant-sized projects of various types and has been an active observer of the evolution in organizational practices that have occurred over this time.



Ronald B. Smith, PMP, joined IBM Global Services in the summer of 1996 as a senior project/program manager and has been certified by IBM as a certified senior project manager. His assignments have included working at American Express, Ameriprise Financial, Amtrak, Coca-Cola, EyeMasters, Exxon Mobil Oil, Florida A&M University, Ford Motor Company, Phillip Morris, State Farm, and White Wave Foods. He also teaches evening project management courses at the University of Houston for graduate students

and has had three books and more than two dozen articles published on project management and the systems development life cycle. He has an MBA in finance from Houston Baptist University and has started two Toastmaster's clubs in the Houston area.

section one

Role of the project

Learning objectives

The objective of this section is to provide an overview of the operational role of a project. Projects come in all sizes and shapes with a common role—it is a unique endeavor with realistic and clear objectives, a start and finish date, and usually a budget. This section is designed to give an introduction to this book and an overview of project management by covering the following learning objectives:

1. Describe the importance of good tools and techniques for managing and running projects. For example, using add-ins to MS Project 2010 and complementary software such as Word, Excel, and PowerPoint are included.
2. Understand that projects should have a standardized approach for defining and building systems, which is called a methodology. This includes requirements definition, workshops, brainstorming, understanding the project business case, and how to evaluate and prioritize project proposals. Even though a methodology is described as a standard approach for an organization, it should always be viewed as a living organism that needs to be reviewed and updated for improvements based on lessons learned and general experience.
3. Understand the root cause behind power and politics in an organization. For many organizations, power and politics occur due to labor resources, monetary resources, facility (space) resources, and equipment resources.
4. Understand the different kinds of organizational structures. Every organizational culture is different, but regardless of the culture, every project, in order to be successful, needs support from the organization so that the organizational structure is supportive and not restrictive to the project manager (PM).

Overview

This section consists of three chapters that focus on the importance of having good project management tools and techniques to help eliminate the negative effects of developing systems, use a methodology to increase an organization's chances of success, and understand while minimizing the root causes of power and politics.

Chapter 1 is an introduction to project management tools and techniques and how they can help projects to be successful. Having good tools and techniques is a smart start for managing and running projects effectively and helps the project team and stakeholders to be more successful. This chapter is an introduction to the topics discussed in this textbook.

Chapter 2 looks at the big picture of project management and how to get projects started by using a methodology. A good starting point for having a methodology is to look at the *PMBOK Guide* (PMI 2008). Many organizations use this model methodology as a starting point and modify it to meet their unique needs. Included in the methodology is to define the project's requirements and evaluating its business case. This chapter also addresses useful brainstorming techniques such as brown papers (as-is and to-be model), process charting, decision logic table (DLT) (displays an entire situation visually), RACI (responsible–accountable–consult–inform) charting, and how to evaluate and prioritize projects.

Chapter 3 looks at power and politics and how it plays out in different organizational structures. This all relates to the internal support environment for the project and the general maturity of the organization. An organization's culture can contribute to a project's success or failure and that is why it is important to understand the positives and negatives of different organizational structures, so the power and politics can be minimized as much as possible.

Reference

Project Management Institute (PMI). 2008. *PMBOK® Guide*, 4th ed. Newtown Square, PA: Project Management Institute.

chapter one

Role of the project

Introduction

This textbook is dedicated to the notion that project managers (PMs) use many tools and techniques. The text is organized and designed essentially around the life cycle of the project. It provides PMs with a toolkit needed to successfully carry out and lead projects. The amount of theory discussed is minimized as the primary focus is a how-to book but with a theoretical project management model as a basis. Therefore, it is a mechanics-oriented approach versus a theoretical one.

The textbook is divided into six different sections, along with a support content appendices. It begins with the *Role of the Project* in Section I. This section consists of three chapters that focus on the operational role of a project consisting of good project management tools and techniques to help eliminate the negative effects of developing systems, using a formal methodology to increase an organization's chances of success, and showing how power and politics affect the performance of a project. Section II is about *Project Formulation Using Tools and Techniques*. This section consists of two chapters that focus on the early stage of a project. Specific concepts at this stage are selecting the right projects for an organization that is in alignment with the business objectives, obtaining organizational support for the project, and the role of a formal project charter in the initiation process.

Section III is about *Developing Project Scope* consisting of three chapters. This section focuses on translating the original project goal into a work unit-oriented structure with initial time and cost estimates. Section III outlines the processes for defining project scope and techniques for estimating the defined work. Section IV builds from the content of Section II with *Tools for Developing the Project Plan* and consists of five chapters. These five chapters focus on the basic processes and mechanics required to develop a viable project plan based on the project deliverables as defined in the work breakdown structure (WBS). In this textbook, Sections III and IV represent the core mechanics that every PM should follow and generally in the sequence described. Scope definition is considered to be the prerequisite management event because it is difficult to execute a project if there is not a clear definition of its goals and work requirement. Many projects fail because this step is not done well. The main artifact to support this goal is the WBS, which is considered to

be one of the most important project artifacts. Much of the following text material uses this definition to bridge over into various other management processes.

Section V is *Project Execution* consisting of six chapters. This section focuses on the tools and techniques discussed to better equip a PM with managing project performance, cost, schedule, outcome, scope, and resources. The sixth section is *Advanced Tools and Techniques* consisting of five chapters. This section of the textbook contains a collection of material that would be categorized as both contemporary and advanced. Each of these topics represents an important aspect of the project life cycle that, if utilized, can improve the overall chance of success. In each case, the method described in these chapters focuses on a different aspect of project decision-making from early in the project selection process through the execution phase. Each of the sections is discussed further below to help the reader regarding how each tool fits into the life cycle.

Section I—Role of the project

Projects come in all sizes and shapes, but across this spectrum is a common model—each is a unique endeavor with sponsor-defined objectives, a desired start and finish date, and a set of resource constraints (humans, dollars, facilities, etc.). This section provides the reader with the operational role of a project to include a model design view and outlines the various tools that will be used in the book. Also, the following learning objectives are discussed:

1. Identify the importance of good tools and techniques for managing and running projects. For example, using add-ins to MS Project 2010 and complementary software such as Word, Excel, and PowerPoint are included.
2. Recognize that projects should have a standardized life-cycle development approach, which is called a methodology. This includes requirements definition, workshops, brainstorming, developing the project business case, and discussing how to evaluate and prioritize project proposals. Even though a methodology is described as a standard approach for an organization, it should always be viewed as a living organism that needs to be matched with each project and updated for improvements based on lessons learned and general experience.
3. Understand the root cause behind power and politics in an organization. For many organizations, power and politics occur due to internal conflicts over scarce labor resources, monetary resources, facility (space) resources, and equipment resources.

4. Understand the different forms of organizational structures. Every organizational culture is different, but regardless of the culture, every project, in order to be successful, needs support from its host organization so that the organizational structure is supportive and not restrictive to the accomplishment of the project goals.

Chapter 1, *Role of the Project*, is an introduction to the project management tools and techniques. Having good tools and techniques is an excellent supporting strategy for managing and running projects effectively and helps the project team and stakeholders to be more successful.

Chapter 2, *PM in a Nutshell*, looks at the bigger picture of project management and how to get projects started by using a process methodology. A good starting point to develop a methodology is to review the Project Management Body of Knowledge (PMBOK) from the PMI. Many organizations use this model methodology as a starting point and modify it to meet their unique needs. A key step in any management methodology involves some process to define the project's requirements and evaluate its value to the organization through a formal business case. When seeking executive approval for a new project, most organizations build a case around objectives, benefits, and value (return on investment). Rarely, though, do they evaluate the project requirements and goals against recently approved or current projects. New project requests should, in fact, have a strong relationship with projects in the queue or in progress, as well as with the organization's strategic plan. Use of a weighted project ranking matrix will highlight the interconnectedness of the company's current and potential projects and will help determine whether to red light (stop) or green light (approve) proposals. Ranking a project in terms of urgency and likelihood of success along with its financial prospects can help make the selection process more global and aligned with organizational goals. In doing so, the selection process is shifted to the value a project deliverable can bring to the company, its partners, and users, rather than just the estimated return on investment, which is often divorced from true business gains.

This chapter also addresses the role of gathering project requirements, which are the further breakdown of the client's deliverables described in more technical detail. This process cannot be done in a vacuum, and the requirements collection process heavily relies on various business and user groups. It is the responsibility of the PM to facilitate this requirements collection process and there are many techniques for doing this. One typical requirement-gathering process is a group brainstorming exercise that is facilitated by the project team. This subject matter group consists mostly of organizational stakeholders. Brainstorming should also include the recognized assumptions, constraints, and potential risks.

Tools for evaluating and prioritizing among all the potential projects for an organization is also discussed in this chapter.

Chapter 3, *Power and Politics*, looks at various organizational dynamics regarding how this plays out in different situations. Projects are natural breeding grounds for conflict that creates ineffective human behavior that must be dealt with effectively for the overall success and health of a project (Richardson 2010). Every organization, regardless of how small or large it is, has political and power situations that affect project performance. These struggles are unique to each project environment with different changing parameters of project resources, environments, goals, and deliverables (Vidal and Marle 2008). Politics can be in terms of which projects the senior management support and are committed to bringing to fruition (Maddalena 2012). Trust between the stakeholders and project team is a powerful asset as it can foster loyalty from key stakeholders and result in a positive project environment (Brewer and Strahorn 2012). It is necessary to identify and manage stakeholders to help in selling and continuing to sell the project throughout its life cycle (Little 2011). Another important aspect of the project is assembling the right team of individuals (Clark and Colling 2005; Maddalena 2012). These struggles root from resources being in short supply. In most cases, this manifests itself in terms of labor, monetary, facility (space), and equipment resources.

Six different types of organizational structures consisting of centralized structures, functional structures, projectized structure, matrix, virtual structure, and composite systems are described in this chapter. Each of these structures has distinct characteristics. There are benefits and challenges for each of these structures that must be understood to use them effectively or manage their shortcomings if the choice is dictated.

Section II—Project formulation using tools and techniques

This section outlines the tools and techniques necessary to carry out the initial project selection process. Key topics discussed involve how to pick the right project, importance of business objectives in the selection process, having common selection criteria for all initiatives, obtaining organizational support for the project, and the role of the project charter in the initiation process. The following learning objectives are the focus of this section:

1. Understand common business factors and priorities when approving a new project while working with limited IT resources.
2. Select the right projects using financial decision models, including techniques for feasibility study, payback period, net present value (NPV), depreciation, and income tax.

3. Select the right projects using nonfinancial models, including project questionnaire assessment, comparing different projects based on different criteria, and weighted criteria.
4. Understand the mechanics of the management of applications and project charters (similar to a press release that formally recognizes a new project).

Chapter 4, *Picking the Right Project*, describes a significant set of common business factors and priorities to consider when approving a new project. Most organizations have many new project requests and not enough money, time, equipment, or resources available to implement all of them, so they need a consistent selection process. Also, competing demands across the organization create complex resource allocation issues that are difficult to optimally satisfy. This requires a process for allocating resources across competing demands based on organizational priorities.

Creation of a project review board with diverse backgrounds and skills is a desirable way to help the organization in picking the right projects. Other approving entities could include the board of directors to approve a large project that implements some of the organization's more strategic goals, or an activation group that deals with the smaller initiatives (e.g., under 400 hours). If an organization wants to be successful and stay in business, there must be a consistent preassessment project evaluation process to build valid and understandable business cases for the decision process.

Chapter 5, *Gaining Support for a Project*, addresses how support for the project is gained, which includes the management approach to officially launch a new project and the purpose of a project charter. Producing a successful project takes an enormous degree of planning and skilled leadership and some would even argue that it also takes a little bit of luck (Little 2011). Organizations have different ways of approaching the official launch of a project. However, the core process should result in a formal management "contract" to explicitly approve the project and establish ground rules for its execution. The first element of this usually revolves around the details of the project (Little 2011; Anonymous 2002). This involves identification of the skills needed to carry out the project. Some of these details may be in the project proposal. However, it is necessary to expand the level of understanding related to technical work details and resources required.

Teamwork is a vital ingredient of success for the project team (Swan and Khalfan 2007). This initial step involves establishing an understanding between the project team and the project sponsor (Miller 2001). The project charter is the formal document that lays the groundwork for this relationship and represents the formal creation of the project in the

organization. PMI (2008) defines the charter as a document that formally *authorizes* a project and documents the stakeholder's needs and expectations. Also, it should clearly define lines of authority to include an accountability framework (Maddalena 2012).

Section III—Developing project scope

This section focuses on model techniques to translate the original project deliverable goal into a technical work unit-oriented structure with initial time and cost estimates. Scope definition is considered as the foundation step upon which to construct an initial time and cost estimate. The important outcome of this is to synchronize scope, time, and cost elements, meaning that all three elements satisfy the project requirement. This section has the following learning objectives:

1. Identify, analyze, refine, and document project requirements, assumptions, and constraints to produce a technical project plan that meets the scope definition.
2. Develop of a deliverables-oriented WBS created from the initial project charter, scope statement, and other project specification documents. From this technical definition, step work units are defined and will be used to facilitate detailed project planning, which is also then used in the executing, monitoring and controlling, and closing processes.
3. Estimate tools and techniques are described to show how development of project work unit specifications leads to a total project budget.
4. Introduce the relationship of scope, time, cost, and resources into the overall management equation.

Chapter 6, *Defining a Project*, addresses the next step in the launch process. The launch process involves the development of the project scope definition that yields a scope management plan. It also involves the development of the scope definition that is outlined in an updated scope management plan, scope statement, and requested changes to the project scope (PMI 2008). Before reading this chapter, it is important to have an understanding of the definitions for a scope management plan and scope statement. PMI (2008) describes a scope management plan as a description outlining how the project scope will be defined, developed, and verified. It will also describe how the WBS will be created and defined. Therefore, the scope management plan provides guidance on how the project scope will be managed and controlled by the PM and team. It is contained within or is a subsidiary of the project management plan. A project scope statement contains a description of the project scope that consists of information

such as the deliverables, assumptions, constraints, and a description of the work that is to be accomplished by the project. The scope statement for the project is documented, so it will be the basis for making future project decisions and for confirming or developing a common understanding of the project scope among the stakeholders.

The creation of the scope management plan and scope statement establishes the foundation for the WBS development, which is discussed in the next chapter.

Chapter 7, *Developing the Work Breakdown Structure*, focuses on showing how the WBS model has a broad impact on various aspects of project management. The initial view of this concept as presented in this chapter is to produce a clear technical deliverable and work definition of project scope; however, threads related to other WBS usage will appear throughout much of this textbook. Many view the WBS as one of the most valuable management artifacts produced in the project life cycle. This chapter will show that there are multiple ways to structure a project WBS, but the key is to organize it “logically” as defined by the individuals who are involved with the effort. In some cases, this structure will mirror the target physical product, or alternatively may divide the high-level box structure into logical work phases.

Regardless of its high-level structure view, the WBS creation process moves iteratively to increasingly more detailed views from this level. This creation process is called *decomposition*, or by the fancier title of *progressive elaboration*. The top levels of this structure focus more on the major deliverables or process components, whereas the lower-level units describe specific work required to achieve those deliverables.

Chapter 8, *Activity Estimating*, explores some of the typical procedural approaches for creating a project time and cost estimate, but be aware that estimating is an art form as much as a mechanical process or scientific formula. Every industry has its unique methods to produce their project estimates. It is also important to point out that the large majority of projects do not meet their original estimates, so this suggests that the typical processes utilized have shortcomings. In reality, most estimates are overrun (Verzuh 2005). Some of this is caused by a poor process to start with and some is related to subsequent poor management of the project. As project management methods have evolved and matured, estimates can be compared more closely to the actual outcome, yet significant variances still remain.

Section IV—Tools and techniques for developing the project plan

This group of chapters focuses on the basic processes and mechanics required to develop a viable project plan based on the project deliverables as defined in the WBS. Upon completion of this section, the following

learning objectives should be understood regarding why they are required as part of the core schedule and cost planning process:

1. Understand the mechanics for translating the WBS into a first cut schedule.
2. Perform the mechanics for translating the first cut schedule into a first cut budget through resource allocation.
3. Describe the management concepts for tweaking a plan's scope, time, and cost to better satisfy the organizational constraints.
4. Identify the general processes required to obtain management approval for the derived project plan.

Chapter 9, *Creating the Project Schedule*, focuses on the development of the first cut schedule to match the scope identified for the project. There is a direct relationship between the WBS boxes and the resulting project schedule. The primary scope-to-schedule linkages are the work packages (WP) and other elements outlined in the WBS. As discussed earlier, the WBS and its associated dictionary of lower-level data contain the primary support data for creating the project schedule (PMI 2008). In a properly defined WBS, the project work unit requirements will pass through into the subsequent initial schedule. In this regard, it is important to emphasize that if the work is not reflected in the WBS, "it is not considered to be in the project scope, schedule, or budget." For this model view, there will be clear tracking visibility of WBS scope boxes in the plan and identified by their WBS IDs. This schedule translation process is the main goal of this chapter.

Chapter 10, *Creating Project Cost*, introduces the resource aspect of resource management leading to a view that shows the total direct cost picture. The intent of a project WBS is to define all project work elements into which these various resource elements will be utilized. Using this approach, direct project costs can be derived using defined resource rates for the allocated resources. This process simply aggregates the resource cost for each work unit based on its internal resource allocation into individual work units. Later, as the project unfolds, planned versus actual comparisons can be made as part of the control process. Even though the goal is to evaluate status at the work unit level, it is important to recognize that some compromise to this mapping goal will be necessary. For example, expenses related to a vehicle used by the entire project team may be difficult to track to a single work unit. Other costing anomalies will also be described.

Chapter 11, *Introduction to Risk*, provides a way to reduce project outcome uncertainty through providing awareness of risks that are present, thereby minimizing future threats, seizing business opportunities, and achieving more predictable results. It also identifies the degree to which a risk may occur and the outcome it could have in terms of impacting the project's success. There are many uncertainties with everything in life,

but planning for uncertainties can prevent or reduce negative outcomes, thus bringing about the term *risk management*. Risk can be thought of as positive or negative events in the future that could occur. Risk planning begins with a series of steps designed to help approach, plan, and execute the risk management activities, which constitute the first major step in risk management. The second process step involves identification of risks through looking at a company's historical records and other techniques to identify risks that should be reviewed and managed. From this review, risks are dealt with in various ways and project contingency strategies are developed. Chapter 22 further expands the introductory view of this topic by going into more detail regarding the overall risk management model.

Chapter 12, *Creating a Viable Project Plan*, illustrates various "tweaking" strategies that the PM has to embrace in customizing the initial plan to fit various constraints or views, while keeping the bulk structure somewhat intact. One of the frequent decision scenarios that occur in the project, especially at the end of the first cut plan phase, is the need to change some aspect of the plan to fit stated constraints such as time, budget, or resource requirements. Based on these constraints, the original plan cannot be approved. Techniques to resolve such issues without destroying the integrity of the original plan are a project management art. Each technique takes some aspect of the project work units and moves them around in some manner to eliminate or minimize the constraint. This chapter will view these processes as the PM's magic tool box of tricks to tweak a plan and attempt to satisfy various scope, time, cost, and resource constraint issues. Common decision scenarios are discussed as examples of this process.

Chapter 13, *Finalizing the Project Plan*, focuses on the key processes to finalize the "tweaked" project plan and move the process into the execution stage. At this point, the plan is in synchronization with all internal components and is designed to serve as a road map for subsequent steps. A viable project plan serves as a road map for the execution process in the same way that a highway road map serves to guide a planned trip. In both cases, we realize that the resulting map may not have identified all turns along the way, but hopefully the detours encountered will be minor and we will always be close to the defined target areas and can use that base to help move back in the desired direction if an interim target is missed.

Section V—Project execution

This section of the textbook contains a collection of tools and techniques that aid the PM in successfully carrying out the project. The learning objectives for this section are listed as follows:

1. Understand the difference between metrics and measures to track project performance.

2. Describe the earned value (EV) suite of status evaluation techniques to provide the PM with sophisticated tools to examine project performance.
3. Identify different types of project status reports to be utilized by the PM to successfully track the project progress.
4. Understand techniques that influence the outcome of a project from the aspect of planning or control as it relates to scope, project, and scheduling management.
5. Implementing changes to the project while managing the project scope.
6. Demonstrate the mechanics related to resource leveling through the Microsoft Project view while learning how to resolve specific resource constraints.

Chapter 14, *Key Performance Indicators*, provides the PM with different metrics and measures used to track project performance. This chapter provides specifically the PM with an understanding of key performance indicators (KPIs) used to track project performance and the difference in KPIs, metrics, and measures. A simple example of a metric is the speed of the car, while the measure for this metric is the actual value of that metric. In this example, the metric is speed and the measure is actual miles per hour. The important management concept for this area is that *you cannot manage what you cannot measure*. Therefore, defined performance indicators provide the PM with specific indication regarding how the project is performing. KPIs are designed to drive the project to the specified metric direction.

Chapter 15, *Earned Value Management*, focuses on using the EV model to produce effective and meaningful project status analysis measures. From these parameters, cost, schedule, and project performance can be reported. EV is a contemporary project management analysis technique that has gained broad industry acceptance over the past few years. Originally introduced into the project management sphere in the late 1960s, this topic lay essentially dormant for over 40 years before the commercial world began to embrace its usage. EV has the unique ability to combine cost, time, and scope completion measurements within a single integrated methodology.

EV analysis is based on comparing actual project work unit performance to a fixed project baseline. To accurately evaluate project performance, the PM must understand not only what created past variances, but also the underlying assumptions regarding what will drive future predictions and challenges. One objective of earned value management (EVM) is to assist in the process of understanding project quantitative variances; however, strictly focusing on past performance does not yield a complete picture. The EV model defines key data elements needed to evaluate aggregate project performance, but more granularities of these

evaluation parameters are often needed for detailed root cause analysis. In addition to the historical evaluation role, derived EV status parameters can be used to create completion forecasts. A third phase of the chapter's discussion illustrates how to use work unit data for analyzing rate and work efficiency.

Chapter 16, *Status Tracking*, focuses on communications management as a guideline on how PMs intend to manage communications of project progress. Project status tracking reporting specifics should be defined at the start of any project through the development of a communications plan, which describes the information needs of the stakeholders and the project team. This overall plan should cover who needs to know, what and when they need to know it, and how they should receive it. There are different formats and technologies for reporting status of a project (i.e., Microsoft Project 2010, Excel, Visio, web systems, and others). This chapter will cover some sample project status report approaches that can be utilized for tracking progress. It is now recognized that the communication aspect of project management is one of the most common gaps in the management process.

Chapter 17, *Techniques to Influence the Project Outcome*, summarizes various management techniques that can positively affect and influence the outcome of projects. Projects that are completed often end up having fewer features and functions than originally planned to save development time and/or costs. Therefore, PMs need to be equipped with many techniques in their toolbox to help them influence the outcome of their projects in a positive manner. The examples discussed represent techniques to accomplish some specific planning or control aspect for the project and these are broken down into three major areas—scope, project execution, and schedule management. All PMs should understand each of these areas and be proficient in their application to the project plan. A PM should never work in a vacuum and always be on the lookout to accept other stakeholder's ideas (and give credit where due) that could have a positive outcome on the project.

Chapter 18, *Integrated Change Control*, focuses on managing the project scope as changes are requested or needed during the life cycle. This chapter discusses the purpose of change requests (CRs) and change boards, explanation of configuration management (CM) system and its relationship to the integrated change control (ICC) process, understanding of the ICC process, and the importance of tracking and documentation of all CRs and associated activity throughout the project life cycle. A CR is the name given to the form used to formally submit a change. The purpose of submitting a CR is to either prevent something negative from occurring or to fix something negative that has occurred. The project charter can be viewed as a control envelope within which the defined objectives must be contained. A formal change management process is required to handle this aspect

of the project and these are under the purview of a project change control board. This board is a delegated authority to make any changes that fall within that control envelope. However, if a change falls outside the envelope, the board will have to escalate the approval decision to the project sponsor (PMI 2008). CRs often result in a cost increase to the project. If the project budget can not handle the cost increase due to any scope changes, management will need to identify how to seek out additional funding for the project. If the project is under contract with a buyer and if the buyer approves of the scope changes, the added budget will then come from the buyer. If it is a multicontract project, the complexity grows as to seeking out the additional resources. An example is the added amount split between all buyers, or one or more buyers willing to pay for the change. If it is an internal project, then the funds will need to be provided by the organization.

This chapter also addresses when a scope change has been made in violation of the approved process. This violation could occur because a CR was either not submitted to the board for approval or a CR submitted was not approved, yet implemented anyway. In all situations, the state of the actual project should be documented regardless of legality (PMI 2008). Follow-up of all change implementation also needs to occur to verify that the change was sufficient.

Chapter 19, *Resource Leveling*, demonstrates mechanics related to matching available resources to the plan requirement. In some cases, overtime is used to bridge the gap between the plan and actual resource availability. This is actually a common way to stretch resources, but there are negatives related to what looks like a universal solution. In most situations, excessive overtime is not a long-term solution. There are several other techniques that can be brought to bear on this subject and these will be summarized.

The area of resource leveling represents a common gap in the planning process and one that can crater the project outcome value if not recognized. Poor capacity planning and lack of available capacity are core causes of poor project outcomes (Ashayeri and Selen 2005). Given current software tools, it is now possible to obtain more control of this situation through computer-driven analysis of available resources mapped to the plan (Porter et al. 1996). For instance, the manager of this process area needs to have immense experience in understanding that a particular resource may not be able to take on the extra work that a mechanic may have. In other words, skill limitations mean that a resource may not be able to be assigned to all tasks. Essentially everything within the project is dependent on availability of adequate quantity and quality resources (Kalyani and Sahoo 2011). There are changes in task outcomes that necessitate tasks to be completed earlier, resources not available as planned, or alternate tasks assigned (Shetach 2010). Even a clever resource scheduling tool in the wrong hands will not be able to adequately perform resource

leveling since much of this decision is based on understanding the internal workings of the project (Porter et al. 1996). A simple example of this occurs in construction where bad weather makes it impossible for some tasks to be completed as scheduled. Given proper knowledge of the project, it may be possible to move the work indoors, change the task schedule, and keep the project on schedule. The alternative to this is to keep the same schedule and let it slip until the weather clears. Good project management should try to save time using the tricks of resource management. This process is a management balancing act but the discussion should equip each reader with a process toolset to make better decisions regarding resource leveling.

Section VI—Advanced tools and techniques

This section of the textbook contains a collection of materials that would be categorized as both contemporary and advanced. Each of these topics represents an important aspect of the project life cycle that, if utilized, can improve overall chances of success. In each case, the method described in these chapters focuses on a different aspect of project decision-making from early on in the selection process to team management during execution. The learning objectives for this section are

1. Understand the use of variable time task estimates through the classical program evaluation and review technique (PERT).
2. Describe how simulation modeling can be used to model future project performance.
3. Outline the basic mechanics of the risk model and illustrate how simulation tools can help with the evaluation of the project performance.
4. Identify tools and techniques for a PM to utilize in the management of the human element of the project.
5. Understand tools and techniques that can be utilized by a project management office (PMO) to be successful.
6. Understand project, program, and portfolio management as it applies to an enterprise PMO.

Chapter 20, *Variable Time Analysis*, focuses on the classical PERT model to represent a fundamental level of understanding related to variable time scheduling. This classic network-based model uses three time estimates for task durations to represent a probabilistic task estimate. In this manner, the PERT model establishes a method for looking at project completion range times through the manipulation of a scheduling network and empirical probability functions. A major goal of this chapter is to show how viewing project time estimates as variables rather than single-valued estimates can bring improved insights to project schedule and cost planning. The first step in this culture change is to understand the logic of

multiple time estimates. Once these are translated into a median schedule, the next question that arises is how to define the overall variability of the project. The mechanics represented by this model will yield a probabilistic-type distribution of the project schedule and provide a confidence range for the outcome.

Chapter 21, *Simulation Modeling*, describes the contemporary method for variable time and cost modeling. This technique is more easily understood and rich in content than offered by the PERT model. Based on the availability of modern computing technology, the use of simulation modeling is recommended to evaluate potential project variance. For this reason, simulation is the focus of this chapter. The goal here is to describe modeling and simulation as it pertains to the project model. Specific mechanics and benefits will be shown in the examples.

Chapter 22, *Risk Mechanics*, outlines the basic mechanics of the risk model to illustrate how simulation tools can help with the evaluation aspect of the life cycle. This chapter expands the introduction to risk provided in Chapter 11 through a discussion specific to the analysis of risks, risk response planning, and monitoring and controlling risks. Risk analysis in the form of qualitative and quantitative analyses takes place after all the risks affiliated with a project have been identified. Risk management should be performed throughout the life cycle in recognition of the ever-changing business environment (Benta et al. 2011).

Once a risk event is identified, the next step is risk response planning, which is designed to develop action plans to reduce or mitigate the exposure. Lastly, risk monitoring and control tracks ongoing performance of the project with careful attention to the potential events that could lead to a risk occurring. This section discusses the core tools and techniques in risk management, which the modern PM must understand and use.

Chapter 23, *Team Tools*, discusses many aspects of management of the human element, providing tools and techniques for the PM. Different tools that help a PM and project team to be organized will maximize team performance in terms of efficiency. This chapter addresses the importance of an organizational chart as it provides all team members with an understanding of how each member fits into the overall project. It also provides internal and external team members with information regarding the different levels of authority individuals on the project team have. Different roles and responsibilities are discussed as a means for the PM and team members to specifically identify different tasks that individuals have and which team members work together on specific tasks. Tracking tools are also discussed to help a PM and the team member track how often meetings or assignments are due internally and commitments made to individuals outside the team. The tracking tools also help the PM and the team track all the team documentation that exists and revisions made to the different documents. A staff management plan also provides information

defining skill requirements needed throughout the life cycle of a project. Lastly, the area of project close-out will be discussed to identify tasks that a project team needs to complete prior to officially ending a project.

Chapter 24, *Enterprise Project Management Office (EPMO)*, focuses on the main reasons why the majority of today's PMOs have mediocre success and what can be done to improve the situation. The chapter also covers project, program, and portfolio management and how to move wisely to an enterprise PMO. The process of starting a PMO in an organization is quite complex and this would generally suggest a modest beginning step. It is best to start small, evolve, and mature at least 2–3 years before expanding to an enterprise view. An EPMO organization should report to the business side of the organization (e.g., CFO or CEO) and not to a functional department. The mature EPMO must have established standard information technology (IT) policies, processes, procedures, change control, and a scalable project methodology for developing new systems that can be easily updated for small and large projects when the times change. The standard project methodology must cover the project phases described in this textbook. Internally, all required tasks and activities within the project plan need appropriate tools and techniques to support these work activities. Moving from a more local PMO to an EPMO will be a significant culture change for the organization and it will require top management support and commitment.

Appendices section

The appendices section consists of the following six different technical support groupings:

1. The first appendix provides supplemental information for the different end-of-the-chapter student lab exercises.
2. The second appendix provides a condensed summary of MS Project 2010 commands and reference materials.
3. The third appendix consists of reference sources for different templates to assist in developing formal project management artifacts.
4. The fourth appendix contains information on various supporting add-in tools for Microsoft Project.
5. The fifth appendix provides the variable time macro for conducting PERT calculations.
6. The sixth appendix contains text support information on supplementary web-based support systems for this textbook.
 - a. The ProjectNMotion site contains custom audio–video tutorials related to MS Project processes.
 - b. The Taylor & Francis website provides additional problem supporting material described in this textbook.

Summary

This textbook contains many tools and techniques that are fundamental to managing projects. Examples illustrating how to use these tools are covered along with various supplemental materials such as templates, video tutorials, add-in Microsoft Project tools, and web links. Collectively, this collection of material provides a very respectable toolkit needed to successfully plan and manage project execution. Even though accepted project management theory underlies all of this material, the primary focus is to show the how-to aspect of managing projects.

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chapter two

Project management in a nutshell

Introduction

The computer field abounds with controversy and different points of view. As Mark Twain said (www.brainyquote.com/quotes), “A man with a new idea is considered a crank until the idea succeeds.” This section (and book) offers useful and practical tools and techniques that have been tested regarding how to execute projects more objectively and successfully. The textbook is designed for easy reading, with minimal jargon as possible. The material covered is appropriate for managing projects of all types. It is also readable for individuals who want to learn more about the internal mechanics involved in the development of new applications and for anyone who wants to learn the “insides” of developing new systems. This book has two related objectives. The first is to find realistic ways to eliminate the negative effects of developing systems using tools and techniques and to look at key ways that are needed to have successful projects that help improve organizations (Smith 1983).

The writing style here uses mostly nontechnical language, which includes a heavy usage of graphics and tables for easy reading and as much as possible adheres to the “KISS” principle. KISS is an old information-processing acronym that stands for “keep it simple stupid” and more recently has been modified or updated to mean “keep it short and simple.” It is usually referred to the building of new software applications. The following is an expanded and updated definition of the elements that make up the KISS principle (Smith 1983):

1. If you are fortunate to have a simple solution to a problem—keep it that way. Sometimes, it is human nature to take a simple solution to a problem and complicate it. Quite often, today’s complicated solutions create tomorrow’s problems.
2. If the only solution to a problem is a complicated one, then the solution should be divided into simple and workable parts that interface with each other. The complicated solution should be like putting the pieces of a puzzle together.
3. Once you have defined your solution, there will be many levels of approaches in planning, designing, and implementing that alternative. The difficult part is to choose the overall approach. In today’s highly sophisticated industrial environment, it is often best to

Table 2.1 Summary of Factor Rankings for Successful Projects

Rank	Factor	%
1	User involvement	17
2	Executive management support	15
3	Experienced project management	14
4	Clean business objectives	14
5	Minimized scope	12
6	Agile requirement process	7
7	Standard infrastructure	6
8	Formal methodology	5
9	Reliable estimates	5
10	Skilled staff	5
	Total	100

Source: Adapted from Standish Group from *InformationWeek Magazine*, December 15, 2003.

partner with other organizations that can perform special segment better than doing it all in-house. The term for this strategy is “out-sourcing” and it is increasingly employed in projects.

What are the odds of having a successful product that is delivered within the budget and schedule? Various surveys indicate that about 25% of all projects are completed on time, 50% have late completion dates and/or go over budget, and about 25% are canceled. *This means that approximately 75% of all projects undertaken will probably come in late or be canceled!* Also, the projects that are completed (on time or late) usually end up having fewer features and functions than originally specified to save development time and/or costs. Table 2.1 summarizes the top 10 reasons why projects are successful and the first five make up 72% of the total.

Methodology

Every project should follow some form of standardized approach. There are many options to look at for guidance in this. Some notable examples of project management definition are found in the *PMBOK Guide* (PMBOK) from the PMI, PRINCE2 (UK), or the more contemporary Agile methodology (prototyping or taking development shortcuts to release more quickly). Each of these approaches attempts to model a project life cycle and through this guidance helps produce a more successful outcome. The most recognized project management methodology is the *PMBOK Guide* and this approach views a project as a defined set of five management groups (PMI 2008). These groups are briefly defined as follows:

- 1. *Initiating*—Tasks and activities that conceptualize and/or authorize the project or phase.

2. *Planning*—Activities and related tasks that define and refine objectives within the project.
3. *Executing*—Activities and related tasks that coordinate resources to carry out the plan.
4. *Monitoring and controlling*—Monitoring and measuring progress regularly to identify variances within the plan, so corrective actions can be taken if needed.
5. *Closing*—Finalize all activities/tasks and above processes to close the project.

The nine organizational knowledge management areas covered in PMBOK are as follows:

1. *Project integration*—These are processes (i.e., coordination of procedures and phases) in place to develop, manage, and monitor your project, which includes change control.
2. *Scope*—These are processes (work included and excluded) in place to define the project work.
3. *Time*—These are processes (i.e., estimating and scheduling) in place to make to support schedule development and status tracking.
4. *Cost*—These are processes (i.e., costing and cost control) in place to support budget planning and status tracking.
5. *Quality*—These are processes in place to support meeting quality goals. There are three types of quality assurance (QA) project reviews: deliverable, compliance, and health. *Deliverable* is any tangible outcome or item produced to complete a project; this can range from a client's approval of a project plan to completion sign-off. *Compliance* covers areas such as meeting the requirements of a project and complying with established standards and processes. *Health* tells how well a project is doing; if it has run off the rails, the team can use the review to decide which actions to take to get the project back on track.
6. *Human resources*—These are processes (i.e., acquiring, developing, and managing) in place to make sure you have the right project team and support people (i.e., sponsors, stakeholders, and end users).
7. *Communication*—These are processes (i.e., planning and managing team, user expectations, and performance) in place to support meeting your information needs.
8. *Risk*—These are processes in place (i.e., identifying, performing qualitative analysis, and planning responses) to support preventing a potential event or future situation that may adversely affect the project.
9. *Procurement*—These are processes (i.e., planning the solicitation and obtaining) in place to support the procuring of goods and services, which includes good contract management.

A good methodology encompasses standard policies, processes, and procedures that incorporate a suite of tools and techniques to help guide the process through its life cycle in an efficient, consistent, and repeatable manner. Even though a methodology is described as a standard approach, it should be viewed as a living organism that constantly needs to be reviewed and updated for improvements based on experience (Whitten 1995).

A large part of improving a methodology is keeping a documented history of lessons learned from project outcomes. Unfortunately, most companies do not do this or they record it and just let it collect dust. Using lessons learned is a way of benchmarking and collecting best practices to help you improve your methodology by updating your policies, processes, and procedures along with your associated tools and techniques.

There are lessons to be learned from every project that you work on and you need to set up a formal process to capture the good and bad experiences for use in future projects. This process could be part of all stages as well as a postimplementation review and the lessons should be included as knowledge passed to future projects for such actions as risk management, team training, and project planning. Finally, lessons learned should be easily retrievable for obvious reasons. Tables 2.2 and 2.3 summarize some of the practical aspects of this process from the author's experiences.

Project requirements definition

One of the major issues in starting the project is getting good requirements! Project requirements are the further breakdown of the client's deliverables that are described in detail. This process cannot be done in a vacuum and the requirements collecting process is mostly the client's or shareholder's responsibility. It is the responsibility of the PM to facilitate this requirements collecting process and there are many techniques (or combination of) for doing this. The following are some of the popular techniques that are used for this collecting process.

Workshops

The PM could have designed workshops with the stakeholders and subject matter experts to gather the detailed requirements, which usually enhance user participation, expediting development and improving the quality of the specifications. These workshops have a set of detailed agenda to eliminate uncertainties between parties and help improve communication between all parties. A popular workshop process is joint application design (JAD), which is usually more effective in small, clearly defined projects and less effective in large complex projects.

Table 2.2 Part 1—Key Lessons Learned

Number	Project guidelines	Lessons learned
1	A project runs best when employee morale is high	Positive employee morale will add great value and effectiveness to your project
2	It is important that the project team and business units understand the “big picture” of the project	Involved or affected people need to know the “big picture” (goals, objectives, master schedule, system architecture, and major milestones) of your project
3	Project plan	Team members need to know that a project plan is their “friend” because it defines what their role is in building/ delivering the system
4	Work breakdown schedule	A project plan must be developed from the scope with input from the participants
5	First build a schedule-constrained plan, and then transition to a resource-constrained plan	Your project schedule needs to reflect the impact (i.e., changing scheduled durations) of staffing on each activity
6	Wherever possible, tasks for testing should be included for any task in the plan for which feasibility is questionable	If you do not have extra testing tasks for related “risky” tasks (doing something that has not been done before), you raise the probability of going over schedule or failure
7	Project buffers	Be sure that project risks are fully understood and correctly quantified. Add sufficient contingency in time and cost to cover the project risks should they turn into issues
8	Major milestones	You need to be able to present a one-page high-level overview and current status of your project to your team and the management
9	Critical path activities in a project plan should be identified	Your project team needs to know the sequence of activities, which has the least amount of flexibility (float) in your schedule
10	Maintain a current view of the plan	Always run a baseline to preserve your original approved dates to show project history of revision dates, which will reflect how the project schedule is going

continued

Table 2.2 (continued) Part 1—Key Lessons Learned

Number	Project guidelines	Lessons learned
11	Project control book	You need a project control book (could be online), so anyone can go to one place to find all the various documents that relate to your project and for historical reasons
12	Work plan discipline	Team members who are not working activities from the approved plan do not have any project discipline. Project discipline is the “glue” that holds it all together!
13	Updating project plan	Overdue tasks should elicit immediate response from the management to solve the problem. It is a choice between being proactive or reactive
14	Variance analysis	You need to have weekly project status meetings to put recovery plans in place to eliminate potential problems
15	Status dashboard	A one-page weekly project-tracking “dashboard” is a fast way to send an overall project status message to the management and the entire team

Brainstorming

A requirement gathering is a group brainstorming exercise that needs to be facilitated by the PM. The group consists mostly of the clients or shareholders. It is always smart if the PM sends surveys along with the project’s charter to key stakeholders to list their requirements or have individual interviews with the key stakeholders before the brainstorming session(s) begins to save time and have a more effective meeting. Brainstorming should also include the areas of assumptions, constraints, and potential risks. As for risk identification, the group could look at risks from past projects. The following are some techniques that could be used during the brainstorming session.

Brown paper

Brown paper is a form of flow-charting used to capture a complete process for evaluation (e.g., finding ways to streamline the system), including highlights of key activities, interfaces, documentation, data sources, strengths, and problems. Brown papers are generally used in the “as-is” and “to-be” model definition phases of a project. They can also be used to develop “should-be” and “could-be” models for evaluation.

Table 2.3 Part 2—Key Lessons Learned

Number	Project guidelines	Lessons learned
16	Sponsor involvement	If you do not have full backing of the project sponsor, the odds of project implementation success and actual system usage are dismal
17	Technology maturity	The education and rework time needed to make the change to new technology must be factored into the project plan
18	Communication is crucial	The timing, content, and distribution of your communication plan are key to building rapport within the development teams and business units
19	In a matrix organization, people have to work harder on their interrelationships	In a matrix organization, people need to work harder to build team rapport and to accomplish goals
20	Employee productivity is at its highest when employees know what to do, how to do it, and do it!	Productivity is at its best when project processes are defined and project members are educated about their roles
21	Plan resources accordingly. People cannot do regular support work and be involved in the planning and the execution of a project	You do not want to have too great of a dependency on a small number of key resources
22	Requirements definition	If you do not have the real requirements, how can you come up with a solution?
23	Actions speak louder than your words	The biggest factor that can make or break a project is the degree of discipline that the PM exercises
24	Actual data collection process	You need charge codes to keep track of your project hours and costs to “gauge” how your project is doing and for historical purposes
25	Unrealistic deadlines	If you cannot stand up to unrealistic deadlines, you need to find a new job
26	Tracking issues	Whenever possible, issues should be converted to tasks in the project plan

continued

Table 2.3 (continued) Part 2—Key Lessons Learned

Number	Project guidelines	Lessons learned
27	Do not delay bringing in expert/mentor resources to the team as soon as there are issues that cannot be resolved by the core team	If you have a need for expert/mentor resources, get them as soon as possible to save your project
28	Change control	A change control process will assure only needed changes are approved and made
29	A software development process must be examined routinely for improvement	Lessons learned from past usage should be adopted to improve your development process
30	Lessons learned	Lessons learned from past projects are essential for organizations to become and remain competitive

Materials needed:

- Brown paper (e.g., 3 feet by 5 feet)
- Post-it notes of two different colors (e.g., yellow and blue)
- Masking tape
- Ruler
- Pencils
- Master color markers
- Flipchart

It is important to gather the right people to develop a model of the process or system under evaluation. Use the yellow Post-it notes on the top half of the brown paper(s) to define the “as-is” process steps and have the users review and validate the flow. Next, look for problems or flaws in the process and brainstorm on ways that steps in the process can be reduced, eliminated, or simplified. Using the blue Post-it notes on the bottom half of the brown paper(s), develop a new and improved “to-be” process while using the strengths from the “as-is” process. Another advantage in having the users involved in this exercise is that you usually will get “buy in” and support from them on changing the process. *A feeling of ownership is important to users!*

Process chart

If you want to learn in detail what happens in a situation involving a document, request, material, or even the actions of a person, consider using a

	Operation	When something is changed or created
	Transportation	When something is moved
	Inspection	When something is verified or checked
	Delay	When something waits
	Storage	When something is kept

Figure 2.1 Process chart symbols. (Shade the appropriate symbol with a connector.)

process chart. The process chart documents the detailed steps of the flow and categorizes the type of action taken. With this information, you can analyze the process for potential improvements. To add value, you should try to reduce a complex process to its lowest common denominator to a series of simple steps to save time and reduce costs. The type of action involved in each step of using this tool is classified by one of the five standard symbols—operation, transportation, inspection, delay, or storage—as shown in Figures 2.1 and 2.2.

Decision logic table

A decision logic table (DLT) is a documentation technique that can display an entire situation visually, with all alternatives shown side by side. If you do not use a DLT, you may miss some alternatives that you never thought of which could sink your project. The following describes the characteristics of a DLT, which increases team communication, and an example of one is shown in Table 2.4:

- Displays all the elements of a problem.
- Shows all the conditions affecting the solution.
- Reveals all the relationships that exist among the defined conditions.
- Indicates which action is appropriate for each set of circumstances.
- Illustrates the IF (condition) and THEN (conclusion or action) concept.

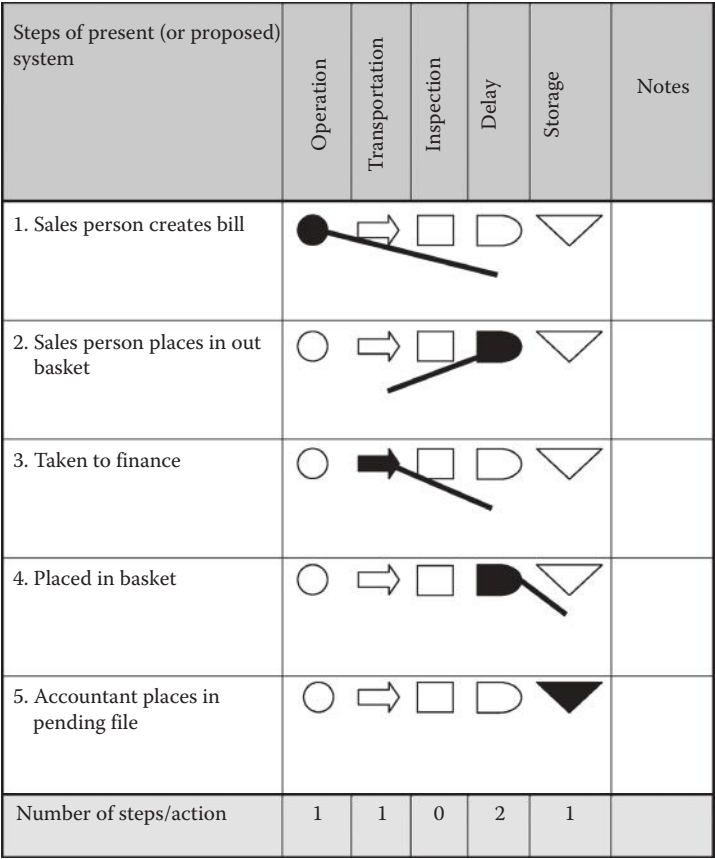


Figure 2.2 Sample situation: Minimal bill process chart.

Table 2.4 Age/Sex Decision Logic Table

	1	2	3	4
Person 65 or older?	Y	Y	N	N
Person male?	Y	N	Y	N
Tally senior males	X			
Tally senior females		X		
Tally younger males			X	
Tally younger females				X

- Comprises the following worksheet areas:
 - *Table header*—name of the individual table.
 - *Rule header*—number of combinations of answers to conditions and their resulting actions.
 - *Condition stub*—a “yes” or “no” answer test to be made as part of the solution to a problem.
 - *Condition entry*—contains the “Y” (yes), “N” (no), and “ ” (blank) answers to the questions asked in the above condition stub. Blanks assume that the condition is not being tested.
 - *Action stub*—itemizes all possible actions resulting from the conditions listed in the condition stub.
 - *Action entry*—contains the appropriate actions based on the various combinations of answers to the conditions contained in the condition stub. The “X” will indicate “take this action” and a blank will indicate “take no action.”

RACI charting

Responsible accountable consult and inform (RACI) charting is an effective means of analyzing and assigning roles and responsibilities. It correlates functional roles or individuals to their level of participation in an activity by assigning codes for responsibility, accountability, and communication interfaces. This simple technique can be used any time the span of control for a process needs to be determined or developed. It is a quick means of bringing redundancies and misunderstandings to light, so that better communication can occur.

Steps to complete a chart include:

- Selecting a business process to be analyzed.
- Listing all of the activities associated with that process in the left-hand column of the chart.
- Identifying all functional roles associated with the process and listing them in the top row on the chart.
- Establishing participation for each activity, for all roles, by assigning codes as described below:

R (responsible)—The individual working on the activity (the doer)

A (accountable)—The individual with yes/no authority; approval or veto power (Note: If two or more A's exist, this *could* be a sign of problems.)

C (consult)—The individual must be consulted prior to action; two-way communication occurs

I (inform)—The individual receives one-way communication and will use the information or take subsequent action

Table 2.5 Help Desk RACI Chart

Roles activities (PC problem resolution)	Client	Help desk	Local support staff
Calls centralized help desk in Dallas	A		
Help desk opens resolution		R	
Help desk resolves problem	C	R	
Help desk closes resolution		R	
Help desk assigns resolution to location		A	I
Location resolves problem	C		R
Location closes resolution			R

Table 2.5 is an example of a RACI chart that depicts what happens when a client with a problem in a remote location (or located in Dallas, Texas) calls the help desk.

Understanding the project business case

From many recent studies, the major reason for project failures is not the specifics of what went wrong, but rather the lack of procedures, methodology, and standards for managing the project. The PM who is asked to manage a project with no methodology, standards, procedures, and processes will have a difficult time keeping the project under control and has a high probability of being unsuccessful.

Also keep in mind that technical oriented projects have unusually high degrees of uncertainty for the following reasons:

- Technology is changing every 6–12 months—new programming languages, new interface mechanisms, hardware platforms, tools, and version compatibility issues
- Immature methodologies
- Resource turnover is high—new teams for each project
- No standard benchmarks for abilities/skill levels of resources
- Dependencies on customer for good requirements and project plan task completions
- Fast-changing business environment

Unfortunately, most projects have no linkage to corporate strategy (i.e., a set of short- and long-range goals), which remains revolutionary thinking in many corporations today. So, in ranking a new project request, you should ask: does this project have any linkage to your corporate strategy? If it does, there is a high probability that you want to execute this project. Also, if the new project request has nothing to do with your corporate strategy, there is a much lower probability that you would execute the project. Going

this way shows maturity in your project management process and adds more overall long-term value to your organization. Another advantage of linking projects to your corporate strategy is having more executive support in gaining resources and needed budget monies. In summary, projects need to have more of a business focus that is aligned to strategic business goals!

Project ranking matrix

What occurs when an organization has a number of requested new projects but you have limited time, resources, and/or money to develop the new systems? The best thing to do is to rank the different requested projects against each other in the area of importance or adding extra value to the overall organization and only work on the high-ranking projects. Keep in mind that about 40% of large-scale projects that IT organizations are working on are no longer relevant to the overall business of the organization.

Below are the characteristics of a project ranking matrix as shown in Table 2.6:

- The key column is the first column, which lists all the requested projects.
- The first column of projects is ranked in importance against the other projects starting in the second column.
- If a project in column 1 is more important than another project in a sequential column, then enter a 1. Otherwise, enter a 0.
- When done, sum up the rows, and then rank the projects by importance with the highest row sum getting the number 1 ranking and so on.

As shown in Table 2.6, an organization might only work on Project D and Project A. Project C and Project B could be permanently dropped or be reviewed again at some other time in the future. Companies need to set up a process (e.g., using portfolio management software) to help them prioritize their projects, optimize resource allocation and staffing, and track project progress and to make sure they were successful in meeting their strategic business goals.

Table 2.6 Project Ranking Matrix

	Project A	Project B	Project C	Project D	Row sum	Ranking
Project A	—	1	1	0	2	2
Project B	0	—	0	0	0	4
Project C	0	1	—	0	1	3
Project D	1	1	1	—	3	1

How to evaluate and prioritize IT project proposals

When seeking executive approval for a new project, most departments and business managers build a case around objectives, benefits, and return on investment. Rarely, though, do they evaluate the project requirements and goals against recently approved or current projects. New project requests should, in fact, have a strong relationship with projects in the queue or in progress, as well as with the organization's strategic plan. The weighted project ranking matrix shown in Table 2.7 will highlight the interconnectedness of the company's current and potential projects and will help determine whether to red light or green light proposals.

Ranking a project in terms of urgency and likelihood of success, in addition to its financial prospects, can eliminate some or all of the political motivation for the proposal. In doing so, the balance is shifted to the value a new technology can bring to the company, and its partners and users, rather than just the estimated return on investment, which is often divorced from true business gains.

When comparing the new request with funded projects in progress, you may discover that because of resource constraints, work cannot begin until another project wraps up. Likewise, you may discover you do not have the staff for a new project, which could delay its start and/or completion.

Table 2.7 focuses on six key criteria. Each is assigned a weight, which, when combined with the others, will determine a new project's request and its ranking compared with already approved projects (Projects A and Z).

Instructions: You can use Table 2.7 for ranking your currently requested projects. Add on the funded projects currently under way in your organization and complete the criteria scoring exercise. You may decide to modify the criteria and their weights to best fit your goals. The criteria scores and weighted total scores you come up with should be reusable for future projects, but expect some of the project rankings to change.

Quality management

The project's quality management (QM) objectives and processes need to be documented. QM consists of quality assurance (QA) which covers the process for improvements and quality control (QC) which describes how to plan to monitor and measure quality performance. There are three types of reviews—health, compliance, and deliverable. It is recommended to have independent reviews of a project to ensure the project is on the right course or what actions need to be implemented to get the project back on track. Besides performing an “outside check-and-balance,” QM people will ensure that the project and related documentation are being developed according to an acceptable process. Projects should have periodic mini reviews that rate its progress against certain defined metrics.

Table 2.7 Weighted Project Ranking Matrixes

Criteria	Weight% Total = 100%	Project request		Funded projects (Weighted scores)	
		Criteria rating 1 = Low 5 = High	Weighted Weight% × Rating	Project A	Project Z
1 Supports company’s strategy, mission, and goals	25	3	0.75	1.25	1.00
2 Potential to increase revenue	20	2	0.40	0.80	0.60
3 Likelihood of success	20	4	0.80	0.80	0.80
4 Readiness, in terms of skill sets, geographic and linguistic differences among 10 members, and availability of HW and SW	15	3	0.45	0.75	0.45
5 Level of urgency, for example, competitive advantage or legal requirements	10	2	0.20	0.50	0.30
6 Potential to decrease costs	10	3	0.30	0.30	0.20
Weighted total score			2.90	4.40	3.35

Source: From Ron Smith, *Baseline Magazine*, March 2008, p. 86.

Table 2.8 combines the three types of QM reviews (health–compliance–deliverable) into one mini review.

The project’s mini review received a very good healthy rating (green) and the PM has a few corrective actions to work on. The corrective actions include reviewing critical path tasks and determine what can be done to bring them back on track, and closing out the two late milestones.

Certain words found in agreements can be viewed as “dangerous” and should be viewed with caution. The bottom line is—are these words or descriptions found in agreements really achievable? If not, there could be legal problems that you want to avoid. For example, words ending in “ly” could turn up words in your agreements such as fully, completely, and satisfactorily, which could have is different interpretations in a court of law. The last thing desired is to have is improper or unrealistic expectations about deliverables. In doing a proposal review, look for the following dangerous words in agreements to avoid possible litigation.

Table 2.8 Project XYZ Mini Review

Date of review		2/22/12	
% Complete of plan		67%	
Reviewers		Julie Smith	
Seq	Metric	Rating 0 = Good 5 = Poor	Comments
1	Critical path (longest sequence of tasks and controls the finish date)	5	There are a number of “level of effort (LOE)” tasks (i.e., handle issues, attend meetings, monitor project, etc.) that are on the critical path and there is an average of 1-week delay
2	Deliverables by phase	0	The solution outline is scheduled to complete within 2 days of original completion date
3	Late milestones (zero duration that achieves a deliverable or key point in the project)	5	There are two late milestones—assist in Sketching Release Plan 2/7 and Approve Success Criteria 2/8
4	Hours in plan versus financial tool	0	The actual hours match exactly and the remaining hours are within 10 h of each other
5	Resource changes	0	Resource overallocations continues, but has minor impact on the project at this point of time
6	Workflow/reasonability	0	The project plan is logical
7	Earned value (a measure of completed/partially completed work units up to a status point)	0	The earned value is on target
8	Client processes in plan	0	The issue of completing client questionnaires on time remains open. PM is following up
9	Risk plan up-to-date and issues unresolved	0	3 of the 24 issues remain open and need to be resolved soon
10	Impact of approved changes to plan	0	2 project change requests (PCRs) are awaiting client signature and if approved, the plan (schedule and/or cost) will need to be updated
Total		10	Rating: 1–19 = Green 20–39 = Yellow 40 or higher = Red

- Always, never
- Any, all, every, none
- Best efforts or best estimate
- But not limited to
- Complete
- For example
- Includes or increases
- Insure, ensure, assure
- Lowest, greatest, earliest, latest
- Optimum, minimum, maximum
- Outputs, inputs
- Partner, partnership
- Uniquely qualified
- Work products

Sponsor and supplier agreements

This section contains sponsor and supplier agreements, which specify the mutual commitments of the involved parties during the life of this project. The agreements provide project team members with access to the baseline of each agreement and its amendments. The statement of work (SOW) that was generated from the request for proposal (RFP) document should also be included. The SOW includes information such as the work to be performed by the vendor, when work is due, how the work will be measured for acceptance, and the working relationship between the vendor and your organization. Finally, the SOW becomes a major part of the eventual contract between your organization and the vendor.

There are three basic contract types—fixed price, best estimate, and hourly services. A fixed price contract has a system solution, defined requirements, fixed schedule, and a high-risk factor because of the possibility of cost/schedule overruns. A best estimate contract has specific amount of hours, defined skills, and minimum risk. An hourly services contract or “body shop” has an undefined amount of hours, rate based on skill type, and no risk.

The structure and content of agreements can vary markedly from project to project. In particular, agreements with external sponsors and subcontractors are usually very different from those with internal organizations. When the parties are from the same enterprise, the agreement is less formal but should exist to eliminate future misunderstandings.

Outsourcing a project can be a long and winding road, studded with sweet points and painful pitfalls. At any point, organizations can make irreparable errors, including inadequate due diligence up front, cost cutting at the expense of quality, and insufficient focus on knowledge transfer and training. Table 2.9 shows 10 key questions to ask to improve an organization’s chances for outsourcing success.

Table 2.9 Ten Questions for Outsourcing Success

Number	Success questions
1	Do we have a methodology for evaluating the business case for outsourcing? Identify your strategic reasons (improving business focus, gaining access to capabilities you do not have) and tactical reasons such as reducing operating costs and making capital funds available
2	Have we identified the hidden costs? Hidden costs could include understanding the price of hardware, software, or the length of the project, losing key resources and scope creep
3	Do we have other projects or events that will hinder the outsourcing project? Overlap might include duplicating efforts with other departments, unknown dependent activities, and working on tasks out of sequence
4	Will our stakeholders and project sponsor be committed? If the stakeholders and/or sponsor are not committed, your project's progress will be hindered and your chances of success will decrease
5	What are our conditions of satisfaction (COS)? Define your COS: Ensure your expectations are met or exceeded and knowledge transfer will be completed successfully before your project starts. Make sure the outsourcer understands the expectations
6	How will we manage our relationship with the outsourcer? At the start of the project, the outsourcer must develop a communication plan that has to be approved by you. The plan should include how stakeholders will be kept informed on a consistent and timely basis
7	What are our responsibilities before the outsourcing project begins? A good outsourcer will have responsibilities—the facilities you are expected to provide, for example—outlined in the final agreement. Remember that the outsourcer's performance depends on you following through on your responsibilities
8	How do we meet our responsibilities once the outsourcing project begins? The degree of discipline your leadership exercises can determine project success. You must have discipline to meet schedule commitments, such as equipment and available people, to be successful
9	Can we free up internal resources to work on the outsourcing project? Your resource considerations should include matching skills to what is needed, staffing ramp-up/roll-off, training time and learning curve, holidays, vacations, and part-time resources
10	Have we selected an outsourcer that understands our business? You must spend the time and energy to select the best outsourcer. You will have to live with the decision during and after the project. Always get two or three bids and consult your legal representatives

Microsoft Project 2010

There is a range of widely used project planning and requirements management packages such as Microsoft Project 2010, Primavera, and IBM's Telelogic DOORS. This text will focus on MS Project to illustrate many of the techniques, but other competitors also offer similar capabilities. Also, there are many different types of add-ins for Microsoft Project 2010 and Microsoft has a large growing library of project plan templates (e.g., for engineering, construction, new business, new product, and start-up business) that could be used for developing new project plans.

Most companies that have a project management process or program using Microsoft Project 2010 as a planning and scheduling tool (MS has about a 90% market share), which is a key instrument that is referenced many times in this book. The first time you access Microsoft Project 2010, the menu ribbon will be confusing because the user interface is not very intuitive! In short, the user interface has many choices, many screens, and much functionality, which can be confusing at times (Biafore 2010). For example, there are multiple ways of adding a new task and resource.

But overall, the new features and utilities added to Microsoft Project 2010 far outweigh its nonintuitive user interface. Some of the new features include faster filtering, grouping and sorting, automatic word-wrapping of long task names, easier formatting, leveling overallocations, playing what-if games, and viewing scheduling issues to be fixed. The following are some time-saving features that you should consider setting up or using within the first tab—File:

- At least 90% of the time you open Microsoft Project 2010, you want to open the last file worked on. You can automate the opening of your last file by choosing Options—Advanced and in the General section, check the box for “Open last file on startup.”
- The default for tasks is “Manually Scheduled” when most of the time you want it to be “Auto Scheduled.” You can change this default by choosing Options—Schedule and select “Auto Scheduled” from the pull-down menu under Scheduling Options.
- Most of the time you probably save your project updates every 10 or 15 min but sometimes you get interrupted and forget to do this. You can protect yourself by choosing Option—Save and check the box for “Auto Save Every” by any time you want. 45 minutes would be a safe choice.
- Why start a project from scratch when Microsoft on-line has a large library of useful project plan templates you can use as a starting point? This is truly one of the great treasures found within Microsoft Project 2010 and currently has more than 70 different

Table 2.10 MS Project Add-Ins

Name	Comments
WBS Chart Pro	Download a demo version from www.criticaltools.com Uses a tree-style diagram known as WBS to plan/display projects
PERT Chart EXPERT	Download a demo version from www.criticaltools.com Uses PERT charts (also known as network charts or precedence diagrams) to show project tasks and their dependencies
@Risk	Download a demo version from www.palisade.com Uses Monte Carlo simulation to show possible outcomes of projects and how likely they are likely to occur
RISKPLUS	Check out for enterprise-wide approach at www.riskplus.com Enables the identification and capture of risks and opportunities at all levels of an organization

types of project templates (Biafore 2010). Some of these online plans include Project Management Institute Process, Engineering Project Plan, New Product Plan, and Proposal Development Plan. To select your online project template, choose New and under Office.com Templates choose Plans and proposals and then Business plans to see the growing library of useful templates.

- To save valuable printing time and paper, which is important, you should get very familiar with Print—Page Setup tabs and the various options you can choose. For example, in the Page tab you might want adjust the scaling to less than 100%, get familiar with the Margins, Header, Footer, and View tab options. Finally, you might want to select None under the Legend tab to not print page legends at the bottom.
- For very useful add-ins (Options—Add-Ins), besides Microsoft Visio and Excel see Table 2.10, which shows products with descriptions that you can use with Microsoft Project 2010 that can save you time and add value to your overall project.

Challenging

The PM position can be very challenging because every project has its unique personality. For example, if companies Path X and Path Y were developing an identical system using the same tools and had similar organizations, there would be differences in how they developed, implemented, and used the new system. Also, it is possible that company Path X completed the project on time and within budget, whereas company Path Y went over schedule and eventually canceled the project. In summary,

good project management can make a difference and that is really the heart-and-soul goal of this book!

QUESTIONS

Review questions

1. What should be done with lessons learned when you have postproject reviews?
2. Why would you rank new project requests?
3. What are the benefits of having QA reviews?

In-class question

1. What would you do to collect project requirements?

EXERCISE

1. List the names of all the available templates found within Microsoft Project 2010.

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chapter three

Power and politics

Root cause of power and politics

Projects are natural breeding grounds for conflict resulting in ineffective human behavior, which must be dealt with effectively for the overall success and health of a project (Richardson 2010). Every organization, regardless of being small or large, has politics due to power struggles. Every project will also have unique power struggles due to changing parameters of the project resources, environment, or goals and deliverables (Vidal and Marle 2008). Politics can be in terms of which projects the senior management support and are committed to bringing to fruition (Maddalena 2012). Trust between the stakeholders and project team is a powerful asset as it can foster loyalty from key stakeholders and result in a positive project environment (Brewer and Strahorn 2012). It is necessary to identify and manage stakeholders to help in selling and continuing to sell the project throughout the life of the project (Little 2011). Another important aspect of the project is assembling the right team of individuals (Clark and Colling 2005; Maddalena 2012). These struggles root from resources being in limited supply.

What types of resources are limited? For many organizations, it comes down to labor resources, monetary resources, facility (space) resources, and equipment resources. If you are a manager and your boss asks you to spare two labor resources as in two employees for 1 year to work on a special project, who is going to be chosen? Will the two star performers or two low performers be chosen? If you choose your two star performers, your boss may be very grateful as it will allow the special project to more likely succeed. However, if your office is without the star performers, will your office dynamics change so much that you are left with a dysfunctional group of employees that will leave you having to pick up the slack contributing to even more work hours a week. If you choose your two low performers, is your boss going to be back in your office a month from now saying that those workers are not suitable for the special project requiring you to still let go of your star performers?

These are the types of decision-making going on inside the head of every lead, manager, and executive in the work environment. So, did you make a decision regarding which employees to send to the special project? Maybe you decide to compromise and send just one star performer and one average performer so that your boss will be successful while your

office is not too terribly interrupted. Now, as a manager, it is also your responsibility to help with the career development of your employees. So, if this special project has high visibility for the employees that are sent, then maybe both star performers are deserving of that opportunity making the decision that much more complicated.

Now, let us divert from labor resources for a moment and discuss monetary resources. There is not an organization out there with unlimited money to spend on the organization. So, executives spend time planning which efforts or projects their company should be investing in that will grow the company's profits. This too is a political game as there may be limited resources, yet unlimited power struggles occurring within an organization at any given time. Different channels of communication go up and down the organization as employees may ask their leads for monetary resources for different reasons such as the need for upgraded equipment. In return, the leads then ask managers for funding for the employee's needs, resulting in managers asking their bosses up through to executives for funding. Unfortunately, every department or office is experiencing the phenomenon of having needs that require funding. Different employees, leads, managers, and executives continuously have to make decisions on the best way to use the limited amount of funding. Sometimes the choices made regarding how to spend the funds have to do with what is best for a company but often choices are made due to politics in terms of making decisions based on other agendas. Sometimes a business unit creates a need for a specific project for their own value and does not think enough about the organizational-level goals. These hidden or sometimes obvious agendas have more to do with returning favors to other individuals to keep conflicts to a minimum. However, this is never the recommended approach to leadership and management. Managers might feel the pressure to provide funding for one project over another based on perhaps the PM having performed a favor to the manager in the past or promised favors in the near future. Ideally, decisions on how to use the limited amount of funding should be based on which projects or needs are best in alignment with an organization, but in reality, this is true only a portion of the time. Another difficult topic is that of outsourcing. The decision to outsource is sometimes made purely on the basis of cost. Middle managers are typically most impacted by this decision. Later, organizations find that the decision to outsource may contribute in ways that are hard to quantify with the result being a gap in operational performance caused by the decision.

Other resources high in demand are equipment or even space. Depending on the organization, there may even be specific rules or guidelines distributed on how much space one level manager gets for their office versus another manager. Even conflicts over which department gets the better conference room to conduct a workshop occur as again the amount

of needs in an organization are unlimited, whereas the resources to fulfill those needs are limited. As for equipment, this can be anything from professors at a university all wanting specific classroom space because one classroom may have computer stations for students and other classrooms just desks. Or, it could be different product managers all needing some of the same factory equipment to produce their product line; yet, as there are only 24 hours in each day, not everyone's needs are met within the time that best fits their needs.

So, let us go back to the labor resource question discussed earlier in this chapter: have you decided yet which resources to give away for the special project? Perhaps your boss will provide a reward if the star performers are sacrificed for the project. Will you then be given the new computer resources requested for all employees in the office? Will you then get to hire a new employee or recruit an employee from another department to fulfill a skill need that is currently lacking? What type of reward will your department, project, or office receive if you allow your star performers to be part of the special project for a year? After all, rewards tend to be resources in the form of labor, monetary resources, equipment, or facilities.

Organizational structures

This section addresses six different types of organizational structures that include centralized, functional, projectized, matrix, virtual, and composite. Each structure has distinct characteristics. There are benefits and challenges in existence for each of these structures as well.

Centralized organization structure

The centralized organization structure is set up by different departments that may overlap according to their functions with an example displayed in Figure 3.1. A centralized organization structure has a very clean way of exercising control over project selection. This occurs because all project requests are submitted to the manager of a group for approval, including identifying the project team members to work on the project. In this organization, there is typically one set of management procedures and reporting systems for all projects within the entire organization regarding



Figure 3.1 Centralized organization structure.

project planning documents, risk management, change management, conflict resolution, and so on. This is a large benefit to the company because these procedures and reporting systems should technically be more perfected in comparison to each PM creating their own procedure and reporting system. Just as the name centralized implies, it means that there truly is centralized organization and control within the company. In this structure, it is easier for higher-level managers to see the health of the organization as a whole and where weak spots may occur because of the standardization in procedures and reporting systems. In essence, managers can compare apples with apples since the company has standardized procedures and reporting systems.

Another benefit within the centralized organization structure is that working relationships tend to be more established. This is due to people on a team already know how to successfully work with each other and managers already know the strengths and weaknesses of different team members. This occurs because these individuals repeatedly are assigned on the same projects together. If one person, for instance, is very good at researching information and another one at presenting to customers, then the PM can use this knowledge to have a very successful meeting with the customer—full of detailed information yet presented by an individual with excellent presenting and networking skills. Since working relationships are established, knowledge of strengths and weaknesses of different individuals and their capabilities make for selecting the project team better. Therefore, the director can decide which PM and individuals are best for different project assignments. This only further contributes to successful projects.

There is also a more clear line of authority within the organization as a whole within the centralized organization structure. This makes it easier for priorities to be set and conflicts to be resolved, so the focus for a team can be quickly set and any conflicts resolved fast for the team to get back on track toward working on the project deliverables. When there is a clear line of authority, it is easier for employees to behave better because everyone is aware of exactly who to meet with if something is not being handled appropriately. PMs and the project teams can easily be held responsible and accountable for the success of a project. Therefore, clear authority increases pressure for people to honor their commitments since performance appraisals, for instance, are conducted in the same organization where the work is being accomplished. Furthermore, clearly defined career paths exist for people who do good work as they are noticed by the upper management and rewarded through incentive pay or promotions.

Although there are many benefits with centralized organization structures, challenges also exist. Potentially, there could be slow response times to project requests since there will be internal politics regarding

which projects get approved. People who know each other may not feel comfortable challenging the status quo. Therefore, if there are not a set of fresh eyes, it can be negative since processes and politics that may remain may be ineffective. It can also be difficult to manage peaks and valleys in staff workloads. Project needs do not match the availability of team members in that there could be too much or too little work at any one time since project team members all come out of just one department. Since there is a smaller pool of labor resources to tap into, there may be a lack of specific skills among the group, making it difficult to staff a project team or rather causing skill gaps within the project team. This can cause problems with the need to pull from another division of the company in hopes of having a labor resource that is a valuable team member and proficient in the skill needed. Benefits and challenges exist within every structure; companies organize themselves based on which organization fits their company the best.

Functional organization structure

The functional organization structure is set up according to major business functions such as aircraft, facilities, logistics, environment, or public affairs as shown in Figure 3.2. Therefore, the different divisions are formed based on the main functions of the company, and employees have one clear supervisor (PMI 2008). A benefit is that people in a specialty unit have an in-depth understanding of the functional area for which they belong because all of their work revolves around that function such as aircraft-related projects. These individuals are truly the experts for that function, and for that reason are called subject matter experts (SMEs). If there is a project that involves the development of a system to support that function, then a person from that functional unit can develop system requirements so that the system deliverable involves a very useful system for that functional unit.

Within a functional organization structure, organizational units do not have to compete with one another to get the support of their specialty groups because only one group is familiar with aircraft and that eliminates competition within the same organization. Reduction of competition equates to less power struggles and therefore politics. This is not to

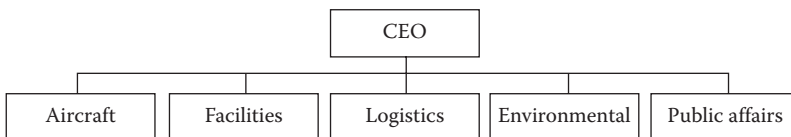


Figure 3.2 Functional organization structure.

say that politics and power struggles are not occurring at the upper levels where different directors of each functional unit are competing for the limited resources that exist. However, there is at least less politics within the lower and middle levels of the organization, which is a true benefit.

Another benefit is that functional groups are often very adept at technical problem-solving within the group because all of their projects are related and thus expertise is acquired by the group. Therefore, individuals within the functional unit have extreme knowledge within their field, so time is not spent getting each team member up to speed on the focus of the project. Instead, the project team already understands specific challenges that exist within their function, so the team can be very efficient and successful at problem-solving.

The challenges of the functional organization structure are, in many respects, the benefits of a centralized organization in reverse. To begin with, each functional unit, since each unit acts almost independent of each other, most likely has different work procedures and reporting systems. Therefore, the organization experiences inconsistent procedures and reporting processes. This results in higher-level management not being able to compare apples with apples when assessing the health of the organization as it will be more difficult to compare one functional unit to another since all the documentation and system output will be different. If the management cannot easily identify strengths and weaknesses within the company, it could be more difficult for a functional unit manager to convince the upper management to make major investments in equipment and facilities that are needed to support a unit's technical work.

Within the functional organization structure, there is a chance for overlap or duplication among projects in the same specialty area performed for more than one group within the company. Therefore, redundant work may be performed throughout the organization as the same work could be performed in multiple specialty groups such as aircraft and facilities, creating a system to track maintenance of aircraft and facilities. If this project was instead being performed jointly, then it would take less effort because maintenance tracking for either aircraft or facilities could actually be contained in the same developed system. This is a waste of resources in terms of labor and monetary resources.

Projectized organization structure

The projectized organization structure is a project organization that has PMs with full authority where employees actually report to the PM (PMI 2008). There is also staff to support the PM. This book has an entire chapter devoted to the enterprise PMO in Chapter 24, which goes into the details of this structure. However, Figure 3.3 depicts a typical organizational chart for the projectized structure.

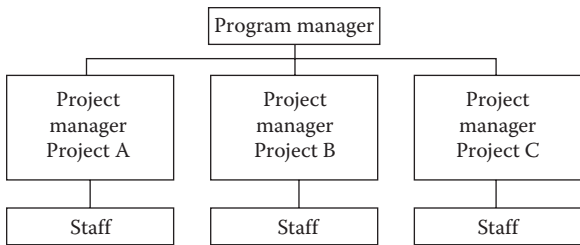


Figure 3.3 Projectized organization structure.

Matrix organization structure

Matrix organization structures involve projects that pull employees from various functional units trying to capitalize on the benefits of both centralized and functional structures. The matrix organization structure can be considered as a weak, balanced, or strong matrix (PMI 2008). The matrix is a combination of functional, centralized, and/or projectized organizations as displayed in Figure 3.4. The stronger the matrix, the more it resembles a projectized organization where PMs have administrative staff with a significant amount of authority. The weaker the matrix, the more it resembles a functional organization where the PM has little authority and no administrative staff. The balanced matrix provides the PM with a greater degree of authority than the weak matrix but still not full authority as found in a strong matrix.

A large benefit of the matrix organization structure is that teams can be assembled rapidly since there is a larger resource pool to tap into and

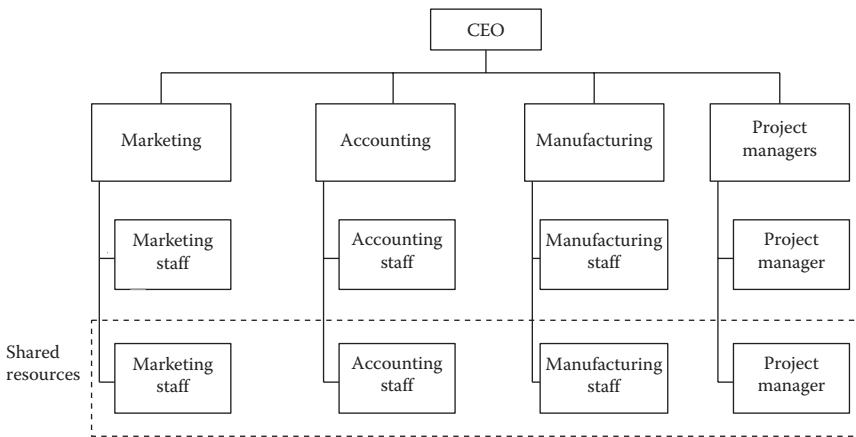


Figure 3.4 Matrix organization. (Adapted from Project Management Institute (PMI). 2008. Strong matrix organization, in: *PMBOK® Guide*, Chapter 2, 4th ed. Newton Square, PA: Project Management Institute.)

the organization as a whole already has employees with different expertise. Scarce expertise can be applied to different projects as needed and therefore the organization as a whole can justify maintaining a full-time employee with a certain expertise because this employee can be used for small amounts of work on multiple projects. The positive aspect of this is that the project cost is lessened since a full-time dedicated resource for one particular project is not necessary since the costs are then shared among multiple projects. Getting buy-in from team members' functional units is easier because employees working in the functional area impacted by the project deliverable will be more likely to support the project such as providing input to help develop a better system design for a particular functional area. Another benefit is that consistent reporting systems and procedures can be used for projects of the same type since employees from the same functional areas with already set systems and procedures work on an array of projects.

The matrix organization structure also has challenges. Team members often respond to two different managers. One manager is the PM assigning the work to be accomplished and the other one is the employee's supervisor responsible for performance appraisals and leave requests. If the two managers do not communicate, it could cause issues such as an employee being approved to be on leave during a critical portion of the project or the employee doing great work but not being rewarded on their performance appraisal since it is work being accomplished that does not serve the employee's manager. In this environment, the PM has a weakened power of control over their team since the supervisors have more ultimate power over the employee than the PM. Therefore, the employee may be more apt to please their supervisor who does the performance appraisal and approval of employee leave. Ultimately, the team member has more forced loyalty to the supervisor because of the control the supervisor has. The PM has also to deal with multiple supervisors as any one team may be comprised of different employees each with different supervisors. This aspect of the matrix organization structure is difficult.

Another challenge is team members working on multiple projects might have to address competing demands for their time such as trying to please all of their managers resulting in an employee's workload being too high. The employee may not have a single manager looking out directly for their best interest and rather want their project being completed as planned according to outcome, schedule, and budget. Furthermore, team members may not be familiar with each other's styles and knowledge because unless the same team has worked together in the past, building trust and being comfortable with each other's work styles do not occur overnight, yet projects have a limited completion time. Team-building exercises can aid in this effort but not help fully.

Potential lack of focus on project team and its goals, as opposed to each person's individual assignment, is another area of challenge. Team

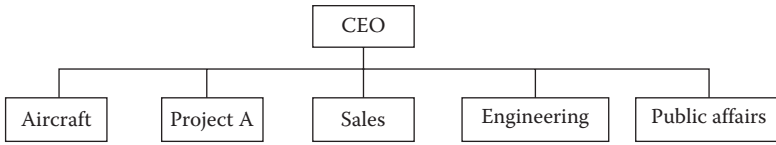


Figure 3.5 Composite organization structure.

members may have a hard time focusing on the overall good for a particular project versus what is best for their particular functional area. For instance, a project may be put in place to build a system that may result in greater efficiency within a function and therefore cause layoffs due to automation. A team member from the affected functional area may have a hard time keeping the project focus since their higher priority concern may be regarding what may happen to her colleagues' jobs. Also, multiple work processes and reporting systems might be used by different team members who could cause internal team politics. In this particular situation, it would be best handled by the PM setting the standards so that each team member is utilizing the same processes and systems. When team members are distributed geographically in different locations, the complexity of coordinating the team is even more challenging. Typically, large and global companies tend to be matrix organization structures, which include the composite organization structure that is being discussed last. The more mature a company is, the more likely it is to resemble a composite organizational structure similar to Figure 3.5 composite organization structure.

Virtual organization structure

Globalization in business is changing traditional organizational structures. The virtual organization can take on any of the structures previously described in this chapter. Virtual teams consist of groups of people with a shared goal who work together without necessarily any physical interaction (PMI 2008). However, the virtual organization consists of many employees working out of their homes or different locations. Therefore, employees are not collocated. Since technology has identified many ways for individuals to communicate at a distance, companies that operate virtually can operate just like any other organization. Technology is a very large component because without it, communication cannot occur, making a virtual firm powerless. There are many benefits and challenges for virtual organizations that can range from any of the benefits and challenges affiliated with the previously mentioned structures. The virtual office makes more sense in its existence where multiple projects are being worked, especially if you are a PM.

A benefit not discussed previously is that costs can be lower when physical facilities are not needed to house employees. The virtual

structure has become a reality due to the ease of virtual connectivity through advances in technology. Virtual offices contain distributed work teams that equate to team members being geographically dispersed and interacting at different times. This structure tends to be best for individuals within an organization that are self-managing and not in need of much supervision. It is also best for a team that communicates to a manager who serves the role of more of a facilitator. Organizations with off-site employees requiring expertise found in multiple locations around the globe have no choice but to conduct themselves virtually. A benefit is that a company or project team can tap into resources around the globe that best fit a project's needs. Another benefit is that there are less water cooler-type politics just by the mere independence of a virtual team.

Challenges within the virtual organizational structure exist with working with colleagues who are not collocated, causing greater potential for miscommunication. Difficulty in trust building is difficult enough with teams that are collocated versus a distributed work team. Communication can greatly suffer when there is no frequent face-to-face communication. This challenge is great and can be detrimental to a company's survival if not monitored and adjusted appropriately.

Composite organization structure

The composite organization may be referred to as the hybrid organization that has units resembling centralized, functional, projectized, and virtual and/or matrix organization structures as displayed in Figure 3.5. This organizational structure was developed to meet or customize the structure to the particular needs of a company. The main benefit that exists is the same as in the centralized organization structure because of standardization throughout the organization regarding processes and reporting systems. Challenges within this organizational structure tend to be in the area of increased conflict within and between projects because of duplication of effort and overlapping authority. Many managers have issue with regard to the performance appraisal and leave requests residing with one manager where one or more additional managers are responsible for assigning work tasks. Typically, large and global companies tend to be matrix organization structures, which include the composite organization structure. The more mature a company tends to be, the more likely it is to be of a matrix or composite organization structure.

Summary

For many organizations, power and politics occur due to labor resources, monetary resources, facility (space) resources, and equipment resources.

Every organizational culture is different, but regardless of the culture, every project in order to be successful needs support from the organization so that the organizational structure is supportive and not restrictive to the PM. In conclusion, different organizational structures serve different needs, so companies will select which structure or combination of structure best fits their needs. Depending on the structure in place, different power struggles and politics will occur. However, even though different structures have different types of power struggles and politics, no structure is without these issues. Six different types of organizational structures were addressed that included centralized organization structures, functional organization structures, projectized organization structure, matrix organization structure, virtual organizational structure, and composite organization systems. Every structure has distinct characteristics, each with benefits and challenges.

QUESTIONS

Student review questions

1. Name the different types of resources that are the root cause of power and politics in an organization.
2. Describe the benefits and challenges associated with the different organizational structures below:
 - Centralized organization structure
 - Functional organization structure
 - Projectized organization structure
 - Virtual organizational structure
 - Matrix organization structure
 - Composite organization structure

In-class questions

1. Identify different companies that follow each of the different organizational structures given below:
 - Centralized organization structure
 - Functional organization structure
 - Projectized organization structure
 - Virtual organizational structure
 - Matrix organization structure
 - Composite organization structure

EXERCISES

1. For the student team working on the car case study, identify the type of organizational structure that may best for the company.
2. What type of power struggles and politics may occur within the car industry?

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section two

Project formulation using tools and techniques

Learning objectives

Upon completion of this section, the following tools and techniques should be understood regarding why they are required as part of the project selection process:

1. Understand common business factors and priorities when approving a new project while working with limited IT resources.
2. Identify mechanics for selecting the right projects using financial decision models, including feasibility study, payback period, NPV, and depreciation and income tax.
3. Identify mechanics for selecting the right projects using nonfinancial models, including project questionnaire assessment, comparing different projects based on different criteria, and weighted criteria.
4. Understand the mechanics of the management of applications and project charters (similar to a press release that formally recognizes a new project).

Overview

This section consists of only two chapters that focus on the beginnings of a project—how to pick the right projects, the importance of business objectives and common selection criteria, and gaining support for the project—and discuss what a project charter is and the importance of having one. Most organizations have too many requests for new projects but have limited money, resources, and/or equipment to implement them all, so a consistent selection process is needed that will benefit the overall organization.

Ideally, all candidate projects should support corporate goals or business strategies that have the most compelling results but some projects will be selected without any choice (e.g., government accounting regulations such as the Sarbanes–Oxley Act). Having a project review board with diverse backgrounds and skills is an efficient way to make sure an organization picks the right projects to work. Also, this helps us to eliminate power struggles and politics from the decision-making process.

In a very few instances, the project review board might be bypassed for approving a new project. Examples would be the board of directives approving a project that will meet a new and important business objective or an activation group that takes on small projects that are under 400 h. The project review board should be an impartial jury that evaluates new project proposals, on its merits, how it meets key business objectives/strategy, and any conflicts and issues. A big part of the project review board's decision-making process should include using financial decision models and nonfinancial models that are covered in Chapter 4. When this entire review process is completed, the project review board will either approve or reject the proposed project.

If an organization wants to stay in business, a consistent pre-assessment project evaluation process is needed to build a business case to do it. Without a good business case for approving candidate projects, an organization is opening the door to more problems (e.g., nonstrategy or weak projects) that can resurface. Having a project review board will eliminate many of these problems and is a formula for success.

chapter four

Picking the right projects

Introduction

Most organizations have many new project requests but not enough money, time, equipment, or resources available to implement all of them. Therefore, an organization needs to develop a selection process that is utilized consistently throughout the organization to pick the projects that are right or rather will most benefit the organization. It is important to note that an organization's resources are already scarce because they are currently implementing approved projects and/or supporting current systems. In short, organizational resources are limited! Multiple goals frequently impose conflicting demands on resources. This requires a process for allocating resources based on organizational priorities.

Having a project review board with diverse backgrounds and skills is an efficient way to make sure an organization picks the right projects. Other approving entities may include the board of directors to approve a large project that implements some of the organization's goals or an activation group that only takes on small projects (e.g., under 400 hours). This chapter describes a significant set of common business factors and priorities to consider when approving a new project (Table 4.1).

Financial decision models

Many commercial cost-estimating tools are available that incorporate algorithms derived from hundreds of projects of various types. These algorithms correlate some project outcomes, such as effort or schedule, with factors such as product size, product characteristics, team productivity, team size, etc. The selected financial decision models should be created by the PM with stakeholder and sponsor input to determine whether the requested project is beneficial to the organization (Heldman 2011). The following models can be easily manipulated with Microsoft Excel.

Feasibility study

Evaluate the overall costs and benefits to determine whether the project is worth pursuing, which would be a short or quick study. See Chapter 15 for more detailed information.

Table 4.1 Business Factors and Priorities

Numbers	Business factors and priorities
1	It has to be done! Government accounting regulations such as the Sarbanes–Oxley Act
2	Local department or sponsor who will support the project
3	Meets short-term or long-term corporate strategy (Crawford 2011)
4	Business survival
5	Cultural readiness
6	Organization readiness
7	Urgency because of a special need or potential competitive advantage
8	Ease of implementing
9	Decreases time to market to be more competitive
10	Decreases costs to be more competitive
11	Decreases waste
12	Enhances customer service
13	Increases market share
14	Increases revenue
15	Increases end-user or customer satisfaction
16	Improves profitability
17	Improves product quality
18	Improves productivity or internal processes
19	Improves supply chain management
20	Improves ability to compete nationally
21	Improves ability to compete internationally
22	Improves an organization's public image
23	If the benefits of a new request far exceed a project underway that is not meeting expectations, it may make sense to swap projects and delay or cut loose the partially completed project

Payback period

Capital budgeting refers to the period of time required for the return on investment (Moore and Jaedicke 1980). However, this method is reliable only if the returns are evenly distributed over the years and if the investments to be compared are equal in amount and have the same life estimates with little or no salvage values.

Assume an investment of \$100,000 is expected to produce annual returns of \$25,000 for 10 years. If you divide the \$25,000 return into the \$100,000 investment, then your payback period for the investment to be recovered is 4 years. The ratio of the investment to the annual return is 4:1. Expressed in another way, the unadjusted rate of return is 25% as follows:

the \$25,000 investment is divided by the \$100,000 investment, which equals a 25% rate of return.

Net present value

NPV is a time series of cash flows, both incoming and outgoing, which is the sum of the present values (PVs) of the individual cash flows that gives a more accurate picture of financial performance than using the previously mentioned payback period (Biafore 2010). For example, if the percentage of someone's annual pay raise is less than the annual inflation rate, then it reduces what each paycheck dollar can buy.

Again let us assume another investment is \$100,000 and the annual returns are estimated to be \$25,000 to be received over a 10-year period and the rate of return an organization requires is 10% annually. Found in standard accounting tables/textbooks (i.e., PV of \$1 received annually for N years, which is broken down by *percentages* for inflation), the multiplying lookup factor (i.e., 10 years at 10% table intersection) would be 6.145. When the annual return of \$25,000 is multiplied by this factor, the PV of returns equals \$153,625. Therefore, the excess value of the returns equals \$53,625 (\$153,625 minus the original investment of \$100,000), which passes the organization's investment test. If the PV value of the returns is less than that of the investment, the investment alternative does not meet the rate-of-return requirement (10% in this case) and should be rejected (Moore and Jaedicke 1980; Loughran 2011).

A robust way of calculating the PV of returns is using Excel's XNPV function found under the Formula tab—Insert Function and type XNPV in the search box and fill in the cell ranges for Rate, Values, and Dates.

Value driver analysis

Value driver analysis is a financially driven process used to help focus on the trade-offs of success probability versus value for project analysis. First, management has to identify the value drivers (i.e., increasing revenue, decreasing costs, high rate of return, or achieving some other goal) and then convert these value drivers into quantitative metrics (i.e., shareholder value or free cash flow). Second, there is a need to focus on resource availability and what impact they will likely have on value creation. See Figure 4.1 for an example of this concept—obviously, the goal is to select strategic projects (white circles) that are value drivers in the top right-hand quadrant in which they want to concentrate their main resources.

Depreciation and income tax

Organizations may need to acquire capital assets that are depreciable for income tax purposes. Depreciation is the process of allocating an asset's

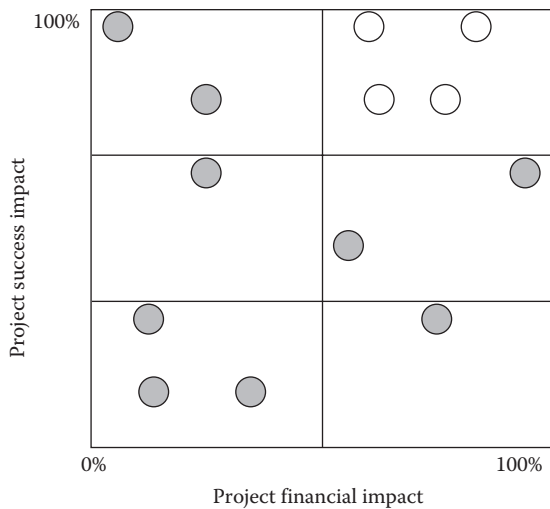


Figure 4.1 Value driver matrix.

cost to the accounting periods over which the asset is being used. Assume a piece of equipment is purchased by an organization for \$800,000 with a life expectancy of 4 years. If there is no trade-in or resale value at the end of 4 years, the annual tax deduction for depreciation would be \$200,000 ($\$800,000/4$) for 4 years. If there was a trade-in or resale value at the end of 4 years of \$200,000, then the annual tax deduction for depreciation would be \$150,000 ($(\$800,000 - \$200,000)/4$). The possible tax effect of depreciation must be considered in evaluating an investment in computer-related products. Ultimately, depreciation deductions will reduce annual cash out-flows by paying less income taxes.

Nonfinancial decision models

In support of using financial decision models, it is always good to use other supporting project request analysis to give more breadth for making a go or no-go decision. The following are useful nonfinancial decision techniques that can be used.

Project questionnaire assessment

The key success questions to ask about a requested project are shown in Table 4.2. Since every organization is unique, the organization might want to delete and/or add new questions and change the associated success rate number in column “A,” which is a constant. This table should be reviewed for any possible updates before a new project request is calculated in the last two columns.

Table 4.2 Project Questionnaire Assessment

Questions to ask about the project	A	B	C	D	E
	Success rate	Example		New project	
	High = 5	Answer	Success	Answer	Success
	Medium = 3	Yes = 1	value	Yes = 1	value
	Low = 1	No = 0	A × B	No = 0	A × B
1. Project is part of the strategic goals	1	1	1		
2. There is a project sponsor	3	1	3		
3. The right stakeholders are involved	3	1	3		
4. Stakeholders understand the big picture	3	1	3		
5. Have the right resources available	1	0	0		
6. Have real requirements	5	1	5		
7. Have timeline that is truly achievable	5	0	0		
8. Using current technology	5	0	0		
9. Project processes are well defined	5	1	5		
10. Project processes are understood	3	1	3		
11. Project processes are accepted	1	1	1		
12. Plan defined by stakeholders/users	5	1	5		
13. Have fallback plan in case of failure	3	0	0		
14. Enforced change control process	3	0	0		
15. Risks are correctly quantified	3	0	0		
16. There is project discipline	3	0	0		
17. Enforced change control process	5	1	5		
18. There is a communications plan	3	0	0		
19. All documentation stored on DB	5	1	5		

continued

Table 4.2 (continued) Project Questionnaire Assessment

	A	B	C	D	E
	Success rate	Example		New project	
	High = 5	Answer	Success	Answer	Success
Questions to ask about the project	Medium = 3	Yes = 1	value	Yes = 1	value
	Low = 1	No = 0	A × B	No = 0	A × B
20. Lessons learned are adopted for future	3	1	3		
Total = sum of 1 through 20	68	12	42		
Probability of success		C/A =	61.8%	E/A =	

Source: Adapted from Smith, Ron, May 2006 *Baseline Magazine*, p. 89.

Note: Probability of success scores less than 75% suggests an organization needs an action plan to modify the project goals in order to improve success probability.

Comparing different projects based on different criteria

Different project requests can be compared (e.g., one or more of them could be a project that is under development for comparison purposes) based on different criteria—competitive advantage, customer satisfaction, potential cost, potential revenue, and ease of implementation. Table 4.3 shows rating and weight—in both cases 1 = low and 5 = high. Finally, a new project request can be calculated in the last column and this table can be expanded to add more projects for comparison purposes.

Comparing different projects based on weighted criteria

Different project requests can be compared based on a weighted ranking matrix. See Table 2.7 for an example. Since every organization is unique, they may change the weight % in the table’s column 3 for the listed success items 1–6. Also, Table 2.7 can be expanded to include additional requested projects for comparison purposes.

Summary

Picking the right projects to pursue sounds so simple, but it is not! Why? This is because organizations have an overabundance of project requests but limited resources like money, facilities, and staff. If an organization wants to be successful and stay in business, it needs a consistent pre-assessment project evaluation process to build a business case to map out the correct pathway to do it. Over time, the chosen financial and

Table 4.3 Comparing Different Projects Based on Different Criteria

Criteria	Scoring	Project A	Project B	New project
Competitive advantage	Rating	3	4	
	Weight	4	4	
	Score (R × W)	12	16	
Customer satisfaction	Rating	3	3	
	Weight	3	3	
	Score (R × W)	9	9	
Potential cost	Rating	3	4	
	Weight	3	3	
	Score (R × W)	9	12	
Potential revenue	Rating	4	5	
	Weight	5	5	
	Score (R × W)	20	25	
Ease of implementation	Rating	2	2	
	Weight	4	4	
	Score (R × W)	8	8	
	Total score	58	70	

Source: Updated from Six Sigma Digital Edition from Information Week magazine, November 26, 2007.

nonfinancial methods or models used need to be constantly reviewed routinely for improvements. Without a well-developed business case for approving a new project request, an organization is opening the door to poorly chosen targets (e.g., nonstrategy, low-value, or overly risky choices, which collectively fail to achieve the desired results) that usually come back to haunt them.

Rejecting a project request should not be viewed as a “failure” but rather as successful resource management that frees up resources to work on projects that have higher-value returns. Also, having standard financial and nonfinancial methods or models to approve project requests helps to eliminate the “politics” from the decision-making process.

Sometimes an organization has to go against to their formal project decision-making process because of other factors external to those views. For example, the expenditure of significant resources to implement a compliant Sarbines–Oxley infrastructure is necessary because of newly imposed government regulations. Another example for approving a project outside the formal mechanics could come from the board of directors who are seeking to improve the company’s public image, which may be at a very low point, or approving a project that implements new goals.

QUESTIONS

Review questions

1. Who approves projects?
2. Could a new project request replace a project that is underway?
3. What should happen if the PV returns are less than the PV of the total investment for a requested project?

In-class question

1. Assume an investment of \$250,000 is expected to produce annual returns of \$40,000 for 8 years. Is this a profitable investment and what is the rate-of-return percentage?

EXERCISE

1. Assume an investment of \$250,000 is expected to produce annual returns of \$40,000 for 10 years and the rate of return an organization requires is 10%. What is the PV of the returns? Does this meet the rate-of-return requirement?

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chapter five

Gaining support for a project

Chapter 4 discussed how an organization selects the right projects that are in alignment with its strategic plan. The goal of this process is to select different types of projects to produce a diverse balance of target initiatives. As stated in Chapter 4, without a good business case for approving a new project request, an organization is opening the door to selecting projects that are not in alignment with the organization's strategic plan and are therefore low-value or weak projects. Now that the project target has been selected, what should occur next? This chapter will address how stakeholder support for the project is gained, including the approach to officially launch a new project and the purpose of a project charter. The processes required to produce a successful project require an enormous degree of planning and skilled leadership and some would even argue that it also takes a little bit of luck (Little 2011). Of course, using the tools and techniques described in this textbook should help the PM even without good luck on their side.

Management approach

Every organization has a slightly different way of approaching the official launch of a project, but the model approach requires that this can be done using a formal charter signed by the management and supported by a business case outlining the value of the project. The initial target vision is used to produce a business case that then leads the management to approve further definition through issuance of the charter. The primary goal of the business case is to validate that the initial project vision has value and is aligned with organizational objectives. At the end of this process, the management will hopefully show approval and support for the effort by formally signing a charter document. The first project team task following this usually revolves around expanding the definitional details of the project (Anonymous 2002; Little 2011). This should also involve the identification of the PM since the effort at this stage has minimal management guidance. Some organizations may wait for this until further scope planning and work definition is complete.

Project manager

At one appropriate point, it is important to formally identify a management individual who will be charged with leading the initiative forward through its life cycle. There are three main routes to develop a PM as identified by Kilkelly (2009). One of the least desired of these is to allow a new PM to learn by making trial-and-error mistakes. However, most organizations are not very forgiving of errors, so it is better to instead learn through being mentored or begin as an assistant to an experienced PM, which is the second method. A third method is to learn the basic mechanisms of the process through some form of training whether a degree, a focused training course, or self-study. Research suggests that the skills necessary to successfully run a project are not necessarily bred (Edmonds 2010). PMs are often selected based on their recognized reliability and technical expertise within their specific field. As a result of this action, they find themselves being responsible for a project team of individuals, but really do not have the appropriate background to deal with the complexity of this task. Lack of appropriate training leaves a gap in the skills required to properly manage the process and can leave the individual dealing with unimportant details and losing track of the important details. There is a saying about not being able to see the forest from the trees and this is another way of describing a PM focusing on the wrong details. Blending all of these approaches offers the best chance of producing the proper outcome. That is, mentorship, work for a successful PM and access to appropriate training materials. Many organizations focus only on the success of producing project deliverables but also need to focus on the growth of successful PMs (Nixon et al. 2012). Project deliverables may be deemed successful if they meet customer expectations; however, the PM is a success if the project was accomplished in alignment with organizational goals and if he or she grew professionally in the process.

Stakeholders

One of the early definitional tasks in the life cycle is to formally identify the project stakeholders. Stakeholders come in many different categories as there will be project sponsors, functional managers (line managers since resources come from these managers), team members, and many others who may not even realize until the signing of the charter that they are a key stakeholder. This definition helps guide sources for further requirements definition. Additional stakeholders may surface as the requirements are further elaborated in the planning process. PMI (2008) identifies a process for stakeholder definition consisting of identification of stakeholders, determination of stakeholder's requirements, and expectations and the management of their influence to help the project

be successful. Some stakeholders will be very active with the project providing financial and political support, whereas others will be more occasional contributors perhaps serving more as participants in focus groups or surveys. Stakeholders generally are thought of as individuals who provide positive outcomes for the project. However, it is important to note that there are also stakeholders who for whatever reason view the project as producing negative outcomes (or a particular stakeholder's agenda), which in turn may negatively influence the project outcome.

Communication is important between all stakeholders. The PM should ask each stakeholder to identify the preferred form and frequency of communication desired. For instance, some stakeholders may prefer email updates monthly, whereas other stakeholders want formal status meetings quarterly or even bimonthly. The only way to know that the stakeholder is getting the appropriate communication is to continuously ask. At each status meeting or email, a simple statement such as "please let me know if you would prefer more or less status updates, or if a different form of communication is preferred." The best way to evaluate this is to directly ask the question to each stakeholder.

Project sponsor

Someone within the organization must take the role of the primary sponsor (Kloppenborg et al. 2011). A sponsor is typically a person in the organization who has a significant amount of influence and often will reap the deliverable benefits of the project. PMI (2008) defines a sponsor as a person or even a group with financial resources who will ultimately champion a project by leading the project through the formal authorization process, charter issuance, and management leadership through later phases of the project as well.

Project charter

The project charter has specific implications to the team. PMI (2008) defines the charter as a document that formally *authorizes* a project and documents the stakeholder's needs and expectations. The basic roles for a charter are to formally give delegation of authority to the PM or the person identified by the management to lead and to formally display management approval for the project. The term "PM" will be used but it is important to note that the charter may, in lieu of identifying a PM, state that the functional departments A, B, and C will support the approved core planning process and that Ron Jones is the team/project leader. What is being said here is that the management believes that this effort is worthy of more expenditure of time, but they have not signed off on the final plan at this point. Also, the execution team is not likely in place

and cannot be named for all these same reasons. The items that should be covered in the charter document are a statement of project goals, general project time and cost goals, purpose, project management, and any other relevant guidance that the management wishes to define at this point. It is important to note that every organization has a different viewpoint on what a charter contains which comes from different definitions and the intermingling of these definitions for the project vision, business case, goal, and scope.

Chartering is an agreement between the PM, selected at this stage of the project, and the project sponsor (Miller 2001). The project charter needs to be established, signed—symbolizing approval of the project—and then documented. It is easy for a department to add in additional needs into the project charter that are unrelated to the original charter (Peled 2000). However, the PM and/or project sponsor need to stop the charter from containing anything but the appropriate target goals. If any part of the project is being outsourced, the role of the outsourced tasks must be carefully and clearly defined. Unclear objectives, unrealistic deadlines, and unclear management roles and lines of authority are weaknesses in project management (Anonymous 2002). A clearly defined line of authority to include an accountability framework must be established, which begins with the PM (Maddalena 2012).

The sponsor sets the physical vision for the output the project produces. The PM turns the vision into the executed work to execute the output desired by the project sponsor. The project vision fed the business case that was appealing enough to be selected by the organization, which set the discussion in the last chapter. The goal turns the vision into a high-level project outcome that needs to occur so that the vision is successfully performed. The scope appears in the WBS which is discussed in Chapter 6. The topic of the scope brings about the question of whether it is the product or the project scope. The WBS top is a deliverables-oriented set of boxes representing the sponsor view of the project, whereas the lower WBS represents the work to be accomplished that produces the desired project output. Some organizations have a very basic charter that does not contain much information, whereas some organizations will almost have a miniature version of the scope management plan as their charter. This chapter focuses on the main charter roles, as the scope planning and scope definition processes will be covered in Chapter 6.

The charter provides the organization with a common purpose for which to exist so that there is a shared goal and it can assist in making individuals affiliated with the project be cohesive with a shared sense of project ownership (Peled 2000). Once the project charter is signed by the management and the PM, it signifies again that management believes this effort is worthy of more expenditure of time, but they have not signed off on the final plan at this point as that occurs at the end of the planning

authority to the PM. A charter can even include specific statements such as the PM has the authority to do the following:

- Communicate directly with the executive team regarding the project
- Communicate directly with all subcontractors regarding the project
- Negotiate contracts
- Authorize expenditures
- Hire subcontractors
- Assign resources to project tasks

A more detailed project charter can contain all the details listed in the basic template and additional categories as well. A more detailed project charter may also list the background providing the rationale for the initiative, general deliverables of the project, perceived risk issues, and even team membership assumptions as the team is likely not known, but the management may provide a commitment to providing the resources needed to carry out the project. The following sections discuss the charter basic template categories as well as additional potential charter items that may be added by some organizations.

Background

In terms of the project background, the project did not just suddenly occur as the organization came about the business need or business case for the project that should be identified. The project may serve to resolve a problem within the organization. A project likely exists due to it being in alignment with the overall organization's strategic mission, which could be discussed in this section as it serves as a justification for the project being funded. In the background, there may also be information on why this project is important such that it serves different key stakeholder needs whether they are internal or external to the company. The project may address a new law or regulation or even a social need that has arisen within the community where the organization's facilities exist. There may be demand for a new product that this project will produce. Or, it could just be a project to update a company's website. New technology may be integrated into the business that resulted from technological advances. There may be a number of reasons why a project was selected, so the charter in this section would identify the reason why the project exists.

Purpose

The purpose section of the project charter in the template doesn't have to only be a high-level description. It can provide details such as the high-level goal of the project and also identify all of the objectives that the

project is anticipated to meet. This provides a much expanded view of the project.

Deliverables

A project charter can also include information relating to the scope of the project but this information will be limited in the charter to the project objectives and possibly the deliverables too. The charter may be a mission statement that identifies the main tasks to be performed by the team. The deliverables section should identify the specific deliverables that the team is required to produce. Additionally, the charter may list project milestones.

Budget

The budget in the basic template displays the overall project budget objective. The budget is just a rough order of magnitude as the project work has not been fully identified yet at the charter stage. Good planning now will hopefully produce a budget within 10% of the actual detailed budget later established, which will be discussed in the following chapters. However, this section may contain details of the amount of the budget for different aspects of the project, such as equipment, labor, and so on. It may also address where the funds are from in terms of funding from a specific program or department or combination of different organizational departments. In some projects, it may state how some of the project income is generated from sales such as a project for an event. The event may be able to pay for entertainment, food, and so on based on the income that comes in from ticket sales.

Team membership assumptions

The team membership section of the project charter may be part of the charter in just listing out the type of resources needed so that the PM does not later need to beg the management for additional resources. The team member's name will be discussed in Chapter 6 as it will be identified in the scope management plan. This section may also outline the authority that is being granted to the PM along with the PM's brief biography. It may provide the PM the power and authority to directly communicate with company board members or specific customers or subcontractors.

The project team at this time will not likely be established but a limited amount of resources may assist either the project sponsor or the PM if one has been already selected. Therefore, actual individuals may not yet be selected but an understanding of the right composition of skills that will successfully be able to accomplish the project goals may be identified,

such as computer programmers, electrical engineers, paralegals, and so on. The project proposal may have identified some of these details already. Many organizations will not put the full team together until the scope management plan discussed in Chapter 6 (Maddalena 2012).

Perceived risks

Risks are an entity of their own. In fact, Chapters 11 and 22 are devoted to the topic of risk. However, the project charter may also include a section of high-level risks that apply to the project. For instance, it may have the risk of weather if the project pertains to an outdoor event. Another risk is that the supplier that the organization has a contract with may deliver supplies late, which will impact the project schedule. Project risks can be identified, but other project documentation that will be discussed later in the text-book will explain how to document and handle the details of project risks.

Project approval

The project approval section in the basic project charter template has signature blocks for the PM and the project sponsor. The project charter can also outline the criteria for which the project will be approved and therefore categorized as successfully completed. Examples of criteria are submission of all project close-out documentation and submission of all program code to the customer. The criteria that are identified should be written in very concise statements so that no two individuals would interpret the requirement differently. This is for the protection of the PM and the project sponsor. Once the signatures are obtained, the project can officially begin. The distribution of the charter is like a project press release, and copies should be sent to the project team and anyone that is affected by the project.

Summary

This chapter addressed how support for the project is gained, which includes the approach to officially launch a new project and the purpose of a project charter. When the project was selected to be performed, it was at that time validated that the initial project vision had value and was aligned with organizational objectives. At the end of this process, the management was obligated to show both approval and support for the effort by formally signing a charter document. A determination is made to identify the PM or person identified by the management to lead the project at this stage in the life cycle and identify key stakeholders such as the project sponsor(s). The basic template for the charter was addressed as well as the purpose of the charter in providing delegation of authority to the PM and formal management approval for the project to exist.

Additional charter items to include were also discussed as every organization has a different viewpoint on what categories of information should be included in the charter. Chartering assists in moving the project definition and process forward to the start of official scope planning and scope definition addressed in Chapter 6. This will include discussion of the scope management plan and scope statement, which are the next documents developed once the project charter is completed.

QUESTIONS

Review questions

1. Describe the different steps involved in officially launching a project.
2. List and describe each section of the basic charter and expanded project charter.

In-class question

1. Find a charter template on the Internet and describe the sections of the charter.

EXERCISE

1. Create a project charter for the car case study using the charter sections described in this chapter or found online.

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section three

Developing project scope

This section of the book focuses on translating the original project goal into a work unit-oriented structure with initial time and cost estimates. Scope definition is considered as the key initiation step for a project and one that is necessary for future success. The chapters in this section have the following learning objectives:

1. Develop the scope management plan as part of the scope planning process.
2. Develop the scope statement as part of the scope definition process.
3. Identify, analyze, refine, and document project requirements, assumptions, and constraints to produce a technical project and product scope definition.
4. Development of a deliverables-oriented WBS created from the initial project charter, scope statement, and other project specification documents. From this definition, step technical work units are defined and will be used to facilitate detailed project planning, which is then used in the executing, monitoring and controlling, and closing processes.
5. Estimating tools and techniques are described to show how development of project work unit specifications leads to a total project budget.
6. Introduce the relationship of scope, time, cost, and resources into the overall management equation.

There are many ways in which project management mechanics could be presented. In this book, Sections III and IV have been defined as representing the core mechanics that every PM should follow and generally in the sequence described. Section III segments the process for defining project scope and techniques for estimating the defined work. Section IV will expand that into measurable output for time and cost. Scope is considered



Figure III.1 The project plan triple constraints.

to be the prerequisite event because it is difficult to execute a project if there is no clear definition of its goals and work requirement. Many projects fail because this step is not done well. The creation of the scope management plan and scope statement establishes the foundation for the WBS development. The main artifact to support this goal is the WBS which is considered to be one of the most important project artifacts. Much of the following text uses this definition to bridge into various other management processes.

Figure III.1 illustrates the process linkage between the three initial holy trilogy knowledge areas.

The sequential flow of project plan development is illustrated in Figure III.1 and is important in that a formal scope definition provides the foundation for schedule development and the resulting schedule then becomes the base artifact for project cost and budget definition. Many projects start off with these assumptions reversed. Schedule and cost can in fact be hard constraints, but the sequence defined here is that the flow of plan development should start with scope and let that dictate cost and schedule. If the three components do not match internal constraints, the tweaking process should then work iteratively until a viable solution is found.

What exactly is this variable, it is called project scope? Basically, it is a formal definition of work required to produce the defined project goal. This process defines the deliverables, work processes, and other information relevant to that result. Scope definition is considered to be the first element of three core project management attributes called the *holy trilogy*. From the scope specification, project time and cost are derived. Even though there is a lot more to project planning than these base elements, they are the most visible plan output parameters and frankly represent more than many organizations do for project planning.

Emulating real-world practices is not necessarily a route to success. In some cases, project failure is not one of deficient planning, but getting the organizational participants to follow the plan. Just recognize that a good plan is not the only condition for success. It is a road map, but there is always unexpected environmental roadblocks found along the way. Think of the planning process as a pathway to get from point A to point B. Each road increment is a work unit that consumes time and resources that when added together constitutes the total trip. Any change in this pathway has the potential to extend the estimates.

The reader must recognize that many real-world project managers will take many shortcuts in developing a plan. Personal experience

suggests that few projects follow the full management rigor as outlined in this book. Nevertheless, each management shortcut brings with it certain negatives that may derail the resulting value of the final project. One must know what the ideal case is and what risks are inherent in any shortcuts before selecting that route.

chapter six

Defining a project

The previous chapter discussed how every organization has a slightly different way of approaching the official launch of a project. However, one of the core requirements is to identify the PM and key stakeholders. The basic roles for a charter were also discussed which consisted of formally giving delegation of authority to the PM and formally displaying management approval for the project. The objective of this chapter is to address the next step in the launch process which is to develop the scope planning. This that yields a scope management plan and the scope definition results in an updated scope management plan, scope statement and requested changes to the project scope (PMI 2008). Before reading this chapter, it is important to first understand the definition for a scope management plan and scope statement. PMI (2008) describes a scope management plan as how the project scope will be defined, developed, and verified. It will also describe how the WBS will be created and defined. Therefore, the scope management plan provides guidance on how the project scope will be managed and controlled by the PM and the team. It is contained within or a subsidiary of the project management plan. A project scope statement contains a description of the project scope which consists of information such as the deliverables, assumptions, constraints, and a description of the work that is to be accomplished by the project. The scope statement for the project is documented, so it will be the basis for making future project decisions and for confirming or developing a common understanding of project scope among the stakeholders.

The creation of the scope management plan and scope statement establishes the foundation for the WBS development. Successful projects are just as much about managing relationships as they are about managing change, so the PM must be vigilant in controlling the project outcome (Bourne and Walker 2005). There is a management concept that says you cannot control what has not been defined, and scope definition is the important beginning step for project definition. Our primary goal now is to begin our journey through planning and defining project scope.

Scope planning and definition

As discussed previously, the scope planning process yields a scope management plan, and the scope definition results in an updated scope

management plan, scope statement and requested changes to the project scope (PMI 2008). The input into scope planning is organizational factors such as an organizational culture, project charter, preliminary scope statement, project management plan, and organizational process assets defined by PMI (2008) as information, policies, or procedures external to a project. The process in scope planning used by organizations to produce the output, scope management plan, is templates and expert judgment. The scope definition input is similar to the scope planning input as it not only has organizational process assets, project charter, preliminary scope statement, but also has the project scope management plan and approved project scope change requests. The process used to produce the outputs of the project scope statement, requested changes, and updated scope management plan consists of the methods and techniques used to translate project objectives into project deliverables, expert judgment, and management of stakeholder's needs, wants, and expectations.

A scope statement typically is a text document used to develop and confirm a common understanding of the project scope. It should include project justification, brief description of the project's deliverables, and summary of all project deliverables and a statement of what determines project success. The scope statement is a first translation of the vague charter language into more specific technical language. Just as every organization may have a slightly different way of approaching the official launch of a project, an organization also has different approaches to scope planning and definition. However, the proper outcome is scope statement used to drive the subsequent scope planning and the scope management plan for scope definition. The difference is that the scope management plan is procedural input into development of the very detailed scope statement. The scope management plan will either already contain the level of detail that is found in a scope statement or will be broader leaving the details to be found in the scope statement. Therefore, the discussion of this chapter revolves around the development of the detailed scope statement since this will discuss all of the necessary scope input needed prior to the next chapter that focuses on development of the WBS.

Identification of the team members is an important part of the launch process as the team will then assist the PM in creation of the scope statement as teamwork is a vital ingredient for success for the project team (Little 2011; Redesigning project management 2002; Swan and Khalfan 2007). Assembling the project team requires the right mix of individuals and composition of skills that will successfully be able to accomplish the project goals (Maddalena 2012).

Unclear objectives, unrealistic deadlines, and unclear management roles and lines of authority are weaknesses in project management (Redesigning project management 2002). As discussed in Chapter 5, if any part of the project is being outsourced, the role of the outsourced tasks

must be carefully and clearly defined. A clearly defined line of authority to include an accountability framework must be established (Maddalena 2012). Clearly defined goals are the first step prior to assigning individuals to different tasks that lead to each of the defined goals.

Staffing and team management

Chapter 7 outlines more specifics in WBS creation and Chapter 23 provides additional team management tools that a PM can utilize in defining role and responsibility-type matrices as the way to establish an accountability framework to be certain that the entire team understands overlapping and individual project responsibilities. The tools in Chapter 23 will also help one to provide expectations to all team members related to communication internal and external to the project team. Examples of these are documents that identify which tasks belong to which individuals and they also include detailed information of individual responsibilities. Time planning tools will also emerge and they will define the amount of time needed to conduct each project task and specific work assignments for the team members. These tools collectively communicate how project team members are *accountable* for achieving the project goals and related deliverables. Organizational charts such as those discussed in Chapter 3 also provide official and therefore formal lines of authority for those internal and external to the team. All of these supporting tools aid in the task organizational processes required to produce not only the scope definition, but are also used through the rest of the life cycle as well.

Scope statement

The scope statement can be highly detailed or broad depending on the organization and the needs of the project (PMI 2008). The team guided by the PM's leadership establishes the project's objectives, deliverables, requirements, and/or specifications as well as criteria for success in terms of realistic, clear, and measurable objectives. Also, many of these steps can occur in parallel.

It is important to limit the scope to include only the project-related (versus adding nonproject scope) specific objectives, deliverables, requirements, specifications as well as criteria for success because including additional requests without going through the change control process will spiral the project out of control and the result unmanageable. A scope statement created by the team can assist in making the team cohesive in developing a shared blueprint for how the team operates (Peled 2000). Developing this with input from stakeholders also facilitates buy-in from that segment about the project's need for existence and ultimate purpose. A sample template for the scope statement is displayed in Table 6.1.

Table 6.1 Project Scope Statement Template

Project and product objectives
Product or service requirements and characteristics
Product acceptance criteria
Project boundaries
Project requirements and deliverables
Project constraints
Project assumptions
Project organization (team)/team assessment
Defined risks
Milestones
Initial WBS
Cost estimate
Project configuration management requirements
Approval requirements

Source: Project Management Institute (PMI). 2008. *PMBOK® Guide*, 4th ed., Newtown Square, PA: Project Management Institute.

Project and product objectives

Objectives are defined as something that is to be accomplished by the project which can be in the form of a tangible product or possibly less tangible project items such as status reports, quality control documents, and other items related to running the project. A project objective would be items such as delivering the defined outputs on-time, on-budget, and within scope. A product objective would be to make sure the software is user-friendly, technical specifications met, and so on. A clear statement of objectives is important since this drives the subsequent WBS and control process. There will obviously be changes requested during the project life cycle. It is important to manage this process as undue volume of these will doom a project. Chapter 18 will describe that aspect of the life cycle.

Product or service requirements and characteristics

After describing stakeholders’ needs, wants, and expectations, the team must translate that into the work requirements necessary to produce that output. Requirements need to be listed in priority order as typically there will not be enough resources or time to deliver every item. Once the requirements have been identified in terms of very concise statements that no two individuals would interpret differently, the requirements should then be communicated back to the stakeholders to be certain that their needs, wants, and expectations have been properly collected and documented. It is also important that the stakeholders agree with the prioritized listing identified. Examples of requirement statements for a product

could be stating that a cabinet be specific dimensions or that a portable game system has the ability to connect to other user's same portable game system through Wi-Fi. An example of a service requirement is that user's emailed feedback comments will be responded to within 72 hours. Or, a caller to the help center will be sent an email after the caller's issue has been resolved to survey the satisfaction the user had by the technical or customer service received. These examples demonstrate that requirements go beyond just describing what the physical product will do.

Product acceptance criteria

The project scope statement outlines the criteria for which the project will be approved and therefore is a definitional guide to measuring success. One example of acceptance criteria would be the requirement of submission of all project close-out documentation and all program code to the customer. Another common example is schedule or cost criteria. In an information technology projects, examples of these could be goals related to performance and quality. For instance, system response times or transaction rates would be performance criteria, where the number of known defects that were not corrected by the completion of the project would be quality criteria (McBride et al. 2007). All acceptance criteria should be written in very concise statements so that no two individuals would interpret the requirement differently.

Project boundaries

Project boundaries need to be set so that the PM does not find himself/herself being placed in a position where the amount of funds provided is firm, yet the scope of the project work keeps growing. Boundaries need to be identified in the scope statement so that there will be no confusion as to what exactly will or will not be accomplished during the course of the project. It is important to point out what is in scope and what is out of scope. This will be important later as conflicts emerge on what is within scope of the project and it protects the project team in these situations. Physical documentation is very important for this purpose, as well as obtaining signatures from key stakeholders so that there is understanding of the scope. This process is an important one to help deal with scope definition and scope creep issues that may occur later in the life cycle. Creeping requirements can be avoided through having a project boundaries section (Cervone 2006).

Project requirements and deliverables

A project requirement can be defined as anything that needs to be accomplished as part of the project. PMI (2008) further defines a requirement as a system, product, service, result, standard, or anything else that is desired by a stakeholder. Just as discussed above in the product requirements

section, it is important to communicate with the stakeholders to collect and confirm their needs, wants, and expectations. Then, the team needs to produce requirement statements that are very concise statements that no two individuals would interpret differently. Then, the requirement statements should be taken back to the stakeholders to be certain that their needs, wants, and expectations are linked to specific requirements so that the team gets feedback that the stakeholders' needs, wants, and expectations were correctly interpreted. The deliverables definition should identify the specific items that are to be produced. These can be systems, websites, products, program codes, password documents, new processes, or technical manuals.

Project constraints

Most projects have constraints which limit their degrees of freedom. Many times these are not recognized and therefore not obeyed. This section provides a means for formally communicating to the key stakeholders what these constraints are for the project and its environment. Politically, it may not be recommended to identify all constraints but when possible, it provides clear communication internal and external to the project team. Constraints are merely restrictions that exist such as funds, timelines, contracts in place requiring that purchases be made from certain suppliers, system interfaces produced to be compatible with existing organization's systems, or even space availability. The PM as part of his/her role is responsible for realistically identifying tasks and timelines based around these constraints.

Project assumptions

Assumptions are statements that the PM believes to be true such as access to some defined level of organizational resources such as all team members are provided adequate computer workstations, office supplies, equipment, and so on. These can even be opportunities for the project. It may also state that some external organizational group will provide support to the team. This section is again just a way to communicate to all parties different constraints related to the project. This section will also contain a statement regarding the impact to the project if the assumptions are incorrect such as a project falling behind schedule if promised resources are not provided.

Likely, one of the most important assumptions to document and make clear to the management approval group is that of resource availability. A perfect plan that is not supported with resources is worthless. The supplying organizations need to be made explicitly aware that failure to support the plan will result in undesirable outcomes. Throughout the life cycle, it is a good idea to review assumptions and verify that they are still valid.

Project organization/team assessment

The team membership section of the project scope statement will likely have very little information at this stage since the project is not completely defined yet. However, in a few cases the scope statement may have additional details if this information has already been defined. The information in this section is more likely to not exist at this stage but instead in the final scope subsidiary plan. Project organization and team assessment information include each team member's name, contact information, and position. This section will further contain the authority that was granted to the PM in the project charter discussed in the last chapter. In addition, it will contain the details on the responsibilities of each team member. The scope statement may list the specialty area held by various team members such as computer programmer, architecture, engineer, and so on. It will identify the degree of involvement each team member has in terms of full-time team member, part-time team member, advisory board member, and so on. It is often difficult to interpret the degree of authority that different team members have, so this information may be integrated into the scope statement. It could be as simple as to list an alternative PM signifying that a team member has the signing power in the absence of the PM. However, this information needs to be clearly documented, so there is no room to misinterpret the degree of authority held by team members. Generally, the team member section will identify certain team members as leads over different areas of the project which is an easy and clear way of identifying the different degrees of authority on the project charter.

There may also be a section of the scope statement that identifies the means of assessment of team members. It may be a statement of biannual performance review assessments that are conducted. It may even list out key areas of assessment for team members. These assessment areas may revolve around the same performance assessments that the PM is held to such as meeting the project schedule or quality of deliverables. The assessments can even be in terms of how well a team member works as part of the team to collectively meet the project goals and objectives. As mentioned earlier in this section, the information above likely would not exist at this stage but it is mentioned in case an organization already has this information defined.

Defined risks

The risk management process at this stage is of high level. This process provides a way to reduce project outcome uncertainty through providing awareness, assessment, and handling of risks, thereby minimizing future threats, seizing opportunities, and achieving improved results. It also identifies the degree to which a risk may occur and the outcome it could have in terms of impacting project success. Risk management is a process

entity of its own and therefore is described in more detail in Chapters 11 and 22. Time spent in risk management up front allows those involved to not be in a crisis mode later when identifying the best way to manage the unplanned event.

Project risk management involves the identification of potential risks affiliated with a project. Potential risk events can be identified by reviewing previous project data and other company historical records to see which risk factors have previously occurred. In addition to this, brainstorming sessions are a potential process to further identify items that may have never occurred before but still pose a threat to the project. Vargas-Hernandez (2011) suggests categorizing risks using major category headings such as environment, technical, resources, integration, management, marketing, and strategy. For instance, the project may have a risk under the category of environment—that is, bad weather during some time frame. At this stage in the project, the risk assessment is of very high level. The more detailed assessment and quantification process will come later in the planning process which will be discussed later in the book. At this early stage, the goal is to give the decision-makers a high-level view of this aspect of the project.

Milestones

Milestones are any significant events, deliverables or achievements within a project or schedule (PMI 2008). A significant event could signify that Phase I has been completed and Phase II is beginning. Another example is that all system testing is completed or that a system implementation is complete at a specific location. Completion at each location may be defined as a project milestone event. Furthermore, it is common to signify a milestone at the end of a project to indicate that it has officially been completed which could even be to have a formal close-out celebration event if appropriate. At this point, timeline estimates may be included indicating target milestones. At this stage, the term “target” might be more descriptive, but eventually these same points often become official milestones and will be met but this may not be listed in this document since the WBS discussed in the next chapter has to be developed to have an accurate timeline.

Work definition

The initial WBS for the project is very high level and subject to significant error is prediction since the speciation details are not yet completed. As the planning process unfolds, the level of definition and accuracy improves. At this stage of the project, it is common to quote ranges of values in the $\pm 100\%$ category for projects that are not similar to previous ones.

The goal of the initial WBS at this stage is to logically organize the work estimate. The level of detail and accuracy at this point is based on

whether the project is similar to others that have been undertaken, or a new initiative. If similar, then these data will be more detailed. A WBS is a common artifact to logically divide the work estimate. This initial view will be expanded as the scoping process unfolds. Chapter 7 will explain the WBS process in more detail.

Cost estimate

This section will describe the budget based on the requirements at this point which produces a high-level estimate. As with the time and initial WBS, cost estimates will often be quite broad regarding the amount of the budget for different aspects of the project such as equipment, labor, facilities, technology, and so on. It will also address where the funds are from in terms of funding from a specific program or department or combination of different organizational departments if this information is known. Finally, within MS Project 2010, the project's budget resource feature can be used to define the budget for different categories of items. In some projects, it may state how some of the project income is generated from sales such as a project responsible for hosting one or more events where tickets are sold. The event may be able to pay for entertainment, food, and so on based on the income that comes in from ticket sales.

Project configuration management requirements

Configuration management is how the entire project is managed from procedures to set-up project documentation to tracking of the project milestones to team interactions. At this point within the project, this section may be incomplete. Each team will have different rules of engagement so to speak which are internal team processes. These rules may be on conducting meetings, keeping sensitive information confidential, communicating within the team, tracking product quality, and so on. The scope statement may have a section devoted to team guidelines. The PM will likely not publish all of the rules of engagement but there may be rules that make sense to formally display on the project scope statement. Inaccurate configuration control is a risk that is particularly present in information technology projects (Cervone 2006). As part of the configuration management requirements, a system could be set-up to centralize all data and information pertaining to the project (Perkins-Munn and Chen 2004). This would increase the speed of information being delivered to team members. Statistics of which information has been read or not read by team members could also be tracked. Team members could be given read access and other stakeholders given access only to specific folders of information. The PM then could be the only one with write access or would control which members have write access. This would be a way of making sure every team member is using the most up-to-date team

information. One aspect of configuration management is having a procedure in place for how to handle any additions, deletions, and modifications made to the project documentation. This aspect will be discussed in greater detail in Chapter 18.

Approval requirements

Approval requirements is for the protection of the PM and the project sponsor for signatures to be obtained so that everyone agrees to the requirements contained within the project scope statement. Just like the analogy used in the last chapter regarding the charter, the same press release analogy applies for this chapter too as the scope statement should be sent to the project team and anyone that is affected by the project.

Summary

A determination is made to identify the skills needed to carry out the project to include identification of, some of the team members and the project sponsor(s). The PM will lead the establishing of the project's scope and criteria for success in terms of clear and measurable objectives. After completing scope planning and definition, the next step is to further define the work by breaking it into manageable pieces which is accomplished in the following chapter. If the scope planning and definition processes are successful, then it will help one to improve the accuracy of time, cost, and resource estimates which span over many of the book chapters. It also defines a baseline for performance measurement discussed in Chapter 14 which focuses on the key performance indicators as well as project control. It will also aid in communicating clear work responsibilities which is further addressed in Chapter 23 which focuses on Team Tools.

QUESTIONS

Review questions

1. Describe the inputs and outputs of the scope planning process.
2. Describe the inputs and outputs of the scope definition process.
3. What is a scope management plan?
4. What is a project scope statement?

In-class questions

1. Find a scope management plan template on the Internet and describe the sections contained within it.
2. Find a scope statement template on the Internet and describe the sections contained within it.

EXERCISES

1. Create a scope management plan for the car case study using the scope statement sections described in this chapter or found online.
2. Create a scope statement for the car case study using the scope statement sections described in this chapter or found online.

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chapter seven

Developing the work breakdown structure

PROJECTNMOTION BACKGROUND LESSONS

Review Section 2, Lessons 1 and 2.

Introduction

The origin of a modern project WBS can be traced to the latter 1950s as a result of successful implementation of the highly technical Polaris missile project. The project management-oriented acronym terms PERT and WBS became popularized as a result of that effort (Haugan 2002). The WBS model became a commonly used project tool by the 1960s and is now a visible concept in all project management standards documents. PERT over the same period has had mixed success as a time management-oriented model. This chapter will focus on showing how the WBS model has achieved broad impact on various aspects of project management. The initial view of this concept as presented in this chapter is to produce a clear definition of project scope; however, threads related to other WBS usage will appear throughout much of the textbook. Many view the WBS concept as one of the most valuable management tools in the project life cycle. This belief is shared by the authors of this textbook. The discussion related to the historical companion PERT model will be deferred until Chapter 20 since its overall impact is less pervasive in the contemporary scene.

One metaphor that might ring with the reader is to view a WBS as the chemical compound representing the project. Within this compound is a collection of molecules that the WBS will define as elementary work units. These work units are pervasive throughout the textbook in various management views. In this manner, the entire project can be seen through the lens of a WBS and its naming structure. For this phase of discussion, think of a project goal as originating as a vague vision in the eyes of some sponsoring entity. From this ill-defined vision, the first step in a project life cycle is to translate this into technical work units that will accomplish the task. Once completed, the WBS is designed

to mirror the project team's view of the work required to produce the defined goal.

There are multiple ways to structure a project WBS, but the key is to organize it "logically" as defined by the individuals who are involved with the effort. In some cases, this structure will mirror the target physical product, or alternatively may divide the high-level box structure into logical work phases. Regardless of its high-level structure view, the WBS creation process moves iteratively to increasingly more detailed views from this level. This creation process is called *decomposition*, or is known by the fancier title of *progressive elaboration*.

Standards organizations

The U.S. Department of Defense (DoD) and PMI organizations are two of the most recognized WBS thought and standards leaders for this topic. Each has a slightly different view of the artifact, but both are quite similar in their broader goals. The DoD version represents the classical and most mature usage view, while the PMI definition is more recent and geared more toward commercial organizations. The following shows the two comparative definitions:

DoD. A work breakdown structure is a product-oriented family tree composed of hardware, software, services, data and facilities ... [it] displays and defines the products(s) to be developed and/or produced and relates the elements of work to be accomplished to each other and to the end product(s). (DoD 2005)

PMI. A deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables. It organizes and defines the total scope of the project. (PMI 2001)

The DoD model has extensive definition of terms focusing on tangible products and standardized templates, while the PMI description softens that view to a more general "deliverable," which could be interpreted to be any project objective. Regardless of the accepted definition, the WBS schematic structure is now viewed as one of the most utilized management techniques in the project domain.

Gregory Haugan offers an interesting perspective on the role of a WBS in suggesting that it represents what has to be accomplished in the project (Haugan 2002). Translating the project's goal into a defined work requirement is the essence of scope planning and the WBS process resides at the core of that effort. Also, there is a corresponding management adage that "you cannot control what you have not planned." A WBS represents both sides of the plan and control target.

Product-oriented WBS

A WBS essentially divides overall project scope requirements into a tree structure of work units that are created by decomposing the project scope statement into smaller and smaller segments until all work and required deliverables are defined. A sample three-level, nine-segment tree structure of an auto design project is illustrated in Figure 7.1.

The top one or two decomposition levels of a WBS identify a high-level view of the project's logical requirement, with little regard for the technical work required to achieve those goals (i.e., note the main auto components). As the lower levels are defined, these logical groupings are further decomposed into work units required to produce that segment of the overall project. The goal of this scoping exercise is to identify all of the work required to execute the entire project. In other words, if it is not shown in the WBS, it is not considered to be included in the project scope.

One of the reasons this project artifact is considered one of the most valuable (if not the most valuable) documents that the project team can produce is its broad applicability. This process helps one to ensure that project requirements are properly translated into understandable work units and this definition later helps in status tracking. These two roles represent a core project management activity that assists in dealing with one of the major management gaps in many projects. Unless sufficient scope definition is synchronized from both the initial vision and later-defined execution views, there is little hope that the final output will be accurate (Richardson 2010).

The formal project-planning phase commences with various definitional activities designed to identify the required deliverables and work required. Because of this core scope definitional role, the WBS drives many of the subsequent technical and management activities (PMI 2008, 117).

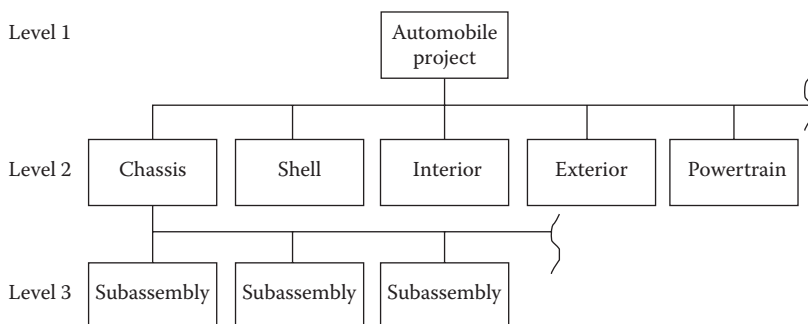


Figure 7.1 Auto project WBS.

Defining project work units

In addition to the schematic box and hierarchy structure shown in Figure 7.1, it is also necessary to supplement this view with a companion WBS Dictionary that further defines specifics related to each work unit. Envision a “package” of work that has been defined as part of a larger project. These “packages” can be any type of project task such as installing piping, testing software, creating a subassembly, or producing a user guide. For now, simply view each box as a work activity or collection of lower-level work units. The official vocabulary term for the lowest-level work units in the tree structure is a work package (WP). One metaphor for a WP is to view it as a box such as the one illustrated in Figure 7.2. In this view, the focus is on the three dimensions representing time, cost, and scope (of work). This visual metaphor will be used throughout the textbook to symbolize various aspects of project management roles.

To complete a comprehensive plan that includes more than surface-level definitions, the project team must make appropriate technical decisions regarding how to organize and view the work necessary to produce the desired output. One model view of project management is to envision the WP as a micro-building block for schedule development. If each WP has a defined duration and cost dimension, then stacking them into some technical sequence defines both the initial direct schedule and budget for the project. The related details of these mechanics will be explored in this section. Because of this definitional role, the WP becomes a major ingredient in the management process.

As the WBS boxes are defined, there is a common nomenclature for the basic elements. The following titles will be used here to identify the role of each box type:

- Top box—project goal
- First-level boxes—major subsets of the project goal

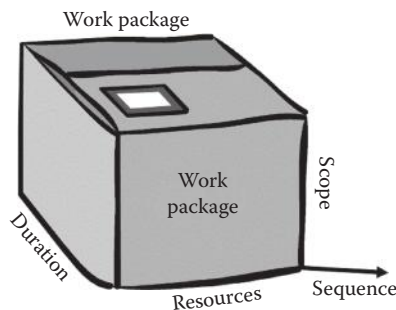


Figure 7.2 Work package dimensions.

- Summary boxes—collections of lower-level boxes (e.g., subsystems and phases)
- Planning boxes—larger boxes not yet decomposed but needed to define the full project scope
- Work packages—lowest-level boxes that represent the fundamental work units of the project assigned to specific organizations teams

From a management viewpoint, the most critical WBS development item is the aggregate definition of WPs that represent the effort needed to produce the desired output. There are many design rules of thumb regarding these units. A few to consider are listed below:

- A WP should be sized so that it can be executed in approximately 80 hours or 2 weeks' duration.
- A WP should be allocated to a single organizational segment whenever possible and that organization has formally approved its definition of work.
- Each WP should have a "performing organization" owner with an assigned manager.
- There must be some formal process to collect actual costs and measure work accomplished either at the WP level or at some level above this as the project manager approves.

Work package dictionary variables

Effective project WP definition requires many related items of information to fully assess the content of the work and integrate it into the rest of the project. Conceptually, it is desirable to capture this information into a single data repository that is officially called a WBS Dictionary (PMI 2008). Such a repository may not actually be visible by that name in real-world projects, but the type of data described below will need to exist somewhere in project records. To estimate and track project activities, it is necessary to define the following types of parameters for each WBS box:

1. ID reference—this is a WBS box code used to identify where the work unit fits into the overall structure (e.g., the WBS chart of accounts).
2. Work effort estimated for each skill group (e.g., hours and skills of each skill type).
3. Estimated duration for the task given the planned labor resource allocation.
4. Material requirements and other cost associated with each work unit.
5. Name of individual responsible for managing the activity.

6. Organizational unit assigned to do the work (e.g., performing organization).
7. Defined constraints (e.g., activity must be finished by ...).
8. Key assumptions made in the course of the planning activity.
9. Predecessors—linkages of this activity to other project work units.
10. Risk level for the activity—more work will be needed on this aspect later. For now, we will simply indicate the perceived risk level (e.g., H, M, or L).
11. Work description—this may be a reference link to another location where more detailed information is kept; sometimes called statement of work.
12. General comments—free-form statements that help describe the technical aspects of the work required.

In addition to these core definitional items, it is also necessary for the PM to have some control over work estimates for each box. One method of doing this is to delegate final work unit estimate approval to the PM. This check and balance prohibits the performing organizational group from excessively padding estimates to minimize overruns in their activities. Completion of data dictionary work unit detail produces sufficient technical information to create a first cut schedule and budget for the project. However, take note of the term *first cut*. This implies that there are more iterations required as new information arises, including that from key stakeholders who feel the plan is too long, too much, or not enough in some area.

It is always difficult to say that any activity is the most significant one to support effective project management and work control processes, but there is heavy evidence from industry researchers that indicates failure to properly create a work view similar to the WBS will negatively plague the project throughout its life cycle.

Role and structure of the project WBS

As the project definition moves from the high-level vision-oriented *what* definition of requirements downward toward the technical *how*, there is a need to translate this into something more akin to a structured technical work definition. This translation process is reflected in the WBS box structure, and embedded in the box definitions is both a requirements and a corresponding work relationship. A related value of this approach is that it serves as a good communication tool between the user's plain language requirement statement and the technical work required to produce those requirements. Both technical and nontechnical groups are able to understand what the tree structure represents and for that reason, it provides a communications bridge to confirm that the stated requirements are being recognized by the defined project work units.

Requirements “ibilities”

On the surface, the process of defining requirements sounds pretty simple: identify what the customer wants and then proceed to translate that into technical goals that will guide the design process. Beyond the basic mechanics of developing project work units, there are several other scope-related issues that are not obvious in this process. We will describe these as the following nine *ibilities* and one more general design attribute:

1. Traceability
2. Affordability
3. Feasibility
4. Usability
5. Producibility
6. Maintainability
7. Operability
8. Scalability
9. Sustainability
10. Simplicity

The parameters in this list are important definitional drivers in the planning and design aspects of the project. Each *ibility* represents a deliverable attribute that is likely not well defined in the original requirements, but quantification that is needed for guiding the design. These items represent supplementary definition to the defined product or process goal. Each of the *ibilities* should be quantified as part of the overall specification elaboration to ensure that the best design choices are made. In many situations, the design question becomes one of trade-offs between time, cost, scope, and quality. Examples of these trade-offs are listed below:

- Cost of development versus future maintenance cost
- Quicker development versus more custom fit
- Ease of use versus lower development cost or time
- Value engineering (VE)—how to produce the product more efficiently based on *ibilities* priorities
- Risks associated with a particular approach

As the project moves through the scope definition life cycle and related physical design processes, each of these considerations should be formally reviewed by appropriate members of the project team. All too often, one or more of the *ibilities* are ignored and the ultimate result is downstream frustration by someone in the chain of users or operational supporters. The section below will offer a brief definition of each *ibility*:

Traceability is “defined as the ability to describe and follow the life of a requirement through the life cycle (i.e., from its origins, through its development and specification, to its subsequent deployment and use, and through periods of ongoing refinement and iteration in any of these phases)”.

Affordability relates to a match of the design approach to the budget constraints. There is always pressure to cut design costs, but there must be a balance between cost and design goals.

Feasibility is a term that can have many different meanings in the project environment. The most obvious of these is the technical feasibility for the selected design approach. However, often times stretching to achieve some higher performance goal will go beyond existing capabilities and create additional project risk. In a similar fashion, the lack of critical skills or budget can make a project infeasible. Think of feasibility as anything that can get in the way of technical, time, or budget success, whether that be a technical item or otherwise.

Usability involves how the process or product functions in the hands of the future user. It is making sure that the product developed, whether a physical device, software, or website, is user friendly. It is common to perform usability testing to gather user feedback on the adequacy of the design.

Producibility is an attribute related to how the actual item will be constructed. In many cases, there is a gap between the designer and the builder, so the key is to be sure that the building function is represented in the design process and probably even in the initial requirements process. Think of this as a “chain” of events that need to be linked together and not just thrown over the wall to the next group hoping that the previous decisions were appropriate. Each stage in the development represents special skills and complexities that need to be considered.

Maintainability deals with the item in production. This relates to the level of effort to keep the device ready to perform its function. In the case of high-performance devices, there is often significant downtime for maintenance, which then means that it does not perform at all. For this reason, it is important to understand the future operational requirement. Having a device capable of “jumping tall buildings with a single bound” sounds good, but what if it can only do that about 10% of the time, with the remaining period being down for some type of maintenance. There is clearly a trade-off consideration here. One design trade-off in this case is to find a way to perform the maintenance quicker or do less of it, but certainly the best choice is not to ignore the issue.

Operability involves the future user’s ability to easily and safely use the product or device. Many years ago, aircraft designers found that the

location of gauges, switches, and knobs had a lot to do with the safe operation of the airplane. Likewise, automobile designers in recent years have found this to be an issue with some of the new devices being installed in the modern car. The author recently spent 30 min reading his auto manual to try to figure out how to get a particular item to show on the multifunction dashboard screen(s). Ditto trying to figure out the options on the modern TV set. Every device or process has some degree of characteristic like this. Think of this attribute as not changing the requirement but making the requirement easier and safer for the user.

Simplicity is an overarching concept. Complexity is the natural state. The goal is to find ways to achieve complex output as simple as possible. This is a motherhood term, but is a real management and design requirement.

Scalability connotes the ability of the product or process to handle higher level of activity. For example, a computer system might be capable of handling 100,000 transactions per second. How easy would it be to expand that capability and to what level?

Sustainability is the least understood of the *ibilities*. This term goes beyond all of the other attributes in that it evaluates the ability of the process or product to exist long term. For example, will the underlying technology survive? Will the design be functional for the required time frame? As an example, Mercedes and other high-end car manufacturers have a reputation for their car designs not looking old for a long time period. In high-technology projects, this can be one of the most difficult factors to deal with given the low predictability of the next new technology. In fact, maybe “predictability” is yet another *ibility*. If the project team had an accurate view of all technical and organizational futures, these goals could be better achieved. All too often, some technology is used in a design only to find in a much too short period of time that some better technology has been introduced and made the current approach obsolete. When that occurs, all of the other *ibilities* have also been adversely impacted.

A final word on this set of requirements elaboration concepts is that they are important to both short- and long-term project successes. One of the key steps in both requirements and design reviews is to examine the *ibilities* list and resolve the trade-offs outlined here. Recognize that the requirements specification process generally involves trading off aspects of one *ibility* for another. Seldom is the goal to maximize all of these. So, the challenge is finding the appropriate mix. This is an important step in completing the requirements specification because of this trade-off decision process. Improper choices made at this point will follow the project through its life cycle. Eventually, the future user will have less satisfaction

with the result if these are not dealt with properly. Recognize that an obsolete, nonfunctioning, or hard-to-use project deliverable item decreases its ultimate value.

WBS design rules of thumb

Various sources describe general rules of thumb regarding the WBS construction process and each of these has a slightly different take on how best to structure the schematic tree. As an example, PMI's *Practice Standard for Work Breakdown Structures* provides guidance and sample templates for various types of projects (PMI 2001). Also, various governmental and DoD sources vary their dialect instructions for their mega project environment (DoD 2011, DOE 1997). According to the Department of Energy (DOE) project management methodology, the first three levels of a WBS are defined as follows (DOE 1997):

Level 1: Major project-end objectives.

Level 2: Major product segments or subsections of the end objective (these are often defined by the major location or by the product goal).

Level 3: Decomposed components, subsystems, or subsets, of the level 2 major segments.

Regardless of the specific methodology used, the key construction principle is to capture the project requirements, organize those into a single tree structure, and then manage the project using this structure. Although there are guidelines regarding what the top structure layers should mirror, the overriding design criterion is it should mirror the way the project is to be executed. In situations where an organization tends to do one type of project, a standard WBS structure template will likely exist. In these cases, a common design structure will cut down on the initial planning effort.

There are several alternative design groupings for the higher layers of a WBS structure. Samples of these are as follows:

1. Using standard templates created from similar recurring project types.
2. Modifying the structure used from a successful similar effort.
3. Defining the major physical product groups and then decomposing that structure downward (e.g., note the physical house components).
4. Starting with lower-level defined work elements and aggregate them upward into a logical hierarchical structure (i.e., bottom-up design).
5. Packaging the structure using the required deliverables as guidance (Schwalbe 2006, 163).
6. Defining major phases at the top level and then structuring downward using one of the other schemes mentioned above.

Regardless of the method used, the resulting structure must represent the total project work required. As a metaphor, liken the WBS boxes to molecules that make up the total project chemical compound, we can also expand this analogy to include views that the associated human and material resources assigned to these molecules are then the atoms, but hopefully it is clear from this discussion that the work unit collection represents the entire project requirement set.

In the ideal model, each box in the WBS will contain a corresponding SOW that can be used by the assigned resources to execute that incremental element and its associated deliverables. In addition, quality and other related technical items would be documented sufficiently to support future testing and other operational aspects. It should be obvious that this process represents a vital management and control concept that should be pursued by all project managers.

In some situations, it may not be feasible to fully decompose the overall structure to the WP level during the planning phase. At some point in the planning process, the decision could be made to move forward into execution with the components that are defined adequately and then leave further elaboration of the remainder for later in the execution phase. This means that some segment of the total WBS would contain work units at a higher level of definition than described thus far. Recognize that this also means that there will be a higher potential for error in the defined planned time and cost values and possibly other “hidden” issues that were not defined. These higher-level nondecomposed work units are called *planning packages* (PP). Except for their size and level of definition, this collection of work units will have the same role in producing the subsequent project schedule and budget. Prior to actual work being performed on a particular work unit, it should be properly decomposed. This form of plan evolution is called the *rolling wave* approach and is another example of progressive elaboration.

WBS decomposition mechanics

The development of the WBS top level represents the project’s highest view. There is no right or wrong answer to this structure, but it should represent the way in which the overall project scope is best understood and managed.

The theory and concepts related to a WBS are quite easy to understand; however, a basic question remains regarding how to identify the correct structure for a specific project. The list below contains items that may help decide on the proper high-level packaging structure:

1. Are there logical partitions in the project? What major phases make sense? These could be candidates for the second-level grouping.
2. Are there major milestones that could represent phases?

3. Are there business cycle constraints that need to be considered (e.g., tax period and scheduled down time)?
4. Are there financial constraints that might dictate phases?
5. What external company life cycles might impact the project?
6. What development methodology is being utilized? It typically would define the basic development process.
7. Are there risk areas that need to be specifically recognized (e.g., technical, organizational, political, ethical, user, and legal)?

In addition to the ideas above, the list below offers some basic decomposition steps to consider in evolving the structure below the top layer (adapted from Haugan 2002):

1. Identify the top-level view that represents how the project will be defined within its program, phase, or project component structure.
2. Identify the goals of the *entire* project. Consider each primary objective as a possible top-level element in the WBS hierarchy. Review the SOW and project scope documents to aid in this decision.
3. Identify each phase or component needed to deliver the objectives in step one. These will become second-level elements in the structure.
4. Break down each project phase into the component activities necessary to deliver the above levels. These will become third-level WBS elements.
5. Continue to break down the higher-level activities into appropriate work units.

This process should continue downward until the work units are well defined and linked to a single organizational unit owner. The lowest level defined work units should fit into the size definition supported by the organization, but small enough to support manageability. If this is not feasible at this stage, the unit should be labeled a PP and handled accordingly. It is a management decision regarding the appropriate decomposition level for the work units, but scheduling accuracy and future control granularity will be decreased if large work units remain in the structure.

Project team involvement during the scope definition process is imperative for moving the WBS through the “yellow sticky note” or white board stage. Using this technique, team members should discuss proposed structures and draft possible high-level views on sticky notes that are then arranged on a wall. A WBS will emerge as these are discussed, combined into groups, and then moved into a desired structure. Figure 7.3 illustrates this group process.

The group development process should normally work from a top-down view. Once a particular WBS high level is defined, it may be possible for a portion of that structure to be allocated to a subteam for more

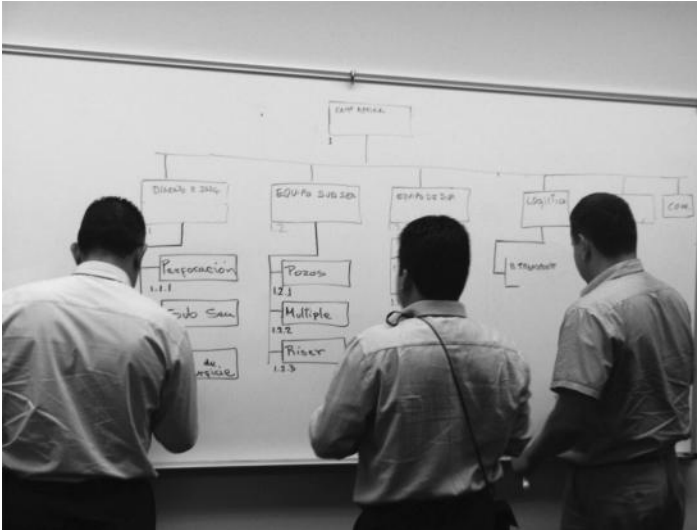


Figure 7.3 Developing the WBS with white board.

segmented and detailed discussion for that portion. Later, each subgroup would make their presentation to the whole team to ensure that other “across-the-tree” editing is not needed. This review should generally occur on a level-by-level basis through at least the major project segments. As the process moves downward, the horizontal level of interaction across the structure often declines as the work begins to align itself into more independent units. Continuing with the earlier house analogy, recognize that a site preparation work unit does not impact the internal house work units such as the electrical work plan. That same segregation is common for other aspects of the design once the structure is decomposed to that level.

As the final WBS structure is completed, it is still necessary to make formal scope-oriented presentations to key organization and technical stakeholders to ensure that the overall plan is coherent.

Facilitated WBS design sessions can often complete a draft structure in fairly short time periods, assuming that the project goal is reasonably familiar. However, if the project involves high complexity or a new type of venture, this process might require multiple sessions to resolve various issues. Regardless, the process of decomposition into lower levels of detail and review remains essentially the same. Failure to resolve the scope of work issue at this stage creates multiplied negative consequences later.

Some level of the overall project design should be shared with future users and key management. This activity is technical and marketing-oriented. Later, as the project is completed, the WBS helps in the review of

outcome status. As illustrated, the communication value of a WBS is broad and will be seen in various aspects of the project life cycle. As new project team members arrive on the scene, a WBS and its dictionary serve an equally valuable role in providing technical and work insights into the project. This helps with team communication and provides a spirit of collaboration.

Sample WBS

Figure 7.4 illustrates a sample abstract WBS, except in this case, the higher-level boxes has been labeled as a phase-oriented structure rather than physical product decomposition. In this format, the focus is on ensuring that the defined project deliverables are covered in each phase. This format helps to link requirements to the associated work units. In other words, if work unit 1.2.3.1 is to produce a specified deliverable, that should be part of a future quality check upon completion of that activity.

Keep in mind that the number of levels in a WBS structure depends on the size and complexity of a project. Another stylistic box naming consideration is to use nouns as titles, rather than verbs. This helps focus on what is to be done and not how it will be produced. *As the scope development migrates from the higher layer, the focus of the lower WBS structure layers evolves toward the work required by an organizational unit to produce the project deliverables!*

WBS numbering scheme

There are various schemes that can be used to label the WBS boxes; however, in most of these, a decimal point-type numbering approach is used to reflect the hierarchical layers (review Figure 7.4 for this view). Mature project management organizations such as the Departments of Energy and Defense have standardized the schemes for box numbering as well as the product-level definitions for the higher levels. The key role of box numbering is to identify aggregations of work units. As an example, if

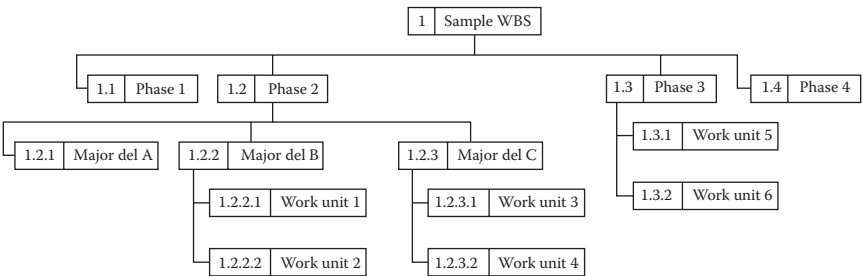


Figure 7.4 Draft WBS with deliverables identified.

the top box in the WBS structure was labeled “1,” then the boxes in the immediate layer below would be 1.1, 1.2, 1.3, and so on. Conversely, if the top layer is labeled “0,” then the layer below would be defined as 1, 2, 3, 4, and so on. Regardless of the top-level number, a decimal-type notation is used to identify the cascading layers below.

Recognize that new work (boxes) will be defined through the course of a project as a result of approved CRs. This means that it would be advisable to leave some gap in sequence numbers so that the future changes and additions can be slotted into the WBS without destroying the overall number scheme. This could be accomplished by using increments of 10 in the numbering sequence. Failure to leave gaps will mean that the codes will be harder to relate to their owning group. As a final point on the schematic mechanics, realize that these numbers will be used in other processes such as time, cost and schedule tracking, risk, communications, HR, contracting, and quality. This numeric coding system provides an excellent reference between the defined work and various knowledge area processes.

WBS structure model comparison

Table 7.1 illustrates a *flattened WBS*. Translating the schematic view into a more linear data list is more compatible for computer processing, but the same data exist in both views. To make an additional point, this table contains two activity lists with the same work units in both. Note that option A divides the work by technical work area, while more of a life cycle process view is reflected in option B. The point of this dual example is to show that the same work units can then be sequenced in more than one way with an identical related schedule for the defined effort. Which one is right? Which one is best? If the performing organization had a strong departmental culture, option A might reflect that view best, whereas option B looks at the effort more as an organizationally coordinated group of activities evolving through life cycle phases and that may be the preferred view. Note that the traditional method for software development is to view the preferred work process as one that moves through a defined life cycle process similar to option B. Regardless of the actual structure used, design of the overall WBS architecture should be one of the early project team conversations.

As an alternative example, if the project target involves a physical product deliverable, then there is a stronger bias toward viewing the proper work structure as mirroring the physical device components at the higher levels. Figure 7.1 previously outlined an automobile WBS showing its physical components at the top level. In this case, there is a major focus on the work required to develop the major components. Under this definitional level would lay more details on the work to produce that item. If

Table 7.1 Modified WBS for Software Development

Software development A	Software development B
1. Software development A	1. Requirements
1.1 Develop initial software design	1.1 Develop software requirements
1.2 Develop final software design	1.2 Develop hardware requirements
1.3 Execute software construction	1.3 Develop documentation requirements
1.4 Develop software and approve	1.4 Develop training requirements
2. Hardware	2. Design
2.1 Develop hardware requirements	2.1 Develop initial software design
2.2 Produce initial hardware design	2.2 Develop final software design
2.3 Perform final hardware design	2.3 Produce initial hardware design
2.4 Perform hardware acquisition and install	2.4 Develop final hardware design
2.5 Perform hardware installation	3. Construction
3. Documentation	3.1 Execute software construction
3.1 Develop documentation requirements	3.2 Perform hardware acquisition and install
3.2 Perform documentation	3.3 Execute software construction
3.3 Approve documentation	3.4 Develop documentation
4. Training	3.5 Develop training materials
4.1 Define training requirements	4. Testing
4.2 Develop training materials	4.1 Develop test plans
5. Testing	4.2 Develop test cases
5.1 Develop test plans	4.3 Perform unit testing
5.2 Develop test cases	4.4 Perform system testing
5.3 Perform unit testing	4.5 Perform user acceptance testing
5.4 Perform system testing	4.6 Approve training materials
5.5 Perform user acceptance testing	5. Project management
5.6 Approve training materials	6. Project close
6. Project management	
7. Project close	

the goal of the auto WBS was to define the entire project, it is obvious that other more detailed boxes would also be required. For example, does the auto need to be designed, do we need to show other support activities, or is any form of testing required to complete the project? Obviously, if the goal of the WBS box structure is to represent the total scope of work, then there are additional definitional work units that would need to be added to various segments of the base structure shown. Decisions such as this then modify that simple initial product component structure.

Standardized templates

Standards documents from DoD and other governmental organizations define WBS templates for various project types. These templates standardize the box structure for the top three layers and are much more rigorous than previously outlined here. DoD Mil-Std-881 offers an example of a standard template for various types of military procurement items. As an example, the following list defines a standard WBS box template at level two to define a surface vehicle system (DoD 2005, 106):

1. Primary vehicle (product components)
2. Systems engineering/program management
3. System test and evaluation
4. Training
5. Data
6. Peculiar support equipment
7. Common support equipment
8. Operational/site activation
9. Industrial facilities
10. Initial spares and repair parts

Note that this view contains both the physical product-related items (#1) and then a set of other required work units related to support, training, and implementation. In addition, this standard structure also defines a third subordinate level below each of these top-level structures. Envision this approach as representing a mature management environment in which similar types of large projects recur. Use of templates such as this aids in minimizing the initial work design activities and provides a common set of historical data for future projects. Realize that the concept of standard templates for recurring project types is a valuable project management practice for all organizations.

The DoD WBS scope definitional model should be viewed as one that has survived the test of time and offers insights into how a large project views its work environment. Also, realize that one rationale for this design structure is based on the fact that most of the work units are performed by third-party contractors and these projects are multibillion dollar ventures. Take away this assumption and some alternative physical structure format might be more appropriate. Also, smaller projects would have lesser definition vertically, so lesser layering would be required.

WBS dictionary

A companion artifact to the WBS schematic is the WBS Dictionary. Its goal is to add further definitional content to the structure. One way to look at a WBS is as a project scope skeleton, while the associated dictionary is the

“meat on the bones.” Together, these two artifacts provide a potentially full view of the project scope, work, and its deliverables. Figure 7.5 illustrates sample data elements that are often included in the WBS Dictionary. Note that each box in the WBS structure would require this type of information to support the related planning and control processes.

Project name:			WBS ID #			Revision # and date:					
Element title:											
Work description:											
Deliverables and acceptance test measurements:											
Guidelines or related policies:											
Assumptions/definitions											
Complete section below only for work packages											
Dependencies											
Predecessors						Successors					
Short name:		WBS #:		Type:		Short name:		WBS #:		Type:	
Performing Org. approval						Project Mgr. approval					

Figure 7.5 Sample data dictionary template.

Other WBS views

The concept of using WBS nomenclature to communicate different project attributes has many operational benefits in the project management process. One common use for this is to sort or segment WBS Dictionary data by various attribute keys. One of the more common examples of this relates to external vendors when they are contracted to produce a WBS subtree, or branch, of the overall structure. In this situation, the contracted segment is essentially “cut off” and transferred to the vendor. That segment may then essentially disappear from the view of the internal project team since there is no internal control or work process for that segment. In a fixed-price contractual agreement, this work is delegated to the vendor with little status visibility required. In more complex project situations, the vendor might have to be fully involved in the original work decomposition process just as though they were internal members of the team. In the case of smaller scope procurements, the subcontracted portion of the work might be shown on the WBS as a single summary box. Other hybrid options for this would need to be established, for example, if there is a status reporting requirement included in the contract—that is, not showing resources but using the ID codes for status reporting. This substructure option is called a contract WBS (CWBS) and there can obviously be more than one such subgrouping within the overall project structure.

A second common reformatting of the WBS is organizational or resource-centric, meaning that the work units are sorted into collections of work by either organizational or resource skill group. If the WBS work units are sorted by responsible organizational performing group, the view is called an organizational WBS (OBS). Also, a similar sort can be made by skill group time-phased across the life cycle. This is typically called a resource WBS (RBS) or staffing plan. Likewise, sorting time-phased WBS units by cost would show the project cash flow or direct cost baseline. These various aggregations are important planning and control artifacts with many different uses, but collectively they illustrate the broad role and value of the WBS and its detailed data. No other management artifact can claim a broader function than this one.

In recent years, yet another WBS structure format view has emerged. This view focuses on project risk management. Risk attributes or levels can be highlighted by WBS segment, or a risk profile, and can be represented by a schematic structure similar to the WBS. This grouping format is called a risk breakdown structure (RBS) (yes, two different views exist with the same acronym). In some situations, a standard risk profile is produced using the tree structure and it divides potential project risk into categories based on category. Sorting data in this manner aids in developing risk mitigation or monitoring strategies. When risks are defined this

way, the exposure to that risk can be tracked through time via the WBS ID and related project plan schedule.

As these various examples illustrate, there are many different acronyms related to the use of WBS-like aggregations of project data, each coming from different domains and focusing on various project management components, that is, goals, work, HR, procurement/contracting, organizations, risk, status reporting, and so on. Because of this multiuse phenomenon, the term WBS is often used to represent many different project variables. Regardless of the format, these variations have emerged more to focus on specific project activities than the classic pure scope-oriented definition of the WBS term. One could quibble with the way this is represented, but the more important idea is to understand how arrayed data in this format aid in the planning and control aspects of the project. It can be thought of as any hierarchical box structure diagram as a topic packaging strategy that can be used for many roles even though the official definition of a WBS is that it consists of only a short description and an ID code for each box (PMI 2008).

What is often lost in the discussion of the WBS concept is the associated work unit data that should be captured in a supporting data dictionary. Discipline in capturing work unit information in a usable and defined repository has great value not only for the current project, but also as a valuable archive for future efforts. Experience will show that the WBS and dictionary companion tool set is one of the most valuable artifacts that can be produced for management planning and control activities. In many of these situations, the WBS ID code will be used to link a particular topic to project work. These box ID code references become project mail box IDs to help identify where a particular event occurs.

Project templates

As indicated earlier, a WBS tends to have a somewhat common structure for similar project types. One can find libraries of such templates on the Internet and these can provide a good source for reviewing project structure options. See Appendix C for a sample review of template sources. Also recognize that an organization may establish a local standard high-level template such as the DoD examples for a particular class of recurring project types. One subtle reason for doing this, beyond saving time in scope development, is to be able to better estimate resources and costs for future projects since costs are captured in a consistent grouping.

Templates can be either structural work unit shells to outline the major boxes for a project type or more elaborate in terms of levels with supporting historical data. A mature organization would also have formal processes to supply supporting information from the historical projects to aid in detailed project planning; however, the more typical template is

Table 7.2 Software Development Template

WBS	Task name
0	Standard development template
1	Planning
1.1	Initiation
1.2	Meetings
1.3	Administration
1.3.1	Standards
1.3.2	Program office activities
2	Define product requirements
2.1	Define requirements
2.2	User documentation
2.3	Training program
2.4	Hardware
3	Detail design
4	System construction
5	Integration and test
6	Project management

more of a blank WBS structure with little supporting background data, but even this can be a real planning time saver for the project team.

Table 7.2 contains what could be considered a software template that an organization might wish to use for all of its internal development. Once local PMs have been trained in using this type of template, the time required to develop a specific plan is greatly shortened. In fact, this particular template actually has other layers not shown here for space reasons. In that case, average work unit durations might be included as well as technical activity sequence data. These additional data add further value to the usage.

There is one more WBS vocabulary concept shown in Table 7.2. This term is called *cross-cutting*. Some projects require a work unit that integrates or supports broader segments of the structure. In the software template example, the need for such an activity is represented as planning or design. These two work units contain activity that “cuts across” the basic deliverables. In a typical project design, these cross-cutting activities are typically supplementary to the core deliverable structure that is typically represented by a physical product-type model. In this example, these work units are needed because it is not possible to execute the core process-oriented deliverables until the overall design is accomplished. In this manner, the cross-cutting activity is required to support multiple other core segments of the structure.

When similar projects have been produced previously, the WBS format should be very well established in regard to the desired work units

that fit the new project. In such an environment, the template may well represent a 90% work unit match. If we add to that the historical or average information from previous projects and lessons learned documents, one can see even more value potential.

One of the common complaints regarding formal project management is the amount of documentation overhead and the time that it requires. In a poorly run organization, this additional management level may be as high as 20% of the project cost and therefore may justify that feeling; however, in a mature organization, project management overhead will be closer to the 5% range, especially when accompanied by reuse advantage of template-type data and well-defined support processes. Templates represent reusability and are one of the key methods to cut “reinventing the wheel” syndrome with each new project. Recognize that there is significant similarity in projects and one of the best sources of planning information comes from historical documents if that data can be efficiently retrieved.

Project scope baseline

Once the overall project scope as represented by the WBS has been approved, this view with all of its related data is *baselined* (frozen). The approved base point then serves as a control framework for follow-on stages of the project. Organizations deal with such baselines in various ways. For example, the initial scope baseline represents an overall project deliverables and work definition specification that has been formally agreed upon by the customer and the management as representing the project requirements. However, as other related planning decisions are made in areas such as procurement, risk, quality, HR, and others, the early project work definition can change somewhat. This has the impact of changing the WBS box detail. As these decisions evolve through the formal planning phase, a final WBS scope view will be presented to the management that includes all of the planning stage decisions. This view would represent the *approved scope baseline* and becomes an official control definition artifact.

Actually, recognize that the term *baseline* can apply to other project metrics such as time, cost, quality, technical performance, and so on. Also, as the project moves into execution and major changes occur, the project management board might decide to approve yet another set of baselines based on the newly approved and revised project definition. This version could be titled *revised baseline* and this change process is called *rebaselining*. Less official approaches would simply label a particular version “*baseline n.*” From a management viewpoint, a defined baseline is used to compare actual project performance. In most cases, the initially approved baseline will be the one used to compare project performance.

Regardless of how one goes about labeling baselines, beware that overuse of this term can confuse the control process. Changing the schedule

every week and saying you are on schedule is similar to changing the baseline frequently and saying that you are working on the same project. Both are misleading. The *iron law of control* says that the project would always be comparatively measured from the original approved version, regardless of any other comparisons.

WBS design exercise

This WBS design example is adapted from a software design project scoping workshop to illustrate how the WBS process is used to structure a project work outline. Stage 1 of this effort is shown in Figure 7.6 and outlines the initial first-level view of a software design scope.

Once the high-level compartmentalization is defined, the next stage is to evaluate what might not be in that view. The list below simulates the type of questions that SMEs might raise about this structure:

- 1. How will the design for this item be done? Should it be partitioned into hardware and software groupings, or would it be better to keep it as one combined team doing both?
- 2. What issues emerge in reviewing the *ibilities* list to describe specific design goals for major sections of the WBS?
- 3. If the idea of needing a prototype is raised to help visualize the deliverable’s functionality, where should this work unit be located in the structure?
- 4. Where in the structure should testing be performed?
- 5. Where should user acceptance processes be performed?
- 6. Assume this project is using untested technology. Is there sufficient confidence that it will work, or would it be prudent to evaluate this technology item early in the life cycle before the development process is committed? Where should that test be performed?
- 7. If there is a contractual commitment to warranty a product for one-year, how can this requirement be shown in the project scope?
- 8. It looks like the training requirement for this effort is much more complex than indicated by the charter. Recall that there is now a requirement for a web-based, classroom, and hands-on-type training in addition to the regular paper user guide documentation. How should this expanded training scope be represented?

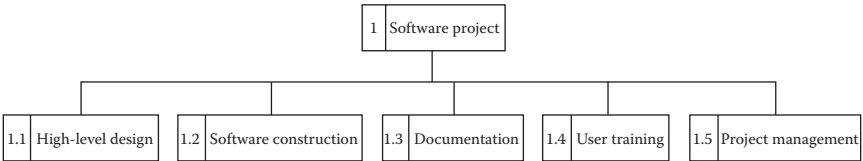


Figure 7.6 Software design WBS stage one.

Note how this type of dialog question/reaction helps guide the base requirements toward a final WBS. It should be obvious that answers to these questions add not only definition to the process, but also potentially new work. This example process illustrates the iterative nature of WBS development and shows how it can lead to an improved scope definition.

Summary

This chapter has described how a logical project goal or vision can be translated into defined project work units. Essentially, this involves a decomposition or elaboration of the initial verbal goal definition into increasingly detailed work units necessary to produce the defined deliverables. The WBS can be viewed as both a deliverables and associated work-oriented view of the project. The top levels focus more on the major deliverables and components, while lower-level units describe specific work required to achieve those deliverables. These defined work units become major elements in both the planning and control processes. When completed, the WBS contains a collection of work entities called summary packages, planning packages (PP), control accounts, and WPs through which the project will be viewed. Remember that the defined control accounts are used to represent the points at which work will be measured, actual resource consumption collected, and status evaluated.

QUESTIONS

Review questions

1. In starting to schedule WBS defined work units, what information would be most valuable for that effort?
2. Describe some strategies for an organization to improve access to historic project information and lessons learned.
3. In the new role of being in charge of organizing a rock concert fully responsible for all aspects of this experience, the first assignment was to look at the major activities for this effort. Four key activities were identified as tickets, staging, talent for the show and security. Review the first cut WBS structure and expand it into a more reasonable project scope view using question/response process outlined above.
4. As the new PM of a large effort to change the work process related to customer support for a large company, develop a first cut (two-level) WBS for the work effort. This is an online-type catalog operation and there are currently many customer complaints that have been documented. For this exercise, recognize the dual role of both the customer and project team member.

In-class questions

Use the list of topics below to discuss the role that the WBS concept plays in project planning and future control.

1. Define the term WBS.
2. What is the SME's role in the WBS development?
3. When did the WBS concept emerge in early project management history? Why did it stand the test of time, while other ideas did not?
4. What is the most frequent WBS structure for a tangible product?
5. What does the term "cross-cutting" relate to? Give some examples of cross-cutting work units.
6. Name at least five major management roles of the WBS in a project.
7. What is the 100% rule?
8. What is the difference in a WP and a control account?
9. How does a PP differ from a WP?
10. What does progressive elaboration mean?
11. What is the basic management issue with WP size targets?
12. What are some of the philosophical differences between DoD-type projects and the commercial environment?
13. Describe some of the roles of the WBS box numbering scheme.
14. Why is a WP represented as a three-dimensional box?
15. What is the fundamental management issue between the WBS and project scope changes?
16. What do *ibilities* relate to?
17. What does flattening the WBS mean?
18. What is the fundamental test of the first level of a WBS?
19. What is the role of a WBS Dictionary compared to the WBS?
20. Describe some of the fundamental WBS Dictionary data elements.
21. What are some of the basic uses for a template?

EXERCISES

1. Using the brief project charter included below, develop a first cut WBS outlining the scope for this project (three levels maximum). From this structure, answer the question set outlined below.

Project charter

Project title: Time-tracking project

Estimated project start date: April 6, 2014

Desired projected finish date: October 24, 2014

Project manager: Bobby User

Project objective: The goal of this project is to implement resource time-tracking software for 1000 employees in a software development

firm having locations across North America. The system will be used to record time spent on specific activities and generate reports. This requires integration into the accounting system for data feed into various company accounts, client billing, accounts receivable system, and the project management system. This system will capture time and resource costs on each project work activity and feed the organization's payroll system.

Assume that the system requires installation of a new hardware and software desktop device for all 1000 employees. All hardware and software components will be acquired from third-party vendors; however, the organization has additional unique requirements regarding how the new software will integrate into the existing information infrastructure. Assume that all standard organizational functions are involved in this implementation (e.g., engineering and development, marketing, finance, sourcing, legal, IT, and admin). This organization is a vendor for government-sponsored projects, which necessitates high data and information security requirements.

The new system will require user familiarization training for each employee that is tentatively planned to be delivered in groups of 20 via face-to-face sessions. The implementation process will likely require a phased implementation, which will then require careful coordination and testing for each element. Also, it is desired to shut down the current system as soon as possible given its high operational cost.

The management has provided the following guidance:

- a. Assume an average fully burdened labor rate of \$90/hour and \$500 K in total project labor costs.
- b. A target budget of \$3 million for hardware and software costs.

The project is to be completed in 6 months owing to high ongoing maintenance and decommissioning costs for the current system.

During the period 1 December through 31 January, there is an accounting process that requires all activities to be frozen to allow the year-end financial process to be completed.

Roles and responsibilities:

Patricia Zyble—project sponsor

Gary Atkins—project manager

Doug Reva—PMO

Scope design assumptions:

- a. Assume that you have adequate staff to meet the project requirements. Some work will need to be done after hours to avoid work disruptions, and overtime pay will be provided at 1.5 times the regular salary.
- b. The corporate standards group has specified the desktop configuration for each user group (e.g., vendor, hardware configuration).

Ideally, all devices would be identical to simplify operational support. Estimated hardware unit price is \$2500 per desktop, plus \$1000 for software/desktop. Users requiring unique software will not be included in this project scope at this time.

- c. Third-party vendors have not yet been selected.
- d. Vendor sourcing requires a standard RFP to be completed and reviewed by the management for at least three competitive solution providers.

Deliverables:

- a. Provide rough order of magnitude (ROM) estimates for work and cost for each WP. From the derived structure, define a first cut-related activity list and estimated duration for each WBS box.
 - b. Create a WBS high-level summary phase structure for this project.
 - c. Create one more activity level for each high-level group and draft a sample WBS Dictionary specification for one of the major work units. The total structure would now be the top box and two levels below that.
 - d. Create one sample brief WBS Dictionary entry for one of the major low-level WPs indicating the associated work requirement and key predecessor relationships to other work units. Use the sample dictionary template described in this chapter.
2. This exercise is adapted from a standard WBS ship project activity list prescribed by DoD in its MilStd-881 specification (DoD 2011). A modified Excel activity list from this specification can be extracted from the publisher website as *7 WBS Ship Activity List*. Use this list as a starting point template for a WBS and then complete the scope definition with associated activities necessary to build a complete project plan. Note that the current list focuses on the physical product. To modify this view into a more complete management-oriented view, additional definition of the initiation and design phase activities should be added. The project team has defined the additional activities for inclusion in Table 7.3.

The initiation phase activities focus on creating a contract for the project, whereas the design activity group involves work related to creating an engineering-level design specification.

In addition to these two supplementary activity groups, systems engineering and program management should be added as a recurring set of activities necessary to manage the overall work effort. The recurring activities are reflected in the WBS as a single work unit (box) and are to be placed at the end of the activity list. After adding these work groups and associated task elements, produce the resulting project WBS schematic using either WBS Chart Pro or

Table 7.3 Ship Supplementary Activities

Activity
Initiate project
Initial requirements definition
Create contract structure
Issue bid requests
Compare biddings
Select contractor
Finalize contract
Ship design
Design proposal
Buyer review
Final design
Buyer acceptance
BOM development
Procurement analysis

Visio, or any graphics utility (see Appendix C for these utility download details). The deliverable for this exercise is a completed WBS properly labeled.

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chapter eight

Activity estimating

Introduction

One of the common questions a PM often gets is “how much do you think this project will cost and how long will it take?” It almost seems a requester believes this person has some magical computer in their brain that can come up with such data. There are many factors that come into play regarding time and cost estimation. This chapter will explore some of the typical procedural approaches for creating a project time and cost estimate, but be aware that estimating is an art form as much as a mechanical process or scientific formula. Every industry has its unique methods of producing their project estimates. It is also important to point out that the large majority of projects do not meet their original estimates, so this suggests that the processes utilized have shortcomings. In reality, most estimates are overrun (Verzuh 2005, 168). Some of this is caused by a poor process to start with and some is related to subsequent ineffective management of the project which in effect causes the overrun. As project management methods have matured over time, estimates are now matched more closely to the actual outcome, yet significant variances still remain.

The process of estimating the accurate project outcome is complex for many reasons. The most obvious of these involves translating a vaguely defined goal requirement into an equivalent work time. Tightly embedded into that view is the variability of human productivity for the defined tasks. Finally, wrap all of this around the organizational process complexities and we have at least a high-level global perspective.

To understand the role of estimating in the project life cycle, envision how an accurate estimate can improve the overall stability of the work process. If this can be accomplished, the project can move along in a reasonable fashion since events can be efficiently prescheduled. Conversely, a poor estimate places the project team under stress in dealing with unplanned resource variance issues, accelerating work activities, and placating unhappy customers. Since one of the management goals for a project is to complete the defined effort on time and budget, an accurate estimate represents one of the core elements to support that goal.

What to estimate?

Although this question seems trite, think about what the term *estimate* suggests. It is normal to think of this in the project environment as a predicted outcome related to time or cost. But in addition to this, the question could also be to estimate the future technical performance for the project deliverable. For this discussion, we will focus on this term only from the perspective of a project time or cost estimate. Even within this limited view, the specific perspective of the term varies based on one's perspective. To further explain this we need to look at the various forecasting and terms associated with this vocabulary term.

Dealing with the estimating vernacular

Most individuals have attempted to estimate time or cost to complete some task. Experience suggests that in most of these cases, the estimates for even small tasks have not been overly accurate. One of the clouding variables within this domain is confusion over what is being asked. Let us use the following scenario to help explain this point. Imagine a senior manager saying "how long do you estimate this project?" It is assumed in this case that he is talking about a calendar view of the effort. Alternatively, if a technician was asked to estimate the time to accomplish some defined task that he might respond with 7 days or 50 hours. What does this response mean? Third, if a team leader was asked the same question, it may have a similar answer but embedded in each of these responses is a different view of the question. Let us see if these differences can be explained by reviewing what each organizational level views as a time estimate. The following perspectives are typical:

Senior manager—calendar date

Performing worker—how many work days for him personally to complete the work

Team leader—how many work days for his group to complete under some assumption of resource availability

Placing this scenario into a more vocabulary-oriented structure, we are talking about combinations of the following three variables:

Elapsed time—calendar cycle time

Work—amount of total work required

Duration—number of work days based on resources allocated

Note for each response above, the view is different, yet each could be perfectly accurate. Confusion over these terms is quite common and something worth to be aware of in conversations.

Cost estimating

Creation of a project cost estimate contains multiple components and layers as addressed later in this discussion. The basic direct work unit estimating cost drivers are primarily linked to the associated labor work component, associated materials, and other miscellaneous costs allocated to that work unit.

Cost estimates within the work unit are essentially the defined labor rate times the quantity of that resource for the duration of the work. So, if the estimate were to be 5 days and we allocate two resources to the task, the total labor resource work effort is 80 hours assuming that the assigned resources work 8 hours each day. If the assumption is an average labor rate of \$20 per hour, then the calculated direct cost for that work unit would be $80 \times \$20$ or \$1600. Note the number of times the term “assume” is used in this description. Any error in these assumptions would obviously affect the accuracy of the estimate. Nevertheless, this set of variables represents the basic mechanics for work unit direct cost estimating. The more accurate the assumptions, the more accurate the result will be.

Material cost

Even though the project estimating process is often thought of as a human labor idea, there are other cost components to deal with. For instance, for some project types material cost is more significant than labor. In that situation, recognition of material requirements in the work unit must be accounted for in an estimate. Recognize that many organizations have a specialized functional group which handles material procurement and storage in support of project needs. This means that raw material for a project may be combined with other project's material and in fact may be purchased for multiple projects over time. For this basic reason, timing and pricing of project material is more complex than it appears on the surface if one is concerned about timing of the expenditure. It is beyond our scope to delve deeply into these mechanics and in fact they vary across industries and companies. Regardless, we do need to recognize that this element is additive to the work unit cost. Also recognize that the billed material cost may be greater than the net cost of the purchased item because of additional allocated costs attached based on various handling expenses. So, a \$100 part might be billed to the project as a \$200 item. In any case, this discussion assumes that an item's cost value is available from the procurement function and that will simply be included as a factor in the work unit cost estimate.

Miscellaneous costs

A third cost component deals with other miscellaneous costs. In most cases, this will be the minority component, but its impact on the budget

and other aspects needs to be understood. Examples of this category are office supplies, business lunches, project shared items (copy machine leases), and the likes. This resource class estimate may simply be added to the total project cost, but the more ideal scenario is to recognize all expenses at the root source. Allocating such expenses at the top level essentially hides the impact from analysis. The goal for all cost estimates should be to link the work unit in which the resource is utilized.

Total project estimate

As each of the individual resource and other cost items are estimated in their respective work units, a total direct project estimate is derived. The goal for this activity is to generate accurate estimates for each work unit's labor, material, and expense dollar costs. However, we also need to recognize that other less direct organizational level variables will be added to these direct cost values. For example, various types of overhead charges would be added to the project, and buffer, values related to estimated time overruns are often added to the base time and cost values. Finally, if the project is being produced for an external buyer, an additional profit value would be added. So, envision the total project estimate as MLOP—material, labor, overhead, and profit.

An estimate for digging a hole

Almost everyone has used a shovel to dig a hole, so let us use that as an example of estimating. Assume that we wished to dig a hole 10 ft × 10 ft × 10 ft using a regular shovel. If we have experience in digging, we might have a pretty good idea about how long this would take based on that history. So, let us say that this estimate is 5 days of digging. At this point, we raise our familiar expression “what is your estimate for this?” Is 5 days the answer? Possibly not, 5 days is the work estimate but it is unknown if that means 5 full days of digging was planned to do each Saturday until finished or if there was some other schedule in mind. Also, maybe there is a friendly neighbor who just loves to dig and wants to come help (remember this is just an example). If this eager helper comes, we still have the same set of questions and it could be more complex to estimate if the new resource is someone who likes to take breaks and talk a lot. Can the assumption be that he cuts the original time in half now? We have to know more about his work ethic to answer that. Since your significant other wants this job done quicker than 5 days, it may be decided to call a third party for a contract estimate. That vendor also has experience in digging and has a

group of trained resources for this task, plus probably some higher level technology that can be added (i.e., a backhoe). This vendor can estimate the job in multiple ways to satisfy your need for shorter time, but might be more expensive based on extra equipment added to the job and his internal overhead factors. He also has a more complex resource management issue and must balance his total work resources across multiple jobs and evaluate their availability for this job. Based on his work load and resource assumptions, he estimates that he can provide three junior diggers who can finish the job in about 3.5 days based on their estimated skill and motivation. However, he could also bring in a backhoe and finish in one day with only one high-skilled resource, but the cost would now double. So, we now see several decision alternatives for this job and that is not an uncommon situation. As the project estimator and decision maker we have to decide how to pursue this work unit (task). There are at least four different alternatives here, each with unique characteristics and all have a fair chance of technical success (i.e., the hole will get dug). Which one of these alternatives do we select? The following sample considerations are intended to show some of the softer factors involved in this decision process:

1. This job can be done cheaper by ourselves, but there is conflict with the chief stakeholder (spouse) that has been indicated as too slow. Also, our regular job limits availability to only one day a week for digging and frankly this is not our highest personal life goal (core competency is a good vocabulary word here).
2. Working with the neighbor often turns into more of a party than a work effort and we really need to get this done without internal conflict with the chief stakeholder, but we think that this option has the potential to be the cheapest and fastest solution.
3. The commercial options should get the job done quicker so long as we trust the supplier to live up to his defined schedule. We think it will not be as fast as promised, but still within the defined constraint. However, both commercial options will have higher cost compared to options 1 and 2.

So which option do we estimate in the plan? As can be seen from this hypothetical example (but based on real experiences), there is no ordained correct answer to an optimal selection. The personal work estimate provided a base comparison from which to calculate option 1 and the other options each contained additional internal factors to consider. In a planning model, the decision would be made as to resource choice. From that, a work unit time and cost estimate would result. It is understood that additional resources tend to cut the cycle time up to a point; however,

there is an old adage that says you cannot get nine women to have a baby in one month. So, it is with most tasks.

We leave this hole-digging example to be pondered. Which of these options should be selected and for what reasons? In most situations, this boils down to deciding which of the goals is highest (time, cost, quality, control, happiness, etc.). Hopefully, this discussion illustrates that the process of estimating has many “interesting” subplots.

Definitional process

Several estimating vocabulary variables are embedded in the hole-digging example. We first started off with defining the level of work. From this came a calculation of duration based on allocated resources. Finally, based on various factors, resource allocation most notably, a calendar or elapsed time could be estimated. All of these issues are symptomatic of the estimating role.

The estimating process should be accomplished at the work unit level and from this collection an overall schedule is derived. However, in many cases, the project desired completion date is defined first and the project is supposed to find a way to fit the work into that time frame. This upside down approach to estimating is all too often the scenario dealt with by the PM. The model planning process defines that cost and schedule be derived from scope-related work units and defined resource allocations. From these steps, an overall time and cost schedule can be defined. We will explore more of these model mechanics in upcoming chapters. Take special note of the sequence that eventually produces the final plan.

High-level estimates

All this may be great in theory, but what does one do when there is no WBS created yet and an estimate is still demanded? When this occurs, the PM is left with less good choices from an accuracy standpoint. The most likely options are

1. Analogous estimates based on similar previous efforts
2. Expert guess based on past experience
3. External consultants who have been involved in this class of effort

Oftentimes, an estimate made using one of these early definitional approaches lives on well after its assumptions are known to be wrong. Mature organizations are generally more orderly in handling early project estimates and they treat these rough-derived numbers accordingly. For example, high-level estimates should be recognized as having high error

rates. The literature suggests that error ranges of $\pm 100\%$ for this class of estimate are not uncommon.

Another method of project estimating is known by PMs as *Project Titanic*. One example of this occurs with a call from a senior manager saying that you have been assigned a great new project and a promotion to go with it. The project is called *Omega* and its deliverable is destined to lead the company into a great new market. The fixed budget is 5 million dollars and the requirement is to have the product ready for the market in 6 months. Congratulations! Your career and image as a good PM likely just got wiped out. What is wrong with this scenario? It comes with promotion, money, title, visibility, and so on. Realize that the missing element here is lack of a clear scope definition, but fixed delivery time and cost budget. Also, there is no statement of resource commitment for this venture. The proper response rule to this “opportunity” situation is the following:

Gee, thanks for the confidence you are showing in me. Here is what I want to do in order to be sure I understand what is needed and that I can deliver what is required. It is vital to success to evaluate the scope of this effort against the required schedule and resource availability. As we note every day, our resources are limited and that is the key element in our ability to deliver in this short time frame. You indicate that this is an important project, but as you know we have several other initiatives underway now that have also been tagged as critical. I believe that this additional time will allow me to assess not only the feasibility of the technical aspects of the project once I am able to get better definition of the requirements and estimate the work involved. The schedule and budget should also be more clear as well.

This will be the last chance to make this type of statement. Your key response has to be that the total definition for this project has not been accepted yet, but you are eager to deliver once that preliminary step is defined. Accepting a high-level view of a vague project scope with a fixed budget and delivery schedule is the recipe for failure. To be a successful PM, there must be a clear definition of the interrelationships between scope, time, and cost. The WBS will provide a reasonable overview of scope and if the defined work units can be reasonably estimated, the last forecast ingredient is the availability of resources to support the schedule. Realize that this is still not the end of the steps to

achieve success, but this set of core definitions is the basis required to start the process. Failure to accomplish this during the planning stage leaves the equation unbalanced and not likely to recover without major compromise.

Estimate creation

As defined earlier, the correct starting point for the estimating process is a reasonable understanding of project goal and related work requirements. The model approach to this process is through a WBS with a hierarchy of defined Work and Planning Packages of reasonable size. This decomposition process defined the existence of work units with a definition of that work. From this specification, we need to produce a direct time and cost estimate to accomplish that requirement. There are many techniques and factors involved in producing such estimates. As illustrated in the hole-digging example, creating work and duration estimates is not only a science but also an art. It is a science because the estimator often utilizes historical data, mathematical formulas, and statistics to determine the effort required for a work unit. However, it involves art because each situation is somewhat different and the ability to customize the value requires skill that is obtained through study, observation, and experience with projects (Baca 2007, 135).

This section will describe different project estimating techniques that can be used to develop various project time- and cost-related forecast values. Essentially in every project estimating situation, the process is designed to determine the level of human resource required and then evolve from that to compute the resulting work, schedule, and cost for the activity or overall project. In this process, the lower-level work unit estimates then become basic building blocks to create the project schedule and budget.

The specific estimating techniques reviewed here include:

1. Expert judgment
2. Analogous
3. Heuristic
4. Delphi
5. Parametric
6. Phased
7. Effort distribution (top-down)
8. Bottom-up

None of these techniques is optimal to use for every case, and in most situations multiple approaches will be used to confirm a specific derived value. Each method has a role and capability depending upon specific need and project phase. The proper choice deals with knowledge

available, stage of the project, and accuracy required. We will look at the characteristics of these major estimating methods in the section below.

Expert judgment estimating

Expert judgment is a very popular technique for making both high- and low-level work unit estimations. According to a software industry study, 62% of cost estimators in this industry use the expert judgment technique (Snell 1997a). An estimator using this approach relies on his expertise and is guided by historical information and experience. In most cases, this method will generate a high-level estimate and the accuracy is always questionable. For improved accuracy, multiple estimating techniques should be utilized for validation comparison. If significant estimate differences are encountered, a better defined scope is needed until the required accuracy level is obtained.

Imagine that an estimate is needed for repair of an automobile transmission. A service provider could say that this job needs further evaluation and that will require some defined evaluation fee to define the extent of the repair. From that review step, a detailed analysis (scope definition) will generate a definitive estimate for the work (parts, labor, time). Alternatively, based on history with this particular brand the service estimator might be willing to give either a fixed estimate or a range estimate to move forward with. Obviously, the less known about the particular issue, the less likely a fixed estimate would be given.

There are three main advantages for using expert judgment as an estimating technique:

1. It requires little data collection and simply uses experience from past projects (Snell 1997a).
2. It has sufficient flexibility to be adapted to conditions of the current project.
3. It provides the user's desire for a quick answer because the expert will have a ready knowledge set from which to derive the estimate.

However, there are also significant drawbacks to consider when using this technique. First, the estimate provided by the expert will not be any better than the objectivity and expertise of that expert (Snell 1997a). An accurate estimate requires an expert that has extensive experience dealing with the type of task or project being estimated. Second, estimates made by experts can be biased which produces a value with no easy way to verify the logic of creation or potential accuracy. Finally, the expert may be basing their estimate from personal memory of past projects that do not fit the current situation. This method is rated as high in usage, but often based on inaccurate base of information.

Analogous estimating

Analogous estimating has similar traits to expert estimating in that the technique is based on prior experiences with and data from similar type projects. However, in this case the comparison is based more on data and less on raw scope definition. This process would typically produce a reasonable estimate so long as the new project is very similar to the older comparison ones. Definitional parameters for this type of estimating technique often use measures of scale such as size, weight, and complexity from a past task to make the estimate (Callahan 2008). When using analogous estimating, the estimator also needs to factor in any differences between the new work being estimated and the previous item used for comparison. Examples of added complexity factors include any new technology that is now being utilized, or perceived changes in the complexity of the task or project (Callahan 2008).

Analogous estimating is best used in the early phases of a project before significant details are available. This method provides quick and easy estimates for projects or tasks that are basically stable from past models; however, Baca (2007, 136) suggests that the results are often not very accurate. To generate appropriate accuracy, care must be taken to properly compare the previous effort used with the current one. Also, to derive the correct forecasting measures, the estimation environment should match the expertise of the estimator (PMI 2001).

A simple example of an analogous estimate would be to determine how long it would take to unload a ship and move it back to its next port. Past experience with this same size ship and cargo type offers the first view. Then, local factors such as resource availability, weather, and any other driver factors would need to be also considered. From these various perspectives, the estimator should be able to derive a reasonable work and elapsed time estimate. In this view, we see both the use of historical data for comparison and expert judgment regarding the environment. Availability of actual data such as resources and docking space would further improve the raw estimate without such data.

Heuristic estimating

A heuristic estimate is called a “rule-of-thumb” estimate. These “rules of thumb” are based on empirical parameters derived from past experiences. So, in that sense heuristic estimating is also based on analogous data and expert judgment, except in this case the estimate is translated into a mathematical-type expression. Expert judgment estimating has to be performed by the expert, whereas heuristics can be transferred to others who are capable of manipulating the defined relationships (Mind Tools 2008). As an example, imagine the situation where you need an estimate

for a new roof on a house. The person that comes to provide this estimate has never seen the house or possibly even done roofing. What he has is the heuristic estimating formula. Assuming that the roof type is specified and relevant to the model the estimate can then be derived by inputting the size parameters of the roof to yield the base estimate. In this case, it may be as simple as roof square footage. An expansion to the base formula could result if the roof has a sharp slope, multiple gables, vents, or other complicating items. Each of these might then be additive to the base estimate to produce the total. This class of estimating would typically be found in situations where the same type project is performed many times and the estimating relationships are well established, for example, roofing, suburban house construction, installation of a water heater, standard repair of a car item, and so on. Whether the vendor is willing to make this a firm fixed price estimate or not is often based on the potential variability of the task. The house construction bid would have to be variable because of various undefined internal options and therefore would be only an order of magnitude estimate, whereas the roofer might feel comfortable making his bid a fixed price.

The major benefit of using simple heuristics is that the estimating process can be performed by many others and does not require a high expertise level. In many situations, the heuristic estimate is not expected to be highly accurate and thus should only be used in situations where the inherent risks are considered minimal (Mind Tools 2008). For instance, if we were estimating that a car can go 100 miles on one-fourth tank of gas across a well-traveled road with frequent service facilities along the way that is one risk perspective. However, a prudent airplane pilot would want a more quantitative metric to estimate fuel adequacy for a cross-country trip over water.

Delphi technique estimating

The Delphi technique is another variety of expert judgment estimating. It is most effective when making high-level estimates in the early stages of projects where there are many unknowns and a single expert would bring too much bias to the solution. An extreme example of this is "How long will it take us to develop a project to go to planet X?" In these complex situations, the Delphi approach gathers the estimates from a group of experts with the goal of combining their responses to eventually reach an unbiased estimate (Snell 1997b). The Delphi technique involves the following sample steps to reach a convergent estimate:

1. Each expert provides an input without collaboration with others.
2. Results are tabulated and returned to the group for evaluation. In some case there is discussion regarding logic for estimates.

3. The process repeats with both time estimates and logic for the estimate.
4. This process recurs until the group results converge toward a single valued answer.

Since this technique seeks estimates from multiple participants, it tends to remove bias and politics that can occur when an estimate is based on only one expert's judgment. Group meetings also allow experts to discuss issues or assumptions that may impact their estimate. One of the main drawbacks for this type of technique is the amount of time it can take for the panel of experts to reach a consensus. Larger numbers of experts will increase the number of iterations required and therefore the time it takes to reach a final estimate. Another potential issue is the experience level of the panel. If the panel is made up of individuals that are not very experienced, the estimate will often not be as accurate. It is also important to make sure that strong facilitators are available to guide the group and keep them focused on the topic. The central idea of the Delphi is to anonymously share the estimates made by others along with their basic rationale. The next iteration would allow the group to think about other views and possibly adjust their estimates. This is essentially a consensus-building process.

Parametric estimating

According to the *PMBOK® Guide*, parametric estimating is a technique that uses statistical relationships between historical data and resulting work levels (PMI 2008, 150). Parameters based on size, functions, footage, or other scope-related values can be statistically modeled to produce time and cost estimates for the related work. Given the mathematical sophistication of a parametric estimating model, these are often computer-based statistical relationships. The process of creating a formal parametric model involves collecting data from many past similar efforts and from this produce a statistical regression-type model that quantifies the impact of each relevant variable. Parametric techniques are most useful in the early stages of a project when only aggregate data are available. These estimates are normally considered order of magnitude in accuracy because they may lack detailed requirement precision (Kwak and Watson 2005).

Parametric techniques were first developed by the U.S. Department of Defense (DoD) during World War II and following that experience were used to estimate high-technology projects such as weapons development and space exploration. The technique is now commonly used in construction and auto repair industries. For example, Eastman Kodak created such a model to estimate construction cost for building additions (Kwak and Watson 2005). Other model application areas include, but are not limited to, determining the conversion costs associated with new

technologies in electronics manufacturing, information technology, or estimating the cost of producing an engineering design for a particular device type.

The parametric technique can also be applied to any situation in which sufficient historical data are available and the project model is stable. From historical data, cost estimating relationships (CERs) can be derived statistically to correlate with resulting work estimates. Project characteristics can include functions, physical attributes, and performance specifications. CERs are based on two different types of variable relationships. One such type is based on an independent variable used to predict the cost of the dependent variable. This type is called a cost-to-cost relationship. One example for this is using the cost of labor hours for the independent variable to estimate the associated cost of labor hours for the dependent component. A second example type might forecast labor hours from a number of estimating variable inputs. The majority of CER relationships are linear which would mean that a single value of the independent variable would be associated with a single output dependent time, cost, or resource variable.

Development of a valid parametric estimating technique requires considerable data collection and analysis. For that reason, they do not proliferate. High-technology environments change so rapidly that the models are often obsolete before they can be validated. The main advantage of parametric estimating is that it provides the estimator with a quick estimate that is based on a limited amount of data. This approach also provides the estimator with an understanding of the major cost drivers of the project. In a fully developed parametric estimating model, CER relationships from historical projects provide interesting insights into the impact of key elements such as design changes, schedule changes, and other such factors. A final subtle point from this approach is to recognize that parametric model estimates will be consistent, although wrong. However, the consistency attribute allows an orderly correction over time as new data are collected.

Phased estimating

Phased estimating involves an incremental approach to the process. In this case, a promising project will be given approval to move into a particular phase with a defined rough order of magnitude schedule and budget. Emerging from that phase, the project is reassessed and the estimating process repeated for the next defined phase. As each phase progresses, the project has to earn its way to the next one and the estimating variability range decreases as more project definition occurs. Each defined decision point, which is called a phase gate or kill point, involves a management review process to determine how the next phase will be approved, with

the options to either continue with the existing plan, redefine project scope, or to terminate the project. According to Verzuh, the performance baseline should be considered reset at each phase gate and the project will essentially be redefined for all future gates. There are a series of definitional steps to follow in terms of using phased estimating to produce an estimate for cost and schedule. These are (Verzuh 2005, 174):

1. Break the product development life cycle into phases. Each phase will be considered a sub-project.
2. For the first phase of the life cycle, detailed estimates are made for the cost and duration. Associated with this is an order of magnitude planning estimate for the total project life cycle. With these two plans, the project is approved to initiate the next phase.
3. When a phase is completed, a management decision is made regarding whether to continue with the next phase and under what conditions.
4. If the project is approved to continue, a detailed estimate is created for that phase and an order of magnitude estimate is produced for all subsequent phases based on current information.
5. This iterative process continues until the project is either completed or terminated.

This *plan and move forward* approach is also called the *rolling wave* technique. Another vocabulary term for this is *progressive elaboration* (i.e., each wave adding detail definition to the next wave).

There are three main definitional components that each active phase gate should contain. First, the next active phase must specify its required deliverables and each subsequent phase will have its deliverable. Second, each review gate should have a defined measurable set of success criteria. These criteria are used to evaluate whether the project should proceed to the next phase or be terminated. The final item involves the specific overall project goal definition, which may change as the project definition unfolds. The number of phase gates utilized depends on the size and complexity of the effort. When the project scope is well defined, fewer phase gates are required. Project teams should try to consistently use the same gates at consistent points for similar projects as this will help one to improve the iteration and review processes.

The main benefit of using the phased rolling wave estimating approach is that it allows the effort to move forward quicker with less pre-definition and it recognizes that early extensive requirements definition in an uncertain world may be a waste of time. On the other side, this approach requires much more monitoring from the management and the future goal predictability is low in regards to the classic early requirements waterfall approach. This management approach will appeal more to those who do not believe in the effectiveness of an early requirements

definition process; however, we must recognize that many management groups will not feel comfortable with these more vague-management-look-forward-iterative-goal techniques.

From a project team management approach, it is important to recognize that there is more potential to meet these short-term phase goals, whereas the longer-term full estimate approach can lead to situations where the team has no chance to be successful because of missed estimates in the beginning (Verzuh 2005, 174). The PM must recognize these strategy tradeoffs when selecting the project estimating and management approaches.

Effort distribution estimating (top-down)

This method estimates the project as a whole and then apportions the total estimate into high-level groupings based on a historical resource or cost distribution pattern. An approach such as this assumes that the overall project will tend to segment into consistent predefined groupings, so identifying the aggregate estimate is the best method to define the life cycle components. Once the high-level value is derived, the effort allocation distribution formula is used to assign a percentage-based allocation to lower levels in the structure. Normally this type of allocation would only go to one or two levels below the top of the WBS. Historical data from similar past projects are typically used to determine the effort breakdown percentages for each phase and the summary activities within a phase (Horine 2005).

This technique works reasonably well in organizations using a common methodology for similar type projects, along with good historical data. The method also works well with the phased estimating technique in that the historical data provide reasonable estimates for future phases with similar definition. For example, when a phase gate is completed, the actual amounts from the current stage can be used to project future values. In a similar fashion items, such as documentation and testing, can be estimated from the direct work unit estimates.

One hazard in using a top-down estimating approach as a driver for the effort allocation values is that an aggregate estimating error is proliferated through all defined segments. Another drawback is that the technique uses historical data to define the apportioning formula (Verzuh 2005, 176). If the projects are not technically similar, these values can provide erroneous results that are once again proliferated through the life cycle. For example, if the new project does not have the same number of phases, or the phases are different for every project, it will be difficult to apply a consistent apportioning formula to new projects.

To illustrate the apportionment mechanics, imagine that a project's goal is to design and deploy a new car model. Assume that there are five

standard phases planned for this effort and an estimated overall budget of \$2,500,000. Defined phases include: Initiation, Planning, Design, Construction, and Deployment. The Construction phase is further decomposed into three subgroup activities—frame, exterior, and interior. Past projects indicate the following resource breakdown across the phases:

Initiation = 10%
Planning = 15%
Design = 15%
Construction = 40%
Deployment = 20%

Activities within the Construction phase typically consume resources in the ratio:

Frame = 14%
Exterior = 13%
Interior = 13%

Using these values, the Construction phase would receive 40% of the estimated budget which would compute to \$1,000,000 (i.e., $0.40 * \$2,500,000$). Within the Construction phase, the framework activity would be estimated to cost \$350,000 ($0.14 * \$2,500,000$). Assuming that the effort distribution technique was being applied along with the phased estimating technique, these estimates could be updated at each phase review point. The original allocation estimate for the Initiation phase was \$250,000 ($0.10 * \$2,500,000$), but the actual cost was \$300,000, which is 20% higher than plan. From this result, the overall cost estimate would then be revised by 20% to \$300,000, so the new estimate for the Construction phase will increase from \$1,000,000 to \$1,200,000, and the estimate for building the frame will increase from \$350,000 to \$420,000. The key issue in these comparison methods is how to handle dynamic estimate changes of this type. The standard control model uses a fixed baseline value for comparison, whereas this technique has approved budget changes within the life cycle. This variability of approval changes what is considered to be the classical control process of planned versus actual. Some organizations will allow this and others will hold the original value constant and pressure the project team to take corrective action to stay on the initial plan. Selection from these two methods will have to deal with local management control philosophy issues beyond the estimating methods outlined here.

Be aware that the example used here is not necessarily a good one since the target product would be very expensive to curtail once it is into construction, but in a radical case that could happen. The normal use would be to test a project goal with less construction involved before making a

decision to commit to the full effort. It is common to either build a prototype or to just execute a plan to some key decision gate. That said, recognize that it is a good management strategy to review project status and continually evaluate cost versus defined benefits. If a project has wandered outside of its value envelope it should be cancelled. All project management approaches can use this approach regardless of how the budget is approved.

Bottom-up estimating

This technique is considered by experts to be the most accurate of all the techniques described here. The estimating mechanics for this process are directly linked to the WBS work packages. Based on this view, the total project consists of a collection of relatively small work units that can be estimated reasonably well by the performing organizations. In most cases, the estimating method used would be expert judgment given that the individuals who will actually be doing these moderate-sized work units would provide the values. Once the full collection of individual work package estimates is complete, they are rolled up in the WBS structure to generate higher-level aggregations. From a statistical point of view, each of these estimates would be subject to a range of estimating errors; however, over the full set of work units the errors should somewhat compensate. As a result, the total estimate is now based on aggregated views of the work to be done and made by individuals who understand that work better than anyone else. There may be cultural issues surrounding this process that can mitigate the accuracy, but technically this method has the best chance of producing an accurate representation of required work.

Figure 8.1 shows an annotated WBS with duration and cost estimates for work units. Note how the estimates roll upward into the total project. This is the essence of the bottom-up estimating approach. As you can see, this involves having a fully developed scope definition translated into a somewhat annotated WBS before it will function as described.

The bottom-up approach also has the advantage of greater involvement from the organizational units which will be performing the work, so there is an improved potential for buy-in and commitment to the estimate by the work teams. It is not hard to imagine the feeling that a work group might have when an external estimator creates a work estimate and says “this is how long it should take you,” when compared with the work group coming up with that same value. The concept of commitment is clearly on the side of the latter approach.

The main disadvantage of this method is the time required to produce the individual estimates and involve the breadth of individuals needed for the process. Another subtle problem that often comes with this process is excessive padding of the estimate to be sure the time is not exceeded. External estimators do not have this motive, but internal groups

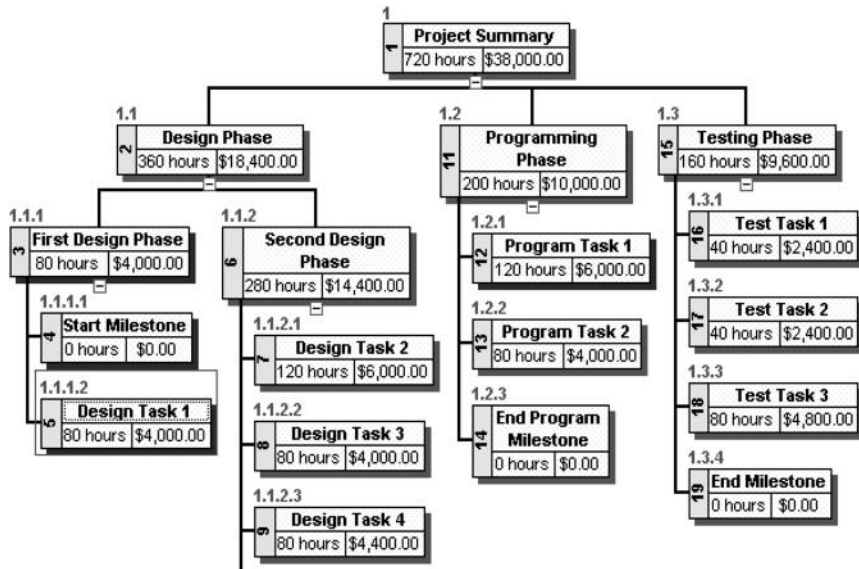


Figure 8.1 Time and cost aggregation in the WBS.

often view a time or cost overrun as a negative event. In some cases, the estimate may also be padded to cover potential variances from perceived risk for the activity (Johnson 2007, 224). However, realize that the proper goal of work unit estimating is to derive estimates that do not have excessive padding, but represent reasonable values for the activity and risk issues should be handled through other processes that will be discussed later in a future chapter. In order to ensure reasonable estimates, some cross-checking between the estimating source and the PM is required. The model philosophy is to isolate padding into separate groupings and not spread extra resources across all WBS work units.

Recognize from the process outlined here that the bottom-up technique is not possible to use as an early estimation technique to decide whether a project idea has merit. First, there are no low-level work units defined yet and even if some level of detail exists, the time required to evaluate each is prohibitive.

Estimating components

The estimating requirement for a project has multiple perspectives. The root mechanic of estimating involves the work required to complete a unit of work and the support resources associated with that work. From this perspective, the estimating mechanics would produce a time and cost result. So long as the requirement for the work is reasonably well defined,

the basic set of mechanics outlined here seems logical on the surface. We will ignore for now the Project Titanic situation where a quick estimate is demanded and the requirement is not well defined. That falls into another category closely aligned with *guessing* or *praying for a miracle*. However, even in the situation where work is defined reasonably well there are a lot more sources for variances. These will have to be explored before the final project estimate is completed.

Earlier in this chapter the estimating focus was on defining the work time required to execute the defined project requirement. We still need to keep in mind the basic estimating vocabulary terms for work, duration, and elapsed time in regard to expressing an estimate, but for this next estimating level, we begin to focus on other more global components that add to this lower level perspective. If someone wants to know the estimated time and cost of a project, the work unit level estimates lay at the core, but in addition the higher-level component issues outlined below essentially add to this core view. As we combine all of these pieces together, we are then able to define a project estimate that will fit any of the stakeholder requirements. This basically means that estimates can be sorted into work unit, major group, or total project view.

The new estimating components described below constitute the various aspects of the estimating process beyond the work package.

Human resource component

Let us assume that work can be accurately estimated for either a low-level work unit or even the total project. If we then examine the issue of allocating planned work to those work units, we find a major source of estimating error. To assume that the defined work will be executed by a predefined quantity and quality of labor, at the exact planned time, and with the exact planned skill is a very unlikely event. Clearly, this aspect of translating raw work into a duration estimate is prone to significant error. In fact, in many cases, this will be the major source of estimating error. The successful PM needs to do everything within reason to ensure that the human resources defined in the plan are allocated to the project as defined. Work estimating errors may exist, but often will not be as great as that which will exist without careful resource management oversight. Think of it this way. If a perfect forecast is predicted but only half of the planned resources arrive on schedule, is it now reasonable to believe that the schedule would be doubled? Similar but more complex to forecast results would occur with resource skill differences.

A second source of human estimating occurs from what is defined here as *bleed off*. That estimating element comes from competing demands for the allocated resource. As an example, does the organization take away significant productive time with other internal, nonbillable, activities?

Some of this can be cultural in nature, meaning that it is common to have frequent birthday parties, departmental meetings, email, internal committees, personal activity, and so on. Some measure of the net productivity of the individual is required to properly estimate how much of a whole resource actually gets allocated to the project. It is not uncommon to find that a full-time project resource is only actively working on direct project tasks 70% of the work day. If the original estimating assumption was higher, this also leads to a significant estimating error.

Work unit direct cost component

Estimating mechanics for cost budgeting require that the work estimate be translated to cost via the items allocated to that work unit. For example, an assumed labor rate value translates human labor time into direct labor cost. Second, defined materials for the work unit are added to the cost. Finally, any other miscellaneous cost items are then added to complete the direct cost estimate for the work unit. Labor and material estimates will be accurate if the values used represent the actual values at execution time. Obviously, significant errors can occur if this is not the case.

In some organizations, the funding source for a project can be very complex. Funds can be allocated from multiple sources and apportioned, or even allocated for different phases. One of the most common fund groupings is tactical versus capital funds. For example, employee expenses might be funded from the tactical funds while equipment charges could be funded from the capital fund. In this mode, a \$100,000 item of equipment might be amortized over 5 years and thus shown in the project budget as an allocated cost of \$20,000 per year. Similarly, allocating material costs to the project can also be complex if the material is purchased for multiple projects in bulk and storage handling or procurement overhead is added to the net purchase price. Suffice to say the cost side of bulk-type material will be more complicated to estimate than direct purchase items used only by a single project.

Miscellaneous direct expenses

The third direct cost category involves miscellaneous charges to various work units. In the typical project these involve business travel, office expenses, support equipment, miscellaneous charges, and other support costs that are often not directly related to producing the defined output.

Reserve accounts

Project cost and time plans should include reserves for risk, management (unknown/unknowns), and scope change. Ideally, the plans should clearly

show allocations for each of these and they each represent an estimate in their own right. Risk assessment is an estimating process designed to create an appropriate reserve for this class of work, but the other two categories are left to define as an experience-based estimate. In any case, time and cost estimates for these three reserve-type costs groupings are additive to the overall project direct estimates. Each of these has the potential to expand the initial planned time and cost of the project.

Overhead

Overhead occurs as a result of the project being supported by the mother organization. The project staff is paid and supported by this organization. In addition to the direct salaries shown as labor rate, additional employee costs are incurred by the organization for medical benefits, retirement, and other support factors. These charges may be reflected in the estimated resource cost and therefore appear as direct costs, or added later as part of various overhead groups. The key point is employees cost more than their visible direct salary and that needs to be recognized in the project estimate.

A second form of less clear overhead comes from the overall organization. This is sometimes called “G&A” and represents the General and Administrative aspects of organizational overhead. Physical facilities, general management, support personnel, and a host of other costs external to the project are examples of this category. This cost line item will appear external to the direct project cost categories, but must also be recognized as additive to the total estimate.

Profit

Normally profit would not be shown in a cost estimate unless the project was being performed under contract as a vendor to an external buyer. In that case, this amount is added much like overhead.

Total project estimate

When computing the total project cost, it is important to recognize that all of the components outlined here should be recognized. Many technical PMs will not like to see the higher-level component costs since they decrease the net value of the project. But all of these are real for an ongoing organization. Failure to properly include any one of these components will result in a numerical overrun of the plan and reflect negatively on the project team performance. A poor estimate performed well has the same external variance view as does a good estimate performed poorly. Both look the same when the results are quantified to the outside world.

Estimating checklist

The checklist below represents a set of questions that should be reviewed as part of the work estimating process. This example illustrates how a formal checklist can help ensure a more standardized approach to the estimating process. An organization wishing to ensure compliance to such an approach will require a formal signoff signature by the estimator (Sommers). A sample set of estimating background questions to review follows:

1. Have you established a formal, documented data collection process for the project?
2. Do you have sufficient requirements definition for the project, including management areas? A fully decomposed WBS is the desired case.
3. Do you have historical information, including costs, from previous similar projects?
4. Have you identified all sources of costs to your project (i.e., different types of labor, materials, supplies, equipment, etc.)?
5. Do you have justifiable reasons for selecting your estimating methods, models, guides, and software?
6. Have you considered risk issues in your plan?
7. Do your estimates cover all tasks in the WBS?
8. Do you understand your project's funding profile, that is, how much funding will be provided and at what intervals? How sure is the funding assumption?
9. Do you know what level of accuracy is needed for the estimate?
10. Do you have a process for keeping records of your project activity for future efforts?

Summary

In this chapter, we have looked at the general topic of estimating project time and cost. Individuals who can successfully deliver accurate estimates are extremely valuable to the organization because an accurate project estimate facilitates a more orderly project task execution and has a similar impact on internal resource management. To the contrary, an organization that is not able to do this well is left with a very chaotic environment, which leads to negative results for project completion and the related goal achievement.

This process has been described as one consisting of both art and science which means that it is not one that can be completely described by a checklist or a math model. Rather, it is a combination of all such approaches. Certainly one of the goals prior to estimating is to create a detailed WBS with well-defined work units. From this base, it is feasible

to achieve forecast cost accuracy in the range 5–10%. This same level of definition accuracy can occur at the individual work unit level for time, cost, and human labor requirements.

We conclude this topic keeping in mind the terms work, duration, and elapsed time. Procedures for estimating time and cost are closely tied to these terms and their different meanings. Also the point in time when an estimate is required and to what level of accuracy are important issues in estimating method selection. Always preface an estimate with some measure of accuracy range confidence. This activity is a major part of the PM's life and equally important to career success.

QUESTIONS

Review questions

1. What are the major techniques for work unit estimating?
2. What are some of the major considerations in selecting an estimating method?
3. If a Work Package has an estimate of 240 hours, what is the appropriate duration estimate for the activity given two resources and a standard work calendar? What assumptions are you making with this value?
4. Using the concept of "profile estimating" if the planning phase required 300 hours and it historically consumed 25% of the life cycle, what would be the overall estimate for the project?
5. Assume a roofing contractor finds that it requires 10 hours of labor per square foot to install a new roof. Use this relationship to estimate future similar jobs. What type of estimating method is this? What is a potential advantage of using this technique?
6. Theoretically, what is the most accurate estimating technique? When your boss asks you early in the project for an estimate why is this method not applied?
7. What is a ROM estimate? What is the hazard of providing such an estimate?
8. Assume that work estimates are defined for all work packages in a fully developed WBS. What needs to be added to this estimate to produce a total project estimate?
9. How are items such as risk and task variances dealt with in the estimating process?

In-class questions

1. Assume that you were assigned a project that was unlike previous projects. Comment on some techniques to provide both an initial estimate and then a more detailed one.

2. Same question as number 1, except the company has no internal skills for this job and you are going to be primarily a contract coordinator. How would you estimate the time and cost of this effort?
3. You have made your first presentation to management regarding the project and they are generally very unhappy with the estimates shown for the plan. What is your strategy to deal with this issue?
4. If you were the PM charged with developing a plan to get astronauts to Mars, how would you go about providing an initial estimate for this effort?

EXERCISE

This is an elaboration of the earlier discussion regarding estimating a hole digging effort. Assume that we wished to dig a hole 10 ft $\times$ 10 ft $\times$ 10 ft using a regular shovel. If we have experience in digging we might have a pretty good idea about how long this would take based on that history. So, let us say that this estimate is 5 days of digging to do this. At this point we raise our familiar expression “what is your estimate for this?” Is 5 days the answer? Possibly not! Here are some other additional factors to consider:

1. You have a full time job and this is to be done for your personal use.
2. Your wife wants it done quickly (whatever that means).
3. You have a friendly neighbor who has offered to help on weekends.

Assume this was a work package that is part of a larger project. Describe how you would go about estimating this task for the project plan. Also, define any other “factors” that would be needed to complete this.

There is no correct answer to this question, so just use your creativity to wrestle with the problem and rationalize your estimate as though it were part of a larger project plan.

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section four

Tools and techniques for developing the project plan

Learning objectives

Upon completion of this section, the following mechanics and concepts should be understood regarding why they are required as part of the core schedule and cost planning process:

1. Identify mechanics for translating the WBS into a first cut schedule.
2. Identify mechanics for translating the first cut schedule into a first cut budget through resource allocation.
3. Understand management concepts for tweaking a plan's scope, time, and cost to better satisfy the key stakeholders.
4. Understand the general processes required to obtain management approval for the derived project plan.

Overview

The goal of this overview is to highlight the key components for developing a “raw” project plan. In this regard, these mechanics represent a core project management process that should be followed for initiating the project plan. Each chapter in this section focuses on an important aspect of project planning, but recognize that there will be more to deal with later after this set of material is well understood. The more advanced concepts that follow are considered supplements to this collection.

Previous foundation work for developing the project scope through the WBS process and initial work unit estimates has been described in Section III and we are now ready to move on to the next two legs of the project planning journey, that is, schedule and budget. The first cut project schedule evolves directly from the scope definition and work estimating

processes. Project schedules are basically derived from linked WBS activities. The main new mechanical ingredient to add at this point is resource allocations to these work activities in order to derive estimated durations and the sequencing of those activities. These two processes are then used to generate a calendar schedule and direct budget for those activities.

The key translation point between project scope and schedule (time) is the set of WBS work units. Recognize that the mechanics outlined in this section are fundamental to generating a schedule and budget, but there are more processes needed to complete the final project plan. More of these ancillary activities will be described in Section V, but this introductory subset is considered a core process mechanic related to schedule and budget generation. In this section, the project plan is represented as a direction aggregation of scope definition, work estimation, and resource allocation to the effort. The result is called the first cut plan, which implies more processes will need to be added to this view.

Model schedule and cost view

No theoretical model view can accurately portray the breadth of technical and political machinations involved in producing a final project plan, but understanding this model does help add a better understanding of the essential technical steps involved. The key target for this introductory model segment is plan schedule and budget. More specifically, showing how scope leads to work estimates and then resource allocation to those work units. The steps for executing these model processes are more sequential than any other aspects of the planning and control process. For example, it does not well reflect the iterative nature of the actual planning process before a formal approved plan emerges. Some have called this laying approach “peeling the onion,” where the layer exposed essentially deals with a subset of decisions used for defining the next layer. One term that is used frequently in this section is “first cut plan.” What this means is that the initial process has been executed, but there are other iterations needed to incorporate other “layers” into the overall view. As an example of this, a formal risk assessment process should uncover additional issues that need to be worked. The implication of this is the potential for more work or additional cost that will be added to the first cut plan in dealing with that aspect of the project. Also, there can be future tradeoffs of various plan segments in order to keep the project moving forward as desired. A classic example of integration is trading off (cutting) project scope to reduce the initial schedule. More examples of this will be described in Chapter 12. One of the common metaphors used throughout this book for examining a project is through the three-dimensional box structure of its collective work units. Recall that these dimensions were scope, time, and cost.

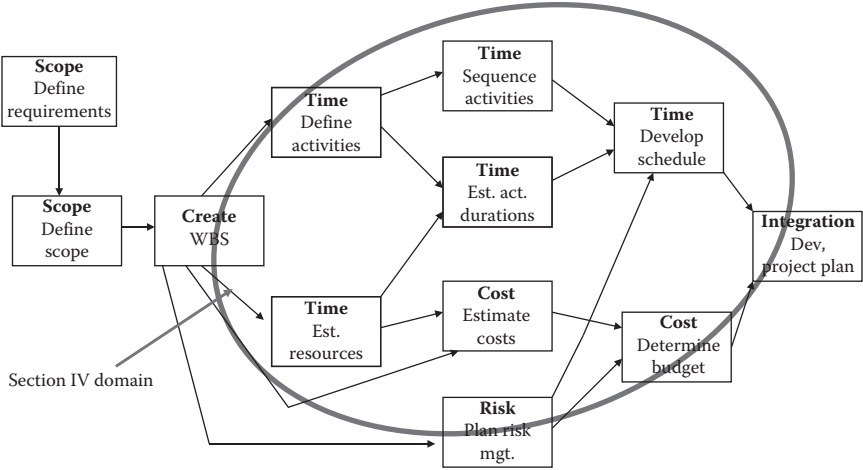


Figure IV.1 Project time and cost plan model processes. (Adapted from Project Management Institute (PMI). 2008. *PMBOK® Guide*, 4th ed. Newtown Square, PA: Project Management Institute.)

Figure IV.1 is a schematic view outlining the basic steps related to the *holy trinity* processes. Many would describe these as the core project management planning processes and certainly the most visible aspects of performance.

Basically, the core project planning goal boils down to defining four management variables related to these work units. These are: estimated work (total effort), resource allocation to the work units, activity duration (from resources allocated), and work sequence.

Figure IV.2 illustrates how the basic work units interact. These items are fundamental building blocks for project management and will be seen throughout the text.

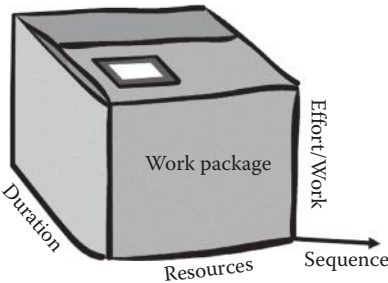


Figure IV.2 Fundamental project work unit.

Chapter 7 illustrated the scope definition (WBS) process work boxes (work units) and their linkage for translating these project elements into a project first cut schedule. Incorporating that view, Chapter 9 will describe the mechanics for using work estimates to create a project schedule. If the project is accurately described in this fashion, it is then possible to descriptively model its future outcome and use that plan view to track status of the ongoing project work activity through its subsequent life cycle. Essentially, the schedule development phase is designed to take estimated work unit durations and link these into an overall project schedule.

Chapter 10 continues the elaboration process by showing how the allocation of project resources to the defined tasks will create a companion first cut budget. A high-level graphical sequence for this scheduling process is outlined in Figure IV.3 and this is a good tutorial overview of the basic mechanics for this entire section.

It is important to keep in mind that the topics discussed in Chapters 9 and 10 represent a scope translation of a high-level project goal with essentially no constraints. After the initial time and cost plan is produced, various stakeholder groups become more involved in reviewing this plan

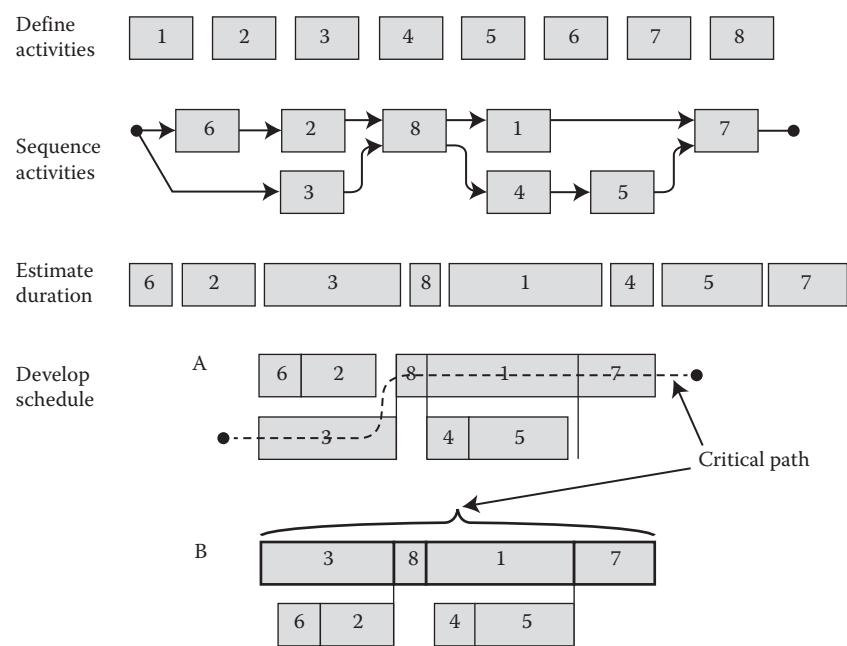


Figure IV.3 Project schedule process sequence.

from their various perspectives. At this point, typical negative remarks emerge such as:

Why so long?

Why so much?

You can't have this many human resources.

What happened to function X that was requested, and so on.

As a result of these stakeholder interactions, it will be necessary for the PM to rationalize the draft plan until management agrees with the results and all stakeholders have the same view regarding what the project will entail. This “tweaking” activity generally means making some change to planned scope, resource commitments, schedule, or budget. A common source for this comes from stakeholders (future users) wanting quicker completion or more function, management wanting less cost, and other conflicts related to the technical approach. Think of these diverse views as conflicts for the PM to resolve using both his technical and political skills. Failure to accomplish only leaves the door open for future conflicts that will be even more difficult to resolve later in the life cycle. For this reason, it is important that the final plan version be formally approved by appropriate key stakeholders since it often represents a compromise on multiple fronts. Too often a project plan is produced more as a wish list than a viable description outlining what can be done with real-world constraints. The five chapters in this section will address the key mechanical and management processes related to creating a project schedule and budget that has these balanced characteristics.

Chapter sequence

To summarize, Chapters 9 and 10 outline the basic mechanics to generate a first cut project schedule and cost from the WBS structure created from the mechanics outlined in Chapter 7. From that base, Chapter 11 offers a brief overview of risk theory as it relates to project planning. This will be a cursory review and the more detailed review of the risk impact is reserved until Chapter 22. Chapter 12 moves the process forward by adding to this planning view the internal resource constraint picture and the reality view recognizing that the various stakeholder desires often do not mesh with the initial plan. Based on typical stakeholder conflicts, this chapter overviews selected approaches for *tweaking* the plan once the first cut scope, time, cost, and resource allocations are combined into a single coherent plan view. Finally, Chapter 13 completes the plan development discussion by outlining the overall process of finalizing a viable plan that will be used to support and monitor the project as it moves through the

execution stage. At the conclusion of this section, the resulting project plan version has been balanced in regard to varying stakeholder perspectives and the required modifications communicated to appropriate stakeholders. At this point, it is important for the plan to be formally approved by the management. That approved version is then baselined and moved into the execution stage. This final modified version represents a view that satisfies technical, economic, and political viability. It is common to describe this as the *approved baseline plan*. These defined baseline performance goal values will be used in the monitoring and control process for plan versus actual status comparison and performance reporting.

chapter nine

Creating the project schedule

PROJECTNMOTION BACKGROUND LESSONS

See Section 2, Lessons 2 and 3; Section 3, 3, Lessons 1–7 as relevant to this material. Note that the lesson on Basic Keystroking is also particularly relevant to this material.

Introduction

Recognize that a schedule overrun is one of the most recognizable negative events for a project. One of the best foundation planning events to minimize this outcome is a clearly defined scope definition. Chapters 7–10 focus, respectively, on each of the holy trilogy management aspects of a project. Chapter 7 has covered the scope definition mechanics and this chapter will cover the second leg of the planning journey in developing the first cut schedule to match that scope. In this discussion, the reader should take careful note of the relationship between the WBS boxes and the resulting project schedule. As we move this description through the scheduling phase into the corresponding budget recognize that these three chapters represent the core focus of project management. However, it is also important to point out that future chapters will add more dimensions to this core view.

The primary scope-to-schedule knowledge linkages are the work packages and other elements outlined in the WBS. As discussed earlier, the WBS and its associated dictionary of lower level data contain the primary support data for creating the project schedule (PMI 2001). In a properly defined WBS, the box structure will pass through into the subsequent schedule and work plans. In this regard, it is important to emphasize that if the work is not reflected in the WBS, then *“it is not considered to be in the project scope, schedule or budget.”* For this scheduling discussion, there will be clear visibility of scope boxes in the plan and identified by their WBS IDs. This translation process is the main chapter goal.

Work activities

Since the intent is to map scope definition boxes (WBS) directly into the project plan, the importance of the scoping activity becomes more evident. This is just the first of many reasons why this tree structure is the most

important artifact in the planning process. If we think of the boxes as representing time through the estimating process, then all that is required to produce a model schedule is to identify the sequence of the boxes. At least this is a starting point and an important conceptual idea. It would not be good to suggest to a real-world PM that this is all there is to project scheduling, but these two components are the key elements to start our description of the scheduling process. Do recognize that the accuracy of the box duration and sequence determines the match to actual schedule.

Sequencing activities

Every project has some logical sequence for performing its defined work. In some cases, the work sequence is technically mandatory. As a visual metaphor for this, think of two related activities such as pouring a concrete slab and then painting it. That technical sequence would be clear—pour first, let it dry, and then paint. In other situations, a work sequence can be more arbitrary in terms of technical requirement, but in some cases there is still a management preference for a sequence. This may be one to optimize project resources, or even based on factors such as weather, that is, it is going to be winter at this time, so the work will be moved inside as much as possible. Defining the proper work unit sequence is fundamentally an art form based on deep knowledge of the technical work and resource availability to accomplish the goal.

One initial method for modeling activity sequence is to link the work units into a connected network view using arrows to represent the activities. The view shown in Figure 9.1 is called a Predecessor Diagram Model (PDM). Figure 9.1 illustrates a sample PDM network. This format is useful for examining a sequence plan and evaluating it both technically and managerially. However, as the project grows in size, the graphical method becomes harder to maintain and other computer-based methods then become preferable. In this case, a graphical WBS view has to be “flattened” into a list containing WBS ID, task, duration, and predecessor. At

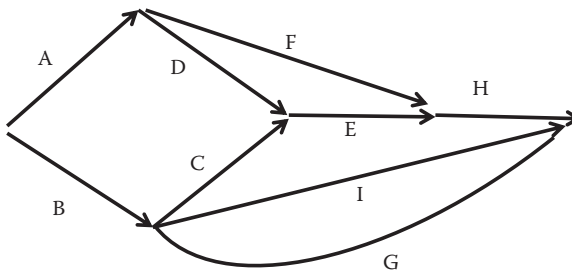


Figure 9.1 PDM network schedule model.

some high level of detail, it is still easier to visualize sequence graphically. The rule of thumb says that a graphical network becomes unwieldy as the size grows beyond 50 or so work units. Maturation of supporting desktop PC tools has greatly aided this planning activity over the last few years.

Software modeling

Computer software does not handle arrows or graphics well, so in order to move the problem into a computer-centric model, it is necessary to translate this schematic view into a more data-oriented format. The data shown in Table 9.1 mirror the network model shown in Figure 9.1 and this is much closer to a required computer data input format.

Note that this shorthand form for sequence coding defines how the various activities are linked to each other. In this way, the defined task sequencing can be correctly modeled by the software. In order to test your understanding of these concepts, the list below contains a few sample interpretations of the activity relationships in Table 9.1.

- 1. Activity A has no predecessor constraint, therefore it start immediately.
- 2. Activity C can start after B is finished.
- 3. A more complex coding example occurs with activity H. In this case, activities E and F have to be finished before H can start.

To accomplish the sequencing step successfully, the project team must understand the required technical process sequence as well as other operational and environmental factors related to the execution process. The interaction of these two factors makes the sequencing specification more than just defining a technical sequence. When translating this information into a computer model, the activity linkages are converted into reference line numbers rather than the activity name as shown in

Table 9.1 Predecessor Coding

Activity	Predecessor
A	— —
B	— —
C	B
D	A
E	D,C
F	A
G	B
H	E,F
I	B

Table 9.1. Thus, the code for activity C residing on line 3 would have a value of “2.” This is simply a shorthand technique to reflect the same decision and save keystrokes. If another linkage is identified, then this can be easily changed as required.

As an example of an arbitrary relationship, it is often desirable to group common skill activities to better manage that work group schedule. For example, if a WBS task defines that a room is to be painted and an adjacent room also needs to be painted, the scheduling sequence could be changed to specify painting the two rooms in sequence rather than simply linking the task to construction of the wall or room. This in effect changes the technical linkage. Logically, once the painters are working in an area, it would be more efficient to just have them move next door and continue working rather than pack up their equipment and come back another time. Likewise, inside activities may be changed to avoid outside bad weather, or a host of other discretionary logic options. These points illustrate that the predecessor coding is not just a technical work linkage. Predecessor coding represents the creative part of the schedule development exercise and as illustrated is both a technical and art-oriented process.

Predecessor relationship codes

The linking process described thus far is called FS, meaning finish–start (FS). This is the end-to-end activity (arrow) relationship specifying that the predecessor work unit has to be finished before its successor can start. However, there are other task relationship options that can be coded to better model the desired work sequences. The other sequencing options are:

- Start/Start (SS)—this indicates that the two linked activities would start at the same time. So, a code of SS6 would define that the activity would start at the same time as the activity on line 6.
- Finish/Finish (FF)—this code indicates that the named activity would need to finish at the same time as its reference activity. So, a code of FF6 would define that the activity should finish at the same time as the activity on line 6.
- Start/Finish (SF)—this is a little used relationship for most projects. Its interpretation is that the successor task cannot be completed until the predecessor begins. This format basically fits the Just-in-Time manufacturing approach designed to “pull” the predecessor activity rather than a “push” relationship like the other options reflect.
- Lag—this is a supplementary relationship to each of the four basic codes above. The term lag means that the coded task obeys one of the basic relationships, but then must wait for some further specified time. One easy way to remember this logic is to recall again the concrete pouring example. In this case, the required technical sequence

for these two events is to pour the concrete slab (task A) and then paint the surface of the slab (task B). There is an obvious required technical sequence between these two tasks; however, in this case the concrete must also be allowed to dry first and this drying time represents a required lag. If we assume the concrete must dry for 5 days, then the predecessor code for task B would be A + 5.

- Lead—a lead relationship is just the opposite of a lag in that the linked task can start before the predecessor is finished. So, the code A-5 would say that B could start 5 days prior to completion of A.

From this discussion, it should also be obvious that the predecessor coding activity has the potential to stretch or compress a schedule depending upon the lead, lag, or other predecessor codes. Think about the impact of changing a relationship from FS to SS, which in effect shortens the total sequence for the two activities involved. The project team must understand the implications of these options and their cumulative impact on the resulting schedule.

Work unit resources

Our model theory has defined the project scope as being represented by a collection of work elements consisting of Work Packages (target sized at 2 weeks duration and 80 work hours), planning packages (not decomposed yet), and summary groups of lower level boxes. Review a WBS layout and verify that you understand how these three box types would be represented in the structure. Once these work units are defined, the following steps are required to allocate the specific resources necessary to produce the defined output for each unit:

1. The initial step in the process involves the decision for allocating various human resource skills required to execute each defined work unit in the WBS. As an example, a work package estimate would specify the total work hours required for a carpenter, plumber, and an engineer.
2. Material resource estimates are defined for each work unit based on the technical specifications.
3. Other supplementary costs are estimated for each work unit. One common example for this category is travel costs or common equipment needed by the work unit.

Techniques of work estimating are unique to each industry as described in Chapter 8. Regardless of the local approach for deriving activity work estimates, translation of that decision into the schedule requires specific resource quantities be assigned to generate duration estimates.

To help refine the plan as it evolves all of the estimates and associated assumptions related to this activity should be captured in the WBS dictionary for use in subsequent steps.

Estimating activity durations

Duration estimates are driven by decisions related to work effort by various labor skills. To translate work into activity duration, it is necessary to define the number of actual bodies by skill type to be allocated into that work unit. This in turn yields the planned work duration of the activity. To illustrate this point, assume that the work package activity is defined to be 160 hours of work. Assuming the skill required is defined, the next step in the sequence involves the actual work schedule of the resource. A typical work schedule assumption is 40 hours per week (standard 8×5 work week). So, if one person was allocated to this task, the activity duration would be 20 days or 4 work weeks. However, the PM may decide that he wants this done in 5 days, if possible. In concert with the work unit supervisor, it is decided to allocate four full-time resources and they believe this will accomplish the desired 5-day goal. This second scenario shows how the resource allocation decision impacts the duration estimate and resulting project schedule. From this discussion, it should be obvious that the complexity of the resource allocation process is significant. Finding the balance among available resources, optimum task times, and compressed schedules is one of the most stressful parts of planning and executing the project.

It is important to note at this point that the planned resource allocations are really ideal scenarios. There is no assurance that the defined skills and quantities are available since the actual time period for the work is not yet defined. This issue will need to be dealt with before the plan is approved, but that will be deferred for now.

Developing the project schedule

There are essentially four decision variables necessary to create a first cut schedule. These are

1. WBS code ID
2. Work unit name
3. Estimated duration (work days)
4. Predecessor code

To develop a simple example, assume that we have only four activities in our sample project and each activity is estimated at 5 days duration. The data setup for translating this into MS Project (MSP) is outlined in Figure 9.2.

	❶	WBS ▾	Task Name ▾	Duration ▾	Predecessors ▾
1		1	Total Project	20 days	
2		1.1	A	5 days	
3		1.2	B	5 days	2
4		1.3	C	5 days	3
5		1.4	D	5 days	4

Figure 9.2 Project schedule parameters.

This set of data can be cut and pasted directly from Excel into MSP with the result shown in Figure 9.3. See the ProjectNMotion website, Section 2, Lesson 3 for more specifics on this loading process.

Notice that the project schedule is essentially derived from the raw data described. However, there are two additional less obvious scheduling parameters embedded in the computer version. First, the resource work schedule has to be defined since the software uses this to translate how a particular work unit can be executed within the resource’s work schedule. Second, the start date for a project must be set in order for the sequence to properly be shown on a calendar view. Observe in Figure 9.3 how the software recognizes nonwork time (gray columns in the Gantt bar area). These nonworking times affect the completion date. For the schedule calculation to be accurate, the calendar must reflect nonworking times such as holidays and vacations for the assigned workers. These two internal components allow a calculation of calendar dates to be added to the raw work duration values that a simple PDM-type network would show. This is another advantage of using a computer model over manual processes.

This first cut version of the plan is quite easy to derive, but it would not be fair to call this the final project schedule. However, it does represent a significant starting place for the project planning model. Because of various other project dynamics and stakeholder pressure, we should expect to go through more decision iterations of this plan before finally getting an

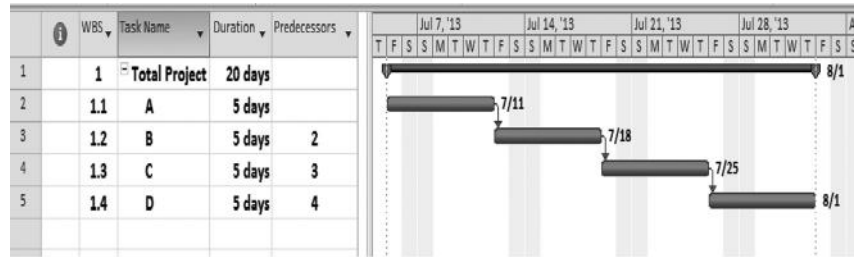


Figure 9.3 First cut project schedule.

approved package of tasks, schedule, and budget that is acceptable to the various decision-makers. It should be anticipated that some stakeholder groups will not like the schedule produced by this initial calculation. Some will think the cost is excessive, whereas others will want more or less functionality (scope). In essence, all of the triple constraints will be challenged in conflicting ways. This will necessitate manipulation of activities, durations, and resources until a suitable combination is achieved. For now, we will just deal with the basic mechanics to better illustrate the model schedule generation process. The good news in all this is that any needed future changes to this view can be made quickly by changing the respective driver data and the results will be automatically translated from that.

MSP schedule generation mechanics (stage one)

The introductory stage one keystrokes described in Appendix B are primarily mechanical in nature, but it will take a little practice to become proficient. To accomplish this, the recommended approach is to review the ProjectNMotion website video tutorials (www.tech.uh.edu/projectn-motion) and also extract a copy of the MSP keystroke documentation from either Appendix B or from the Supplemental Documents section of the website. Various video lessons in the Scope and Time sections will help to illustrate specific keystroke details for translating data from a WBS format into a first cut plan. The keystroke summary list will offer more specific mechanical guidance. It will be worthwhile to execute the steps outlined in Section I of this checklist with sample project data to ensure that you understand this initial set of planning mechanics. Following that, test your competence with one of the sample problems from this chapter.

Sample first cut schedule problem

This example problem is designed to illustrate basic mechanics for translating scope-oriented data into a first cut project schedule. A spreadsheet with this table data are stored on the publisher's website for your use under the file name Table 9.2 *First cut plan parameters*. Table 9.2 represents that file. Note that the data is in WBS flattened format. The goal of this example is to manipulate this data using the keystroke checklist. The following note list will help guide you through this process:

1. The top of the WBS is line #1
2. Bolded line numbers are summary tasks (i.e., 2, 6, 11, etc.)
3. Line 19 is a summary task for #20 and #21 (they must be indented)
4. Task #33 is a milestone (zero duration)
5. Load the scope data into MSP and set the start date to April 1, 2014
6. Indent the data to mirror the WBS structure defined

Table 9.2 First Cut Project Plan Parameters

WBS	No.	Task name	Predecessors	Duration
1	1	Desktop refresh project		
1.1	2	Hardware selection		
1.1.1	3	Determine technical specifications for hardware		4 days
1.1.2	4	Selection of hardware vendor	3	1 day
1.1.3	5	Test hardware that is selected	4	8 days
1.1.4	6	Procurement of hardware	5	10 days
1.2	7	Software selection		
1.2.1	8	Licensing negotiations with software vendors		5 days
1.2.2	9	Test software from each vendor	8	8 days
1.2.3	10	Procurement of software	9	10 days
1.3	11	Integration of hardware and software		
1.3.1	12	Implement new security model	18	5 days
1.3.2	13	Customization for each organization	12	7 days
1.3.3	14	Testing of the integrated desktop	13	10 days
1.4	15	Verifying existing infrastructure		
1.4.1	16	Test server capacity	5,9	5 days
1.4.2	17	Test the network hardware and software	16	5 days
1.4.3	18	Procure necessary infrastructure upgrades	17	10 days
1.5	19	Training for employees		
1.5.1	20	Create documentation materials	12	15 days
1.5.2	21	Technical architecture documentation	12	8 days
1.5.3	22	User manuals	12	20 days
1.5.4	23	Review documentation materials	20	2 days
1.5.5	24	Conduct user training	23	12 days
1.6	25	Deployment by organizational area		
1.6.1	26	Marketing deployment	24	8 days
1.6.2	27	Engineering deployment	26	8 days
1.6.3	28	Finance deployment	27	8 days
1.6.4	29	Executives deployment	28	8 days
1.6.5	30	Legal deployment	29	8 days
1.6.6	31	IT deployment	30	8 days
1.6.7	32	Administration deployment	31	8 days
1.7	33	Project complete	32	0 days

- 7. Once the activity data are loaded and the first cut schedule produced, insert a recurring task after #30 defined as “Project Management” (see the MSP checklist)

Load the table data below into MSP and manipulate these data using the “Stage One Keystroke” checklist described earlier. Also, review the companion video tutorials that cover these specific commands. Both of these sources are helpful in learning these important steps. Once accomplished, this represents basic MSP scheduling competency.

Results for the first cut plan

The WBS resulting from Table 9.2 manipulation is shown in Figure 9.4 (this example is created by WBS Chart Pro). It would be a good learning exercise to compare the original table view and the resulting WBS schematic. This offers reinforcement that the resulting plan is tightly linked to the WBS scope definition and that all defined work is included in the plan. If your output WBS does not match that shown in Figure 9.4, the most likely source of error is either activity indention for WBS structure or predecessor code values.

Critical path

One of the most important plan status elements is to define which tasks are constraining the overall schedule. Opening up a table variable called Total Slack will show how long that activity can be delayed without affecting the project schedule. Also, red Gantt bars indicate those tasks with zero slack. This is created by selecting the critical path option check box (see checklist). All non-red Gantt bars have some amount of idle time and do not limit the schedule as defined.

Activities that have positive total slack would generally require less rigorous monitoring since a slippage in these will not affect the planned completion date so long as slack remains.

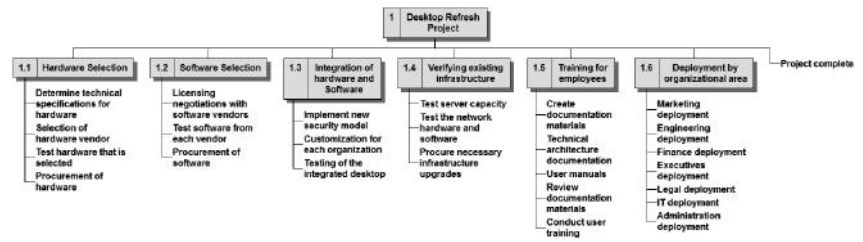


Figure 9.4 WBS for first cut plan.

Understanding both critical path and slack concepts is vital for effective time management and requires that the PM keep these parameter values in mind as the project unfolds. Also, recognize that errors in duration estimates will cause the slack values to change during project execution, so this is not a static view by any stretch. Understanding activity slack or float gives the PM flexibility in scheduling the start of a particular activity (Uher 2003). This also helps to facilitate prioritization of resource allocations across the project plan. For example, if there are two activities occurring within the same time range, one critical and one noncritical that are competing for the same resource, the PM can allocate the resource to the critical activity first, then use the slack or float time on the other to delay the start of the noncritical activity.

Discussion questions

1. What is the critical path of this plan?
2. How long will this project last?
3. What is the calendar date for completion?
4. Which activity has the most slack time?
5. When will the project be complete according to the model?
6. Open up a new data column for total slack. What does this indicate?
7. What is the most logical strategy to reduce cycle time in this plan?
8. If you have either the WBS Chart Pro or Visio WBS add-ins loaded, produce a graphical WBS from the first cut model. Add additional data parameters to the WBS structure to help communicate the overall project schedule data.

Summary

This chapter has explored the basic mechanics required to create a first cut project schedule. Also, important core vocabulary has been introduced. Both of these items represent basic skills needed in various other project scenarios. Remember, as good as the first cut plan looks it is important to recognize that there are other steps required before it can be considered a viable plan ready to receive management approval and move into execution. Our final goal is to produce a plan with this basic structure that is agreed upon by key stakeholders and can then be used as a road map through its lifecycle and serve as a baseline for status analysis. The mechanics are now in place, but now the approval remains a forward goal.

Supplementary technical reference

Some readers may not wish to go through this upcoming set of more technical schedule calculations since MSP performs similar calculations. However,

the manual graphical view offers more insights into the actual mechanics involved, so this section is defined as an optional technical reference.

Manipulation of the project network sequence diagram involves a fundamental set of calculations used to produce both the critical path and noncritical path (slack) calculations embedded in the project network plan.

Plan status mechanics

After supplying the basic activity, duration, and predecessor parameters for defining the network plan, there are seven management-oriented parameters that can be calculated from these data. These are:

1. ES or $T(E)$ —early start; earliest time the activity can commence.
2. LS or $T(L)$ —late finish; latest time the activity can start and not affect project schedule.
3. EF—earliest time that an activity can finish.
4. LF—latest time the activity can finish and not affect project schedule.
5. Total slack (float)—the difference between the *earliest* date that the activity can start and the *latest* date the activity can start before delaying the completion date (LS–ES).
6. Free float—the amount of time an activity can be delayed before any successor activity will be delayed (EF–ES).

For the sample network exercise, we will assume that all activity relationships are *Finish–Start* (see Figure 9.1), meaning that each predecessor activity has to completely finish before the successor activity can commence. A schematic view of this type of relationship is shown in Figure 9.5.

Table 9.3 defines a sample project activity list that will be used to show the manual network mechanics.

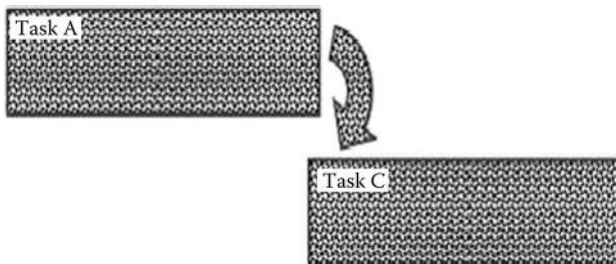


Figure 9.5 FS relationship.

Table 9.3 Sample Project Definition

Activity	Duration	Predecessor
A	3	—
B	4	—
C	4	A
D	6	B
E	5	C
F	2	C
G	4	D,E
H	3	F
I	5	G,H

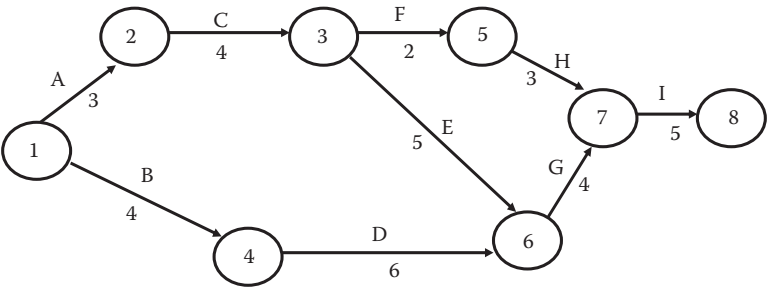


Figure 9.6 Sample activity-on-arrow (AOA) network.

From this definition, the following arrow-on-arrow network shown in Figure 9.6 can be produced.

Review the network setup to be sure that this setup step makes sense as it is the base for the remainder of the mechanics.

Forward path calculations

Step 2 of the mechanical plan calculation is to perform what is defined as a *forward pass*. This process basically adds the arrow lengths to calculate the total duration time moving from left to right through the network, while obeying the predecessors. Early times to reach each node (end of arrow) are recorded by the format of “T(E),/,” which is the notation for earliest time to reach that point in the network. Figure 9.7 shows the calculated values for each of the nodes. These example calculations are quite straightforward except for nodes 6 and 7. For node 6, two incoming activity paths have to be considered for the activities D and E. Node 4 has a T(E) value of 4 and activity D has a duration time of 6, therefore, the resulting value for node 6 would be 10. However, the other parallel

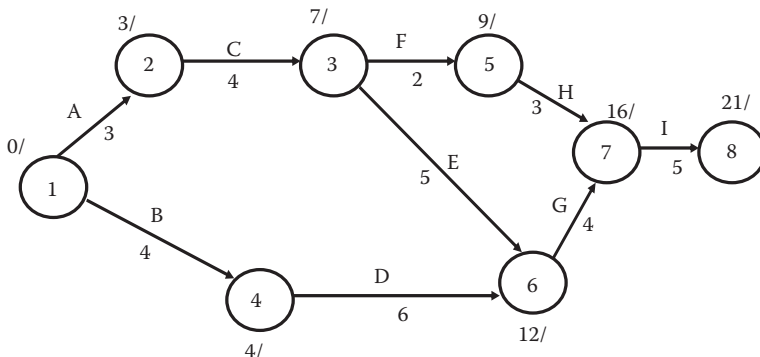


Figure 9.7 Forward pass calculations.

path coming into node 6 starts at node 3 with a value of 7 and an activity E time of 5, so that path value is 12. For forward path calculations, the highest value among multiple incoming paths is selected for such parallel paths, thus we assign the value 12 for $T(E)$ at node 6. This calculation indicates that the earliest we can claim completion of these project activities at this point is 12. The same type logic applies to node 7 where a value for $T(E)$ of 16 is calculated. *The calculation rule for the forward pass is to remember to take the highest value for multiple input paths at the node.* $T(E)$ values at each node represent the earliest time that these points in the project can be reached from a schedule viewpoint. This calculation process also shows that the final node (8) can be reached at time period 21. The final node value defines that the project duration is 21 given this set of parameters. The forward pass then defines a crude project time schedule (Figure 9.7). However, even though this is an interesting value, there are other more worthwhile parameters that need to be defined. We will see these in the next step.

Backward pass calculation

Step 2 of the calculation process involves performing a backward pass on the network model. The rationale for needing this is not clear as yet, but let us first describe the mechanics of the calculations before attempting to describe the function of these values. The backward pass generates a variable defined as $T(L)$ and it is formatted on the network node as " $T(E)/T(L)$." Notice that the nodes in Figure 9.8 now show two such numeric values above each node. For this basic network, the assumption is made that the planned time at termination is equal to the forward pass calculated time shown (i.e., 21 time units for the example). Stated another way, we are saying that the forward plan specified that

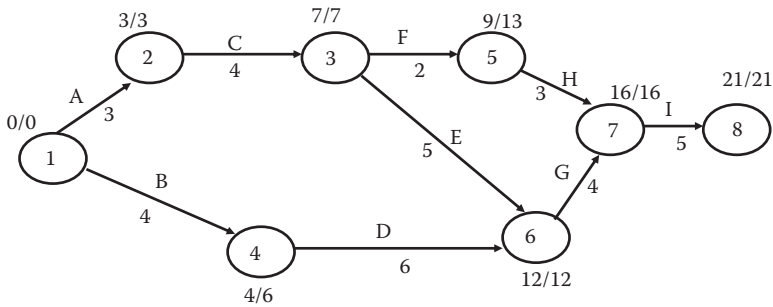


Figure 9.8 Backward pass calculations.

the project would take 21 time units and we are accepting that value for the backward pass.

To calculate $T(L)$ values, we start at the completion node (8) and insert the same time as calculated for the forward pass—which is 21 in the sample case. From this starting value, work backwards to the front of the network one node at a time. For node 7, the $T(L)$ value would be 21 minus 5 (for activity I), or 16. Node 6 would be calculated as 16 minus 4 (for activity G), or 12. As described in the forward pass mechanics, the $T(L)$ calculations are straightforward until a node that has multiple paths coming back into it such as node 3 is encountered. In this case, the $T(L)$ calculations would compare the two paths for activities F and E yielding a 13 minus 2, or 11 for activity F, versus 12 minus 5, or 7 for activity E. The calculation rule for the backward pass is to take the lower value of the two reverse paths and record that as the nodal $T(L)$ time. This same process is required for node 1 and at that final node the value should be zero since we started with 21/21 at node 8. Failure to return with a zero value indicates that an error was made in the return path. Review the values shown in Figure 9.8 to be sure that you understand the basic idea of $T(E)$ and $T(L)$ mechanical values.

Once the values for $T(E)$ and $T(L)$ are calculated, it is possible to analyze two additional important time management factors. These are the longest path through the network (critical path) and slack time details. The simplest item to calculate of these two is nodal slack time. This is simply the difference in $T(L)$ and $T(E)$. So, node 3 would have a slack value of zero (7 minus 7), while node 5 has a slack value of 4 time units (13 minus 9). Each of these values defines the amount of time that this node can set idle without affecting the planned project completion date. Also, note that the computed slack for the start and finish of the network will be zero from using the assumption of 21/21, that is, this says that we are happy with the original computed project duration. You might be thinking about what you would do if some other value for $T(L)$ was desired.

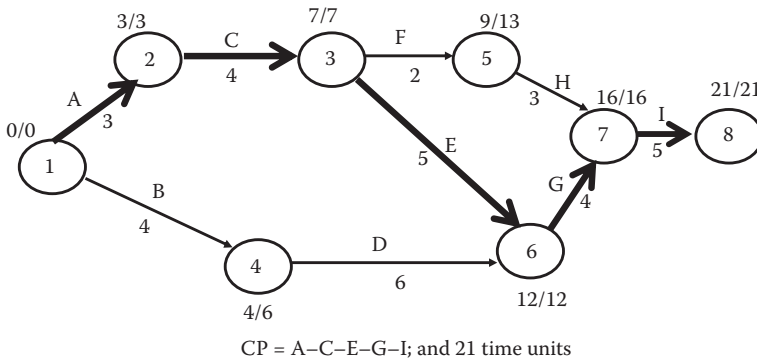


Figure 9.9 Critical path.

Several other slack-type status parameters can be derived from this view. The most interesting ones are Total Float, Free Float, and Late Finish. Each of these relates to activity views rather than node calculations, but this same value set can be derived from the node values. Total Float relates to the amount of activity slack (variability) before project completion is impacted, while Free Float deals with the same view only for the successor activity. Late Finish describes the latest time that the activity can be completed without impacting the schedule. Since these arrows represent required project work, the various slack views represent vital schedule information for the PM. MSP can also generate this type of information with its internal calculations.

To find the network critical path activities, the key mechanic involves checking any activity bounded between zero slack nodes to see if in fact that path is a critical activity. In some more complex networks, parallel paths can both appear to be on the critical path, whereas only one actually is. In this sample case, the critical path definition is straightforward and is outlined as bold arrows in Figure 9.9. Note that the critical path passes through nodes 1-2-3-6-7-8 and the critical path activities are A-C-E-G-I. Specifically the critical path should be thought of as a vector containing both the activity list and the total duration value, so it would be more proper to state the critical path as A-C-E-G-I, and 21 time units. To reiterate, this is the longest path through the network and represents a critical management issue for the PM (Brown 2002).

MSP equivalent output

To see how the schematic network output compares to an MSP Gantt view, it will be instructive to compare the two views. The equivalent MSP core output is shown in Figure 9.10 and the associated network slack calculation parameters in Figure 9.11.

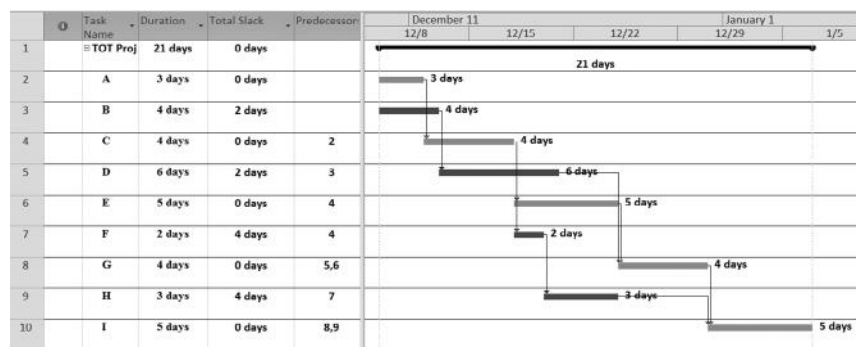


Figure 9.10 MS project equivalent for schematic network.

	ID	Task Name	Duration	Predecessor	Early Start	Late Start	Free Slack	Early Finish	Late Finish
1		TOT Proj	21 days		12/9	12/9	0 days	1/6	1/6
2		A	3 days		12/9	12/9	0 days	12/11	12/11
3		B	4 days		12/9	12/11	0 days	12/12	12/16
4		C	4 days	2	12/12	12/12	0 days	12/17	12/17
5		D	6 days	3	12/13	12/17	2 days	12/20	12/24
6		E	5 days	4	12/18	12/18	0 days	12/24	12/24
7		F	2 days	4	12/18	12/24	0 days	12/19	12/25
8		G	4 days	5,6	12/25	12/25	0 days	12/30	12/30
9		H	3 days	7	12/20	12/26	4 days	12/24	12/30
10		I	5 days	8,9	12/31	12/31	0 days	1/6	1/6

Figure 9.11 MS project schematic network data parameters.

There are several items to examine in the MSP view of its associated Gantt bar schematic. It would now be worthwhile to review the status parameters shown below to ensure that the meaning of the terms are understood:

1. Note that the total project duration is correct at 21 days and the critical path is correctly defined.
2. Total slack and free slack calculations are correctly shown, although they are converted into calendar dates rather than duration equivalents. This is more meaningful for the management aspects related to slack. The example is set to start the project on December 9, 2013, so it is possible to manually check the calendar versus raw duration results.
3. The MSP model also shows nonworking periods and corrects the completion date based on that. The network model does not deal with this level of granularity.

4. The other early and late activity calculations are shown in Figure 9.11 as calendar dates.

Hopefully, this comparative review is sufficient and convincing that the software is easier to use than manually creating a schematic view of the schedule and then performing the same calculations. The rest of the chapter will revert back to the software approach based on this belief. Think of the software view this way—MSP is doing nothing other than building the relationship defined and describing the resulting output based on the input parameters.

QUESTIONS

Review questions

1. What is the process sequence necessary to move a work package estimate into a schedule?
2. What are the four predecessor types used to model work unit sequencing?
3. What is the role of a PDM in the schedule development process?
4. What does a milestone signify in a project plan?
5. To generate a schedule using MSP what are the four basic data items required?
6. If we wished to delay the time between two work units, what is the vocabulary term for this?

In-class questions

1. If a schedule is longer than desired, what would be the simplest method to shorten it?
2. What are the implications of not having actual resources defined in the plan?
3. Provide some examples to illustrate how a well thought out plan will in fact not be met?
4. Discuss some of the methods that might be effective in making the actual project outcome more closely match the approved plan.

EXERCISE

An activity list for the car development project is shown in Table 9.4. This data file will also be stored in the publisher website as *Table 9.4 Car project activities*. Translate this structure into a first cut project schedule in order to test your understanding of the schedule creation process, then answer the same status questions outlined for the earlier example problem.

Table 9.4 Car Problem Activity List

ID	WBS	Task name	Predecessors
1	1	Nine car problem first cut	
2	1.1	Planning and project initiation	
3	1.1.1	Charter	
4	1.1.2	Stakeholders identification	3
5	1.1.3	Scope definition	3
6	1.1.4	Schedule development	5
7	1.1.5	Risk assessment	6
8	1.1.6	Budget definition	7
9	1.1.7	Management charter approval	8
10	1.1.8	Set baseline	9
11	1.2	Engineering	
12	1.2.1	Body/engine draft design	
13	1.2.1.1	Initial draft	9
14	1.2.1.2	Integration analysis	13
15	1.2.2	Mechanical engineering	
16	1.2.2.1	Engine design	10
17	1.2.2.2	Mechanics design	10FS + 10 days
18	1.2.3	Electrical engineering	
19	1.2.3.1	Electrical design	17
20	1.2.3.2	Wiring	19
21	1.2.3.3	Others elect	19
22	1.2.4	Structural engineering	
23	1.2.4.1	Body	12
24	1.2.4.2	Other body parts	12
25	1.2.4.3	Design integration review	14,17,21,24
26	1.2.5	Body/engine structure	
27	1.2.5.1	Chassis	23
28	1.2.5.2	Other structures	23
29	1.2.5.3	Mechanics parts	28
30	1.2.5.4	Electric–electronic parts	28
31	1.2.6	Engineering final review	30
32	1.3	Logistic and procurement	
33	1.3.1	Part ordered	31
34	1.3.2	Part delivered	33FS + 20 days
35	1.4	Manufacturing assembly	
36	1.4.1	Station mechanic	34
37	1.4.2	Station electric	36
38	1.4.3	Finishing	37

continued

Table 9.4 (continued) Car Problem Activity List

ID	WBS	Task name	Predecessors
39	1.5	Testing	
40	1.5.1	Components testing	
41	1.5.1.1	Electronic components testing	38
42	1.5.1.2	Mechanic components testing	38
43	1.5.2	Test drive	42
44	1.5.3	Safety test	43
45	1.6	Formal closing	
46	1.6.1	Documentation	44
47	1.6.2	Close records	46
48	1.6.3	Formal shutdown	47
49	1.7	Project buffer	48
50	1.8	Close project	49

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chapter ten

Creating the project budget

PROJECTNMOTION BACKGROUND LESSONS

See Section 4, particularly Lessons 4.1 and 4.2. The lesson on Cost Allocation Process links closely to this chapter's material.

Introduction

As in many project management decision areas, the process of cost planning is both simple and complex. Yes, it is possible to mechanically calculate resource costs for the project using reasonably straightforward techniques, but that simple view may not be either adequate for all concerned or represent an accurate cost picture. For example, accountants look at resources (money) for the enterprise in much more complex ways than the laymen. Likewise, team members are more concerned with the actual expenditures since that represents one of their basic control measures. The PM must understand these variable views of budget, as well as those needed to manage the project. Likewise, he has to deal with various other cost-related considerations in order to fulfill his responsibility to the organization. Previous discussions have taken a *peel the onion* view to the project management process to explain sequences or phases of the process. That seems even more appropriate here. Let us start this process by describing the labor side of resource management, then work on expanding that segment into a view that shows more of the total cost picture. For the first segment, we will focus on defining some key terms related to the direct cost of work and planning packages.

Key terms

Several different resource types are utilized in the execution of a project. These essentially are categorized by human labor, material, cash expenses, reserves, and overhead. Some of these items are controllable by the PM, while others are less so. Four of the more common visible resource items are

1. Direct labor, material, and expenses related to the work unit level
2. Level of effort (LOE) expenses allocated to the project (technical support, for example)

3. Third-party contractual expenses
4. Various types of overhead (direct and indirect)

The intent of a project WBS is to define all project work elements to show how various resource elements will be utilized. This highlights the requirement for all project work to be reflected in the WBS. Using this approach, direct project costs can be derived using the defined resource rates for the allocated resources. This process simply aggregates the resource cost for each work unit based on its internal resource allocation. Later, as the project unfolds, planned versus actual comparisons can be made as part of the control process. Even though the goal is to evaluate status at the work unit level, it is important to recognize that some compromise to this mapping goal will be necessary. For example, expenses related to a vehicle used by the entire project team may be difficult to track to a work unit. In that case, the vehicle costs might simply be collected at some higher WBS level. Whenever possible, it is desirable to evaluate resource consumption at the point of occurrence and thus be able to compare plan versus actual values during the execution phase.

Direct costs

Direct costs are linked to specific project work units, whereas indirect resource charges are allocated in various ways and may be less visible to a specific project work unit. Each project work unit (e.g., work package, planning package, or summary package) requires some combination of human resources, material resources, and other expenses for its execution. If we can estimate these resource requirements to some degree of accuracy, the overall project plan accuracy will follow. Of course, it should be pointed out that this is easier said than done. Recognize that there are estimating challenges in all of the resource types.

The human resource is often the most significant cost element in a project, but not always. Mechanics for computing the project cost of this resource follows a few basic steps. First, the initial work unit estimating process defines values for skills and work level in each work unit. Once that is defined, the next step translates that into a direct cost estimate by allocation of defined resources into the work units. A direct cost is then produced through the corresponding rate values for those resources. That arithmetic process is simple, but the accuracy of this can be suspect. One potential such error source is related to the rate value of the allocated resource. This originates from the realization that the name of the person who will do the specified work is unknown at the time of estimation; therefore, by necessity an average “generic” rate must be used. At execution time, there will likely be a corresponding error once the specific person is assigned. This approach obviously has the

potential to create estimating errors, but this is a necessary planning process. As a project unfolds and actual resource names become known, it is possible to replace the generic resource name with a specific name and rate to achieve a more accurate estimate. However, even though this may improve arithmetic accuracy that step is not typical because of the administrative overhead involved. In the examples shown here, generic names and rates will be used, but the process described is the same for a named resource. Also, be aware that the rate errors can be evaluated as part of the project evaluation process and refined for future projections. This is just one example to illustrate how organizations mature in the project management process.

Cost allocation mechanics example

The mechanics involved in computing the human resource cost component will be illustrated using the following work unit example:

- Two generic carpenters are assigned and their work schedule is a standard 5×40 work week.
- Generic resource rate is \$30/h.
- Estimated work unit duration is 2 days assuming a standard work day calendar.

So, the total resource commitment is two carpenters working for 2 days at 8 h/day, which constitutes 32 total hours of work at \$30/h. The calculated direct labor resource cost for this work unit would then be $(32 \times \$30)$ \$960. We will discuss later whether this represents their base salary or a fully burdened organizational overhead cost view. For now, let us assume that this is the human direct cost basic process.

Indirect costs

Indirect costs include enterprise machinery, plant, and other indirect expenses associated with the organization support of the project. For instance, if direct labor cost is \$100,000, the organizational labor overhead rate for this item might be an additional \$100,000. Also, there may be an additional general organizational overhead charge allocated to the overall project which could add another 50%, or more to the calculated costs. These additional overhead charges are not controllable at the project level, but certainly affect the cost viability of the project.

Indirect costs are often combined in various cost pools referred to as *overhead*. Sometimes, it is very difficult for a PM to understand where all of the indirect charges come from and the term *overhead* is often used with a negative connotation. These charges are typically allocated to

the project on a percentage basis with no real explanation. For example, 100% might be added to all direct labor estimates, 5% to all material purchases, and another 50% to the total project for corporate overhead. Obviously, numbers like this will significantly increase the initial budget estimate of a project, yet they are organizational reality that must be dealt with along with the direct cost items. Recognize that these charges arise as a result of the project being housed inside a larger organizational structure and there is no control from within the project as to these allocations. In many cases, the only way to minimize the indirect allocation is to finish the project as quickly and efficiently as possible since some administrative overhead fees are time based. It is necessary for the PM to understand the required various indirect allocation processes and be sure that these are included in the planning budget. If not, an unplanned allocation showing up later would represent an undesirable budget overrun.

Miscellaneous budget components

The listing below illustrates five somewhat less visible budget components that need to be understood as to their impact on the project budget. A brief explanation of each group follows:

Level of Effort (LOE): This cost category can arise in many ways. A common example of this is support services that are allocated to various levels within the project WBS. For example, an agreement could be reached with the IT department to supply needed technical support to the project. That agreement might be for \$10,000 per month. The actual work performed is not linked to specific work units, so this amount is added to the total project and possibly called service agreement. Realize that there are many other similar examples of this type of project cost source. These are different from overhead in that the support resource is direct, but hard to isolate to a particular work unit or even summary level.

Scope change: Let us assume that scope creep history with past similar projects is 2% per month. The project WBS activity list does not reflect this as it has not yet occurred. However, we fully believe that similar changes will occur, so if we are trying to estimate the project cost, some recognition of this category should be included in the budget. Recognize that a project being performed for a buyer under contract would not have this since the scope of work is fixed by the contract. However, it may be important to recognize that scope can change simply by a misunderstood work requirement definition, so even here WBS changes can occur without a formal change request. Regardless of the project structure, careful consideration should

be given to the process for handling scope change. This has to be funded in some fashion and recognized in the budget.

Management reserve (MR): A common definition of this term is an *unknown/unknown*. This means that unanticipated events occur that require funding. Some reserve is needed in the budget to cover this class of activity. Activities overrun, material is spoiled, and a host of other such variances occur that fit this definition. This reserve class is needed to protect the project budget from overrun. Our goal is, budget definition is, to identify a resource level for the project that will not be violated and this is simply one more category of variance to deal with. Proper project management suggests that such reserves be held separate from defined work units to minimize padding across the work units which essentially would hide these variances from their source.

Risk: The formal definition of project risk is a *known/known*. This says that we have identified various events that have a probability of occurrence and if they occur would require extra resources to resolve. This budget category is covered by the existence of a *contingency reserve* fund. When the risk event occurs (triggers is the proper vocabulary term), this reserve fund would be used to cover the new requirement. There is much more to say about these mechanics, but for now let us just assume that we can quantify these events and allocate a fund to protect the project in the same manner outlined for the MR. Note that if this is not recognized a risk event occurrence would create a budget overrun.

Overhead: This general budget category has already been discussed. Allocation procedures for various overhead categories are formally defined in most organizations, and the mechanics for calculating these various factors are formalized. Regardless of how the overhead values and categories are reflected in the budget the PM needs to be sure that they are included in the final cost structure.

From a management viewpoint, the ideal categorization of the budget is to have the direct charges kept separate from these noncontrollable categories. The rationale for this is to allow more attention to be paid to the controllable aspects of the process and to improve management visibility into that segment (Figure 10.1).

Budget overruns

Budget overruns are common in a large percentage of projects. Various studies over the years have shown this to be a common fact and budget overruns of 50% and higher are common. There are many factors that contribute to this and one could argue that poor estimating is a factor in

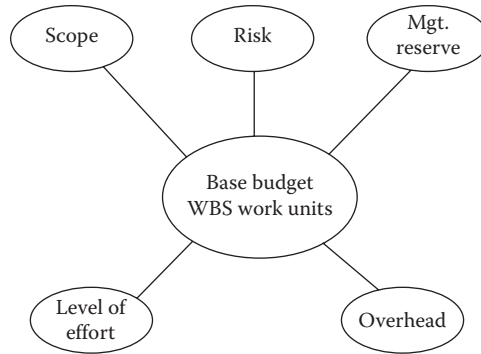


Figure 10.1 Budget components.

this, but many other causal factors exist as well. Two other mechanical allocation-oriented factors are poor initial requirements definition and poor scope control. Three broader categorizations of explanation for cost overrun are

- Technical factors create cost overruns from imperfect forecasting techniques, inadequate data, and so on.
- Psychological factors account for overruns in terms of optimism bias with forecasters. A belief in the lack of future scope creep is one example of this.
- Political-economic explanations can cause overruns as the result of instability in either of these macro environments. For instance, planners may interpret the implementation environment to be the same as found locally, only to later learn that the assumption is wrong.

From these root causes and others, the project plan often suffers in the following ways:

- Cost of the entire project is higher than planned.
- Tasks expand from scope change which affects both planned cost and time.
- Poor human resource management shows that the plan is not obeyed with either quantity or quality of the actual resources allocated.
- Poor overall management creates an environment that allows the project to drift, which then causes all plan elements to suffer overruns.
- Risk events occur beyond the planned level, which affects all aspects of the plan.

Cost accuracy

The process of developing an accurate project budget is an often misunderstood concept. Too often, a rough estimate given in the project initiation phase gets accepted as an approved project budget before detailed planning takes place. It is important to understand that cost estimation accuracy should improve as more is known about the project. Mature organizations realize this and make their decisions accordingly. For instance, budget estimates at initiation can easily be $\pm 100\%$ for a large, complex project (maybe higher). For smaller repetitive projects with historical experience, this range would be much smaller. Regardless, in general terms, the cost accuracy estimates evolve through the following three basic stages (Blocher et al. 2008):

1. Rough order of magnitude (ROM): An estimate based on general knowledge of the requirement, but little specific knowledge regarding detailed requirements ($\pm 100\%$).
2. Definitive: An estimate based on reasonable requirements resulting from a scope defining WBS, but a yet incomplete analysis related to such areas as risk, resource availability and capacity ($\pm 25\text{--}50\%$).
3. Budget: The normal goal for a project budget formulated at the completion of a formal planning phase should strive for an accuracy level within 5–10%.

In a mature organization, this evolutionary process would be more the norm and is an important concept in the overall project management process. To illustrate this estimating mindset, one very mature organization color-coded their project plan documents. So, an estimate presented on red paper fit the ROM category, while a yellow one would be assumed in the definitive range. Finally, the formal budget would be called a green estimate. This approach lets everyone know how to adjust their view of the plan. It is more typical to have only a single view, but one can see the hazard in randomly interpreting such planning data.

Cost capture process

The enterprise accounting system is one of the most mature processes in any organization. For that reason, it is common for projects to link to this system to obtain actual resource consumption status information. Figure 10.2 shows schematically how direct costs are collected and loaded into various WBS levels. The direct costs are linked to the accounting system through special named WBS accounts called Control Account Packages (CAPs). Think of a CAP as a formal data collection point. This can be a Work Package, Planning Package, or Summary Package based on the

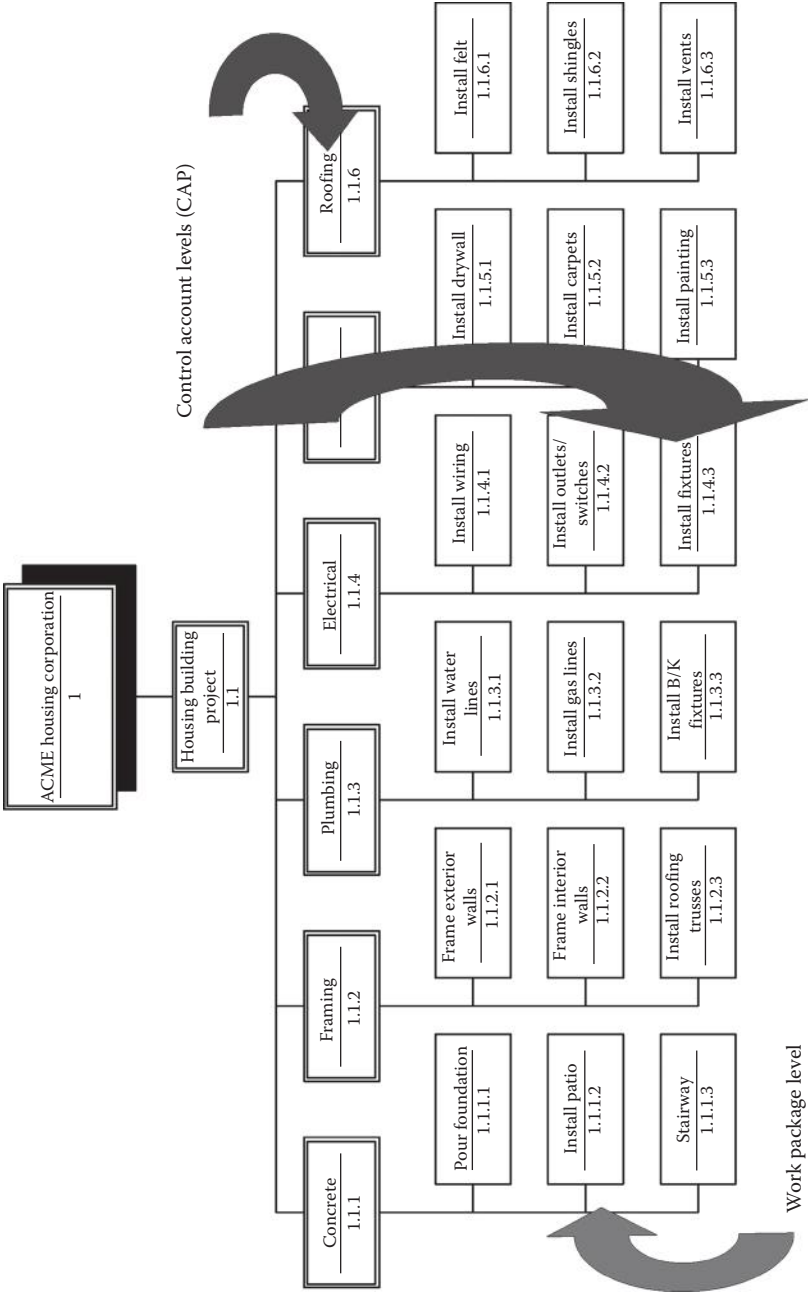


Figure 10.2 Control account packages (CAPs).

level of detail needed. This collection process requires that the enterprise accounting system chart of accounts codes be mapped to the project WBS CAP codes. In this manner, data can move from the accounting view into the project view. Note from the schematic that a CAP can be located at any level in the WBS hierarchy. It is up to the PM to select the level of status visibility that best fits the control requirement for the project. Be aware that a high-level CAP will not support a detailed analysis of costs below its level, but also recognize that low-level CAPs require much more administrative effort for recording and analysis. So, the location decision is a tradeoff of administrative overhead versus data detail.

Resource components

Project resource management has many tentacles into the budget process. We have seen that allocating resources to work units drives the direct cost of the project. There are three critical management components associated with resource management. These are

1. Resource pool—provides a definition of human resources available for the project.
2. Resource capacity analysis—mechanics related to comparing a project plan to actual available resources.
3. Cost baseline—resultant status of the human resource allocations to work units. This process creates a direct linkage through the project schedule to produce a life cycle cost view.

The next section will discuss the management implications of each of these component views.

As part of the time planning process, work estimates are made to define how long a particular activity should take to complete. Duration estimates are then based on the anticipated skill of human resources involved and quantity of those resources allocated to the work unit. During the estimating process, a decision is made regarding these two elements—skill and quantity for each work unit. Those assumptions are recorded in the first cut project plan and they determine each work unit's duration and labor cost.

Resource pool

To execute the direct budget costing process, a defined pool of names (actual or generic) and/or skills representing assumed availability for the project is required. This is defined as the *resource pool*. During the early stages of planning, *generic* names and salary rates will generally be used since future availability of a particular name is often unknown. One of the reality issues that have to be dealt with during the planning phase is the

	Resource Name	Type	Material Label	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code
1	Electrician	Work		ELEC		200%	\$40.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
2	Plumber	Work		PLUMBER		200%	\$40.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
3	Concrete laborer	Work		CONLB		200%	\$35.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
4	General laborer	Work		GENLB		200%	\$25.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
5	Rebar labor	Work		REBAR		200%	\$40.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
6	Supervisor	Work		SUPER		100%	\$50.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
7	Front loader	Material	.d	FL			\$1,000.00		\$500.00	Start		MATL
8	Backhoe	Material	.d	BH			\$1,000.00		\$500.00	Start		MATL
9	Concrete blower	Material	.d	CB			\$1,000.00		\$500.00	Start		MATL
10	Other Expense	Cost		O						Prorated		Expense

Figure 10.3 Project resource pool.

lack of specific resource forecasting data values. This constraint typically means that the first cut plan will inherit these estimating errors. Figure 10.3 contains sample resource pool data that illustrate the key data items for a resource pool. This view is a Resource Sheet table from MSP, but it serves the role of illustrating a project resource pool. A brief explanation for each data element in the example pool follows:

- *Resource Name* is an identifier for the resource.
- *Type* represents one of the three direct resource types—work (human), material, and cost (expense).
- *Material Label* is used to define the unit of measure for the resource—square feet for sheet metal, per day for equipment, and so on.
- *Initials* represent an abbreviated name for the resource.
- *Group* can be used in multiple ways—team name, organization, shift, and so on.
- *Max Units* is the assumed maximum quantity of the resources—200% represents two; 50% would indicate a person half-time.
- *Std* and *Ovt Rates* are the charge rates for the resources in either regular time or overtime. This can be hourly, daily, annual format.
- *Cost/Use* represents a one-time setup type cost for the resource.
- *Accrue At* signifies when the cost is to be recognized—start, end, or prorated through the work time. In the example, the setup time is specified to occur at the beginning of the work unit. All other resources are prorated.
- *Base Calendar* indicates the work schedule for the resource. The standard work schedule is 8 h/day, 5 days a week. The organization or project will define any holidays or other nonworking days in their calendar.
- *Code* can be used to sort the resources. In the example, the resources are shown as generic to signify that is the type being allocated. This does not affect the calculation process.

The total available supply source of labor, material, and cost items are defined in the resource pool. From this, the planning process will allocate some quantity of a resource to specific work units. This allocation will then produce duration and direct cost for that item. When linked to the work unit predecessor data, a project schedule is generated as was demonstrated in the previous chapter, except that we now have direct cost included in the plan. A total direct cost for the that work units is calculated and a time-phased distribution of that cost is phased through time by the predecessor logic.

Direct material costs are more complex to accurately calculate since this class of resource is often purchased in multiple batches in advance of need. As a result, this makes the cost timing and value of this resource more difficult to estimate. At the work unit level, this often involves a prorated-type cost allocation from the overall organizational bulk purchase. For example, if stainless-steel sheet costs an average of \$1/sq. foot and the work unit requires 10 square feet, then \$10 might be allocated for the work unit material costs. However, from an enterprise view, there may have been several orders for stainless steel and some amount may still be housed in inventory. The organization will have to decide how to allocate the overall raw material cost to the using entities. Items such as inventory overhead may be added to the prorated material cost. For some material types, there is a shelf life that requires it to be scrapped at a defined date, so there is an additional cost from that source as well. Many such factors complicate this resource costing model.

There is a second factor associated with project material that is important to mention here. Material does not have the same productivity characteristic that direct human labor does. So, from a management viewpoint, it may be necessary to extract material costs from this a performance analysis to get a truer picture of productivity. The first consideration for this is to view the ratio of material cost to human resource cost. If material cost is a significant component, it will need to be separated from the productivity review process.

For this discussion, we will assume that some internal process will value the material according to an approved internal standard. Once again it is up to the PM to understand what this represents. It is often possible to buy an item outside of normal procurement channels at a lesser cost, but resist the idea of setting up a project procurement department to “save” that increment. The project must live within the organization and its infrastructure, accepting the overhead that comes along with it.

A third direct expense item involves a myriad of nonlabor and non-material sources that consume dollars. Examples of this third resource group are food, plane tickets, car expenses, payments to vendors, and other miscellaneous cash flows related to project activity. This category is labeled “cost” and it is any resource expenditure not related to internal

labor or material. In some cases, payment to a vendor for a durable item might be considered material, whereas payment to a vendor for a contract worker might be considered human labor. Third-party expenditures sit on the fence of resource categorization and may in fact represent a fourth resource category. As in the case of material, it may well be important to segregate contractual items of expenditure from a work unit productivity analysis. A clear understanding regarding how these cost groups are captured in the accounting system is important when looking at overall project status analysis.

Resource analysis

Planning for resources and actually obtaining a commitment to supply these are two different events in the project life cycle. Think of the early planning phase as a wish list. From that base, an initial schedule and budget emerge. Later in the execution phase, additional work may be defined. Management and other stakeholders may press for shorter delivery or less cost. Regardless of the sources, the initial plan will be under dynamic stress to change and this will impact the resource requirements.

One of the status variables that must be monitored is the evaluation of planned versus available resources. Figure 10.4 illustrates this mismatch. Note that the area under the plan curve and above the capacity dotted line represents a resource overallocation.

For this situation, the defined plan is not viable and must be adjusted until there is a consistency between the time phased resource plan and availability. Also, recognize that this type of analysis is needed for all skill types.

MSP provides this type of analysis for each skill group. These data are provided in two different formats—graphical and table views. An example of the graphical analysis available in MS project is shown in Figure 10.5.

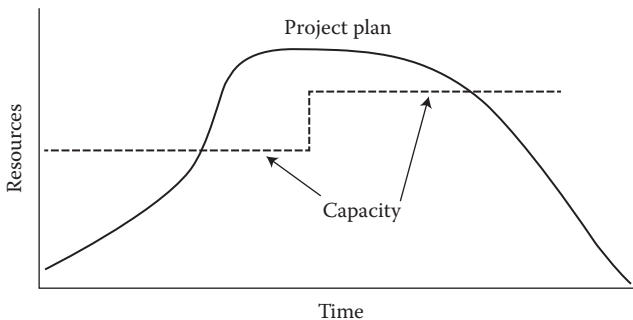


Figure 10.4 Resource capacity analysis.

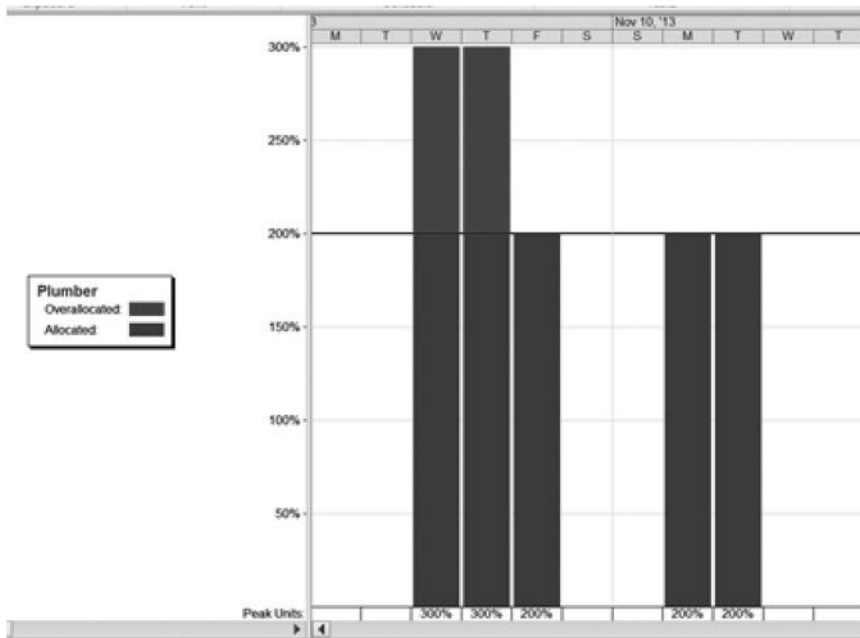


Figure 10.5 Resource capacity review.

In this case, the X-axis is time and the Y-axis is resource capacity. The horizontal line shows the capacity and in this case there are two periods for which an additional plumber is needed. There are multiple decisions that can be executed to deal this and we will describe that shortly. Increased model complexity exists when a resource pool value level varies through the life cycle. For this discussion, we are ignoring that potential, but it may be an additional plan factor to evaluate. If so, actual resource availabilities will have to be manually reviewed against the plan through time.

When a resource mismatch occurs, the PM will have to decide how to bring the overall scope–time–cost–resource equation into balance. The following options are typical strategies for this:

1. Work the resource overtime to compensate for the resource capacity gap. If the gap is small and the team size is sufficient, this may be viable; however, using overtime over a long period can decrease morale of the team and hurt overall productivity. The major advantage is that there is no additional learning curve required as there would be if new resources were used.
2. From the PM's view, the best answer is simply to obtain extra resources within the organization. The negative here is that they were probably not shown in the pool to start with for a reason. Also,

bringing in a new resource may cause disruption as they come up to speed regarding what needs to be done.

3. External resources can be used to fill the gap through new hires or contract labor. Once again there can be a significant start up with external sources such as this. They often need to be brought in early for training and that further adds to the project cost.
4. Often the best technical strategy is to just admit that the resources are not available to support the plan and stretch out the work until it fits capacity. This may be the best technical solution, but is often the least desirable from the user community since it delays completion.

Hopefully, these examples have highlighted the significance of evaluating a plan against available resources. What is not so obvious from this initial discussion is the added impact of work unit overruns and scope change. If a work unit estimate is overrun, the related resource requirement may well be overrun as well. Likewise, when a scope change is approved that often adds the requirement for additional resources. Both of these events are common occurrences. Based on this, it would be prudent to maintain extra resource capacity to cover these events. The capacity level shown earlier would then be the net level with an additional reserve likely needed to cover the anticipated growth events.

Dynamics of resource planning and allocation are one of the more complex activities for the PM. Identifying changing needs in a timely manner and taking appropriate action to supply the appropriate resources is a fundamental action required for success. Failure to have appropriate resources in place on schedule represents a high probability schedule slippage.

Cost baseline

One important aspect of project performance measurement is the project cost baseline. A sample cost baseline is shown in Figure 10.6. For this view, it should be obvious that these bars represent time-phased work units and their corresponding costs. Collectively, these work units constitute the cost baseline. This term simply means the project cost arrayed across its life cycle. From a financial viewpoint, this is the direct cash flow of the project.

This project view is an important organization information item. As we have moved from the WBS activity structure through estimating and resource allocation, we can now see more clearly the project time and cost parameters. Assuming work units have WBS codes the scope dimension is also represented by this view. In this one figure, the holy trilogy is captured. There are interpretative issues related to this view, but in many ways it represents the high level summarization of the planning process.

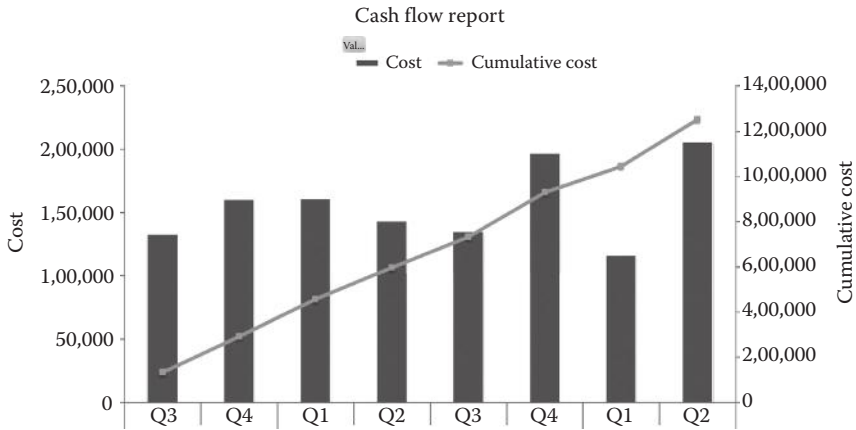


Figure 10.6 Cost baseline.

From this base point, we now have both quantification and a visual picture of the project that collectively help evaluate both the plan and a method to track status of the project. The mechanics described to this point are viewed as the core planning processes in project management. There certainly are more activities required to evaluate the viability of a project plan, but much of the basic mechanics to evaluate these other considerations are in place. One way to conceptualize what has been shown thus far is mechanics that can be used to translate requirements definition, work estimating, and resource decisions into a descriptive view of the project. In this view, we have combined the requirements of the project into a work plan that considers time, cost, and resources.

As we begin to look forward into the process, there are two other significant activities that would potentially modify the elements of this core view. The future analysis areas are

1. Identified risk events that could add new work and/or cost to the project.
2. Make or buy decisions can create third-party relationships that likely impact time, cost, and resource plans.

After these are added to the core plan, view the planning considerations then shift to more nondirect cost items such as LOE, reserves, and overhead items.

A simple example of direct cost mechanics is shown below using the pool project originally introduced in Chapter 9. This will illustrate mechanics for the direct project budget generation as driven by resource allocation to the WBS activities. The example cost allocation program will illustrate the basic mechanics outlined thus far.

	Resource Name	Type	Material Label	Initials	Group	Max. Units	Std. Rate	Use Rate	Cost/Use	Accrue At	Base Calendar	Code
1	Electrician	Work		ELEC		200%	\$40.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
2	Plumber	Work		PLUMBER		200%	\$40.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
3	Concrete laborer	Work		CONLB		200%	\$35.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
4	General laborer	Work		GENLB		200%	\$25.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
5	Rebar labor	Work		REBAR		200%	\$40.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
6	Supervisor	Work		SUPER		100%	\$50.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	Generic
7	Front loader	Material	.d	FL			\$1,000.00		\$500.00	Start		MATL
8	Backhoe	Material	.d	BH			\$1,000.00		\$500.00	Start		MATL
9	Concrete blower	Material	.d	CB			\$1,000.00		\$500.00	Start		MATL
10	Other Expense	Cost		O						Prorated		Expense

Figure 10.7 Pool project resource data.

Pool project example problem

The first step for this example is to identify the resources available for allocation. Figure 10.7 defines the resource pool data to be used. Using the resource pool data from Figure 10.7, each task is loaded with its defined resources. The results of this are shown in Figure 10.8 under the Resource Names column.

The cost indicated for each activity is automatically calculated based on resource rates and the activity duration estimate. As a sample calculation, line four shows two plumbers (200%) being allocated for the 4-day *install piping* activity. Plumbers make \$40/h and the assumed schedule is 8 h/day. So, the direct cost for this would be as follows:

4 days × 8 h/day × 2 plumbers × \$40/h = \$2560.

The same calculation is automatically produced for each resource allocation and then aggregated for each activity and the total project. Finally, the cost values are “rolled up” into higher-level summary and total project values. In this case, there is no summary activity, but the total project is properly summarized at \$30,540. This example illustrates that the software model is merely performing the arithmetic to calculate the direct cost as shown.

Pool project overallocation

After the allocation process is completed, the resulting plan has to be matched against available resources. Note in Figure 10.8 the small icons at

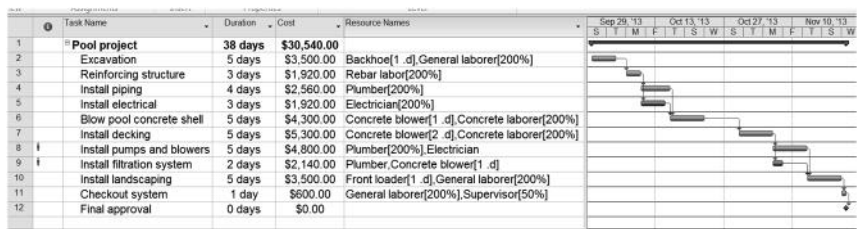


Figure 10.8 Pool project (resources allocated).

lines 8 and 9. These icons indicate an overallocation for one of the resources in those work units. These overallocation points simply mean that there are insufficient resources in the pool to support the plan. If the underlying activity estimates are accurate, this says that the plan as defined will not be met. For this reason, some management action is then necessary to deal with the resource capacity mismatch issue. MSP does have a leveling wizard that will attempt to resolve this issue, but be warned that it can also create more issues than it fixes, so always save a backup copy of the original plan version before turning the solution over to the software to manipulate. Earlier discussions outlined several strategies that could be employed to resolve this problem and those should be manually reviewed before seeking computerized logic help.

For the pool example, the allocation capacity issue is easy to see visually from the Gantt view bars. In this view, you can see that three plumbers are allocated in the same time period across lines 8 and 9. This analysis can be seen more clearly through the Resource Graph for plumbers. Figure 10.9 shows the data for the plumber resource level and time frame for the overallocation.

The Resource Graph provides a good pictorial view of the allocation issue, but an even better analytical source can be found in the Resource Usage sheet. This third more granular display is organized by resource

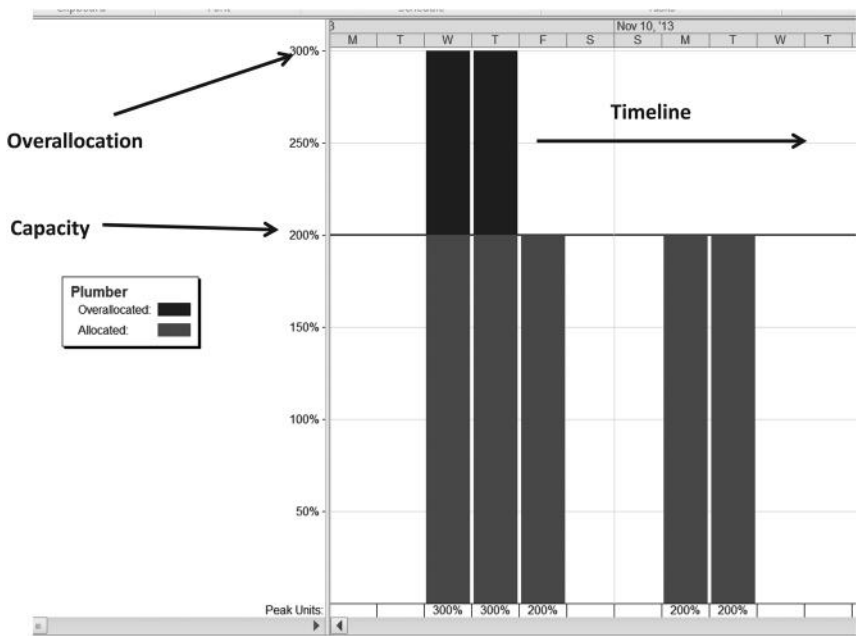


Figure 10.9 Plumber resource graph.

2	⊕	Resource Name	Work	Start	Details				
						W	T	F	S
		Plumber	160 hrs	10/10	Work	24h	24h	16h	
					Overalloc.	8h	8h		
		Install piping	64 hrs	10/10	Work				
					Overalloc.				
		Install pumps and blower	80 hrs	11/6	Work	16h	16h	16h	
					Overalloc.				
		Install filtration system	16 hrs	11/6	Work	8h	8h		
					Overalloc.				

Figure 10.10 Resource usage table.

and hours in specific time periods, with linkages to the resource’s work assignments. A segment of the plumber resource usage view is shown in Figure 10.10. Inspection of these data show that the plumber was allocated 24 hours of work on Wednesday (W) and Thursday (T) and we have already commented that there were only two plumbers working 8 hours each day. As indicated by the chart, the overallocation for this period is therefore 8 hours.

Even in a simple plan, such as the pool project, the best solution to this problem is not obvious without in-depth knowledge of the underlying technology and workers. The following list of possible solutions is designed to provide some potential alternative ways to resolve the resource overallocation:

- 1. Start activity 5 earlier since it has no predecessor that limits this activity move.
- 2. It would also be good to question the predecessor code for these activities to see if that would be a way to change the conflict.
- 3. Add another plumber.
- 4. Split task 8 in some fashion and perform some portion of #8 in parallel with #10.

In a more complex activity structure, these decisions require experience, but equally important is the data view as represented here to work with. The process of dealing with the overallocation of resource will require experience to learn how to best resolve. The examples here have been very theoretical, but knowledge of the project and organization environment can only be derived from local experience.

With this topic described, we have completed what one might call the definable variables of project planning. This infers that there are other variables that have to be dealt with. What has not been completed at this point is recognition of the broader environment within which all of this spins (a carefully chosen term).

Dealing with Murphy’s law

Every PM soon becomes familiar with Mr Murphy (i.e., something unexpected will go wrong and at the worst possible time). If this were not the reality, project management would mostly involve checking off activity status items as they were completed. However, because of this phenomenon, we need to recognize some of the more frequent environmental events that can cause a plan to deviate. Each of these uncertain events can add variability to the actual results.

Many project plans cover these phantom uncertainties by simply padding each task, sometimes as much as doubling the expected time and cost. This is a poor management practice, but one that will be hard to break in organizations where time and cost overruns are viewed negatively for the work unit involved. The recommended approach to handling variability is to utilize defined buffers to protect the project from overrun. On the surface, this looks like an attempt to pad the schedule and budget. In fact, it is just the opposite. Its role is to help isolate the variances rather than hiding them within each work unit. There are many ways of using the buffering technique. They can be added to project phases, major groupings, or the entire project as shown here. For the simple pool, project a single project level buffer is appropriate. We can illustrate this by modifying the pool project with a completion buffer (shown as a phantom work unit on line 12 in Figure 10.11). From a stylistic point of view, this bar should have a different format or color from other bars.

Note that the buffer is sized at approximately 25% of the direct time estimate and contains a similar allocation of cost. The role of this work unit is to buffer activity overruns and protect an approved project schedule and budget. Task 11 indicates a scheduled finish date of 11/20 for the defined project; however, the approved project buffered completion date would now be 12/4. As the project drifts away from the planned dates during execution, the buffer would be reduced accordingly (or “eaten” as it is often described). With experience and lessons learned from previous

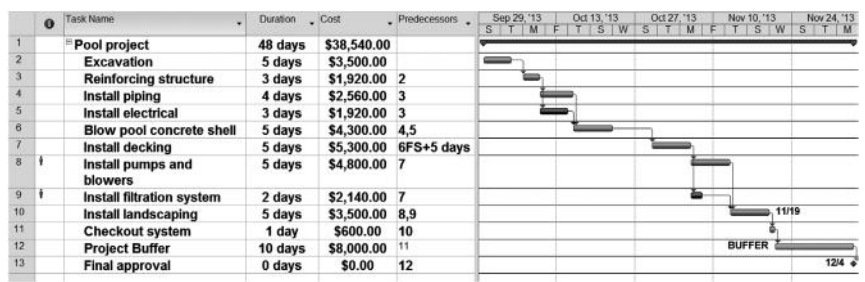


Figure 10.11 Pool project with completion buffer.

projects, buffer sizes can be defined more accurately and with this promised completion dates will be met more frequently. The difficult part of this process will be in explaining to management and others why a buffer is needed. On the surface, it looks like padding and it is, but with a valid logic behind it.

Variability sources

If the PM wishes to minimize visits from Mr Murphy that negatively impact the project, there are several sources to watch out for. A sample of common variance drivers is summarized below:

1. Changes to the original requirements definition are one of the most common sources of overrun. Failure to control requirements changes will most assuredly doom any completion prediction. Some industries quote an average change rate of 2% per month. It is important for the PM to have a general estimate for this in his project. One can quickly see that if a project is experiencing scope creep 2% per month, it would require a 24% buffer size just for that variability source. Remember, the mindset of this view is that we are trying to predict project time and cost at completion, so this type of forecasting is needed.
2. Task estimating errors will occur and the original estimates tend to be lower than actually found. Overruns in work estimates has the effect of increasing project duration and cost.
3. Resource pools give the impression that appropriate skills and quantities are standing by to serve your project. That is not the case in reality in regard to time availability, skill quality, or quantity. Even if the work estimate is correct, the resources will often not be available as planned. Careful control of the project resource allocation is a critical success factor.
4. Various "bumps in the night" will occur during the project life cycle. For example, material will be scrapped and have to be reworked. Various other unanticipated events will occur that collectively add variability to a work unit outcome. Much of this variance will be dealt with through MR funds.
5. Another source of variability that is difficult to quantify is a segment called "known/unknowns." What this means is that some portion of these yet to be observed events may probabilistically occur, but their timing and magnitude is difficult to quantify. These are called risk events and more about this topic will be covered in a later chapter. The prudent PM should attempt to forecast this class of variance and deal with its impact through a contingency reserve.

Each of the variation sources described above can cause difficulty to define and control deviations in the future project schedule and budget. Be aware that the typical project overrun is in the 50% or higher range and these are some of the villains driving that result. Obviously, a major goal of project management is to improve the project completion prediction and manage that process successfully. That goal should be accomplished in some manner other than just arbitrarily padding each task and hoping that it covers any overruns. Task estimates should be what they are anticipated to be and variances should be visible where they occur. Selectively placed buffers would then protect the final result. This is the essence of a learning organization, that is, not hiding variances, but surfacing them and looking for their root cause. There are techniques to help deal with each of the variance factors described above, but for now recognize that they exist and each potentially adds time and cost to the first cut mechanics described to this point.

The total project budget

A first cut budget has many shortcomings from a real-world perspective. Let us assume that this view is offered to the external stakeholder world for review. We have hinted that the typical response to this is “too much, too long, more functions.” From this reaction, the project team will alter the plan views in various ways until some agreement is reached. We will call this the second cut view and it still contains much of the original data rearranged in some fashion, but the operational mechanics stay the same. At this point, we have to prepare what would be called the total budget for the project. That involves adding several layers to the base view. Figure 10.12 shows the formal layers of the project budget hierarchy. Most of the

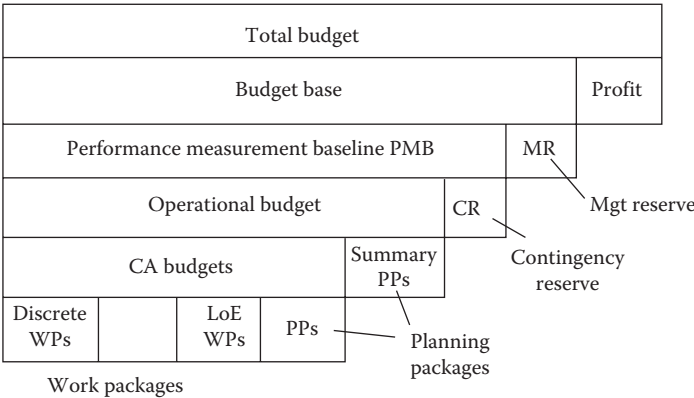


Figure 10.12 Total project budget components.

terms shown in the figure have been mentioned in earlier sections of the chapter. In this view, the assumption is made that all elements shown are fully burdened with appropriate overhead values included.

So, the question now is “which of these budget elements is the PM responsible for?” The most accurate answer to this is “everything,” but that is not exactly the case. The model rule is that the PM would theoretically be held responsible for all of the layers up to the performance measurement baseline (PMB) and in some cases would be assigned a portion of the MR. This view also assumes that formal risk analysis was performed and a contingency reserve defined. In some cases, all of part of the management and contingency reserves will be held outside the control of the PM. For example, the approved PMB might be set at 10% above the layers shown in the diagram and that would represent the financial segment allocated to the PM. This added increment is in fact a visible portion of the total MR. Each organization handles this situation somewhat differently, so the local practice needs to be understood. Basically, the question here is “how much overrun is considered excusable?” In some cases, that value is zero, so one must not assume that any level of overrun is acceptable without formal confirmation.

Note that there is no cost element shown in the budget diagram for scope changes. In the author’s opinion, this is a gap in the model process. Where are the funds going to come from for this well-anticipated event? Once again, it is important to understand how scope change will be funded. If each change is funded from new external sources, the diagram is accurate. However, if all changes will need to be covered from the approved budget, we see the gap. That issue needs to be clear before the final budget version is presented for approval.

The following list contains some of the budget philosophy questions that need to be resolved and understood by all parties:

- If the project plan time or budget overruns, how do we handle the variance? How much variance is tolerable?
- Since there is no visible scope change budget shown in the model view, where do these additional funds come from?
- Who controls the contingency and MR funds and what is the process for moving the resources from reserve to operational status as these categories of events trigger?

Note the final layer in the budget schematic is Profit. This implies that the project is being performed under contract for a third party and the internal organization wishes to earn a profit on the venture. Recognize that as overruns occur in the layers below the profit layer is the last buffer and without careful management the project becomes a financial loss. This normally would not be a career enhancing event.

Let us review what we now know. First, project requirements are converted into work through the WBS. From that we translated the defined work into a schedule and budget by estimating the work and allocating appropriate resources to those work units. This generated what was called a first cut time and cost plan. We then evaluated the resource situation and adjusted the plan accordingly until the allocated resources did not go beyond the available levels. It is then recognized that there are additional cost items above the direct core plan. These additional cost elements relate to items such as overhead, reserves, and scope change are then added to complete the total cost picture. Each of those elements must be included in the final schedule and budget views. With this discussion behind us, we have covered what would be considered the core elements of project management planning. There is yet more to be discussed to cover the other knowledge areas, but this is a significant milestone in our journey.

Summary

Basic time and cost mechanical plan development processes have been described at this point. Our model theory to this stage has indicated that project requirements drive the defined work units, which in turn evolve into a schedule and budget as resources are applied to those work units. We have indicated that there are other cost and potential work units that will emerge during the life cycle. These events will add additional scope and potential to add work to the plan. Likewise, risk events could occur with the same result and other unplanned “bumps in the night” can also change these defined views.

The next step in the project planning process is less orderly, but more real world in its perspective. As this first cut view is communicated to various key stakeholders, there will be reactions to the plan that will require changes, or as we call it “tweaking.” As a result, our beautiful three-dimensional scope, time, cost box triangle begin to show cracks. There is now pressure to adjust all sides of the holy trilogy in a manner that implies one or more dimensions of the box will need to be changed without affecting the others. In order to deal with these pressures, we have to manipulate the plan underlying variables in an attempt to deal with these conflicting views. Our current theory says that one cannot just squeeze a box dimension without changing its contents. Time or cost cannot just be changed because some key stakeholder desires for one of these variables to be decreased or increased, but that is the scenario.

This real-world stage is now set where the art side of project management has to be highlighted. The PM also will need salesmanship and negotiation skills to work through this as well. Chapters 11 and 12 will deal with some of the techniques needed to morph the first cut versions

of the plan into an acceptable and viable format using a variety of “tweaking” techniques.

Practice exercise

This example is designed to support a more advanced tutorial that illustrates the interaction of resource allocation to the resulting plan outputs. In order to get full value out of this exercise, it is advised that the reader extracts the sample car problem labeled *10 Car Problem Cost Example* from the publisher website (extraction details for the website are described in Appendix F). View this sample version as the first cut plan. It contains sufficient complexity to illustrate a more realistic analysis challenge than the earlier simplified examples.

This example is designed to guide you through a step-by-step analysis of resource capacity, but will not attempt at this point to resolve these issues. Chapter 19 will pursue these mechanics in more detail. Our goal here is to open up the various status analysis views in more detail to show the plan’s resource details. The discussion below will describe the basic steps of this process.

Start up

Retrieving the problem from the website will save the data entry process and make the example much simpler to execute. So, the starting point is a Gantt view of the car problem. From this, the steps below will lead step by step through the various resource-related views.

Resource allocation to activities

The cost values displayed in the Gantt view are driven by the resource allocations made to each task (we are ignoring the practice of just entering a cost value with no background rationale). Opening up the Resource Names column will reveal the specific resource allocations for each activity. To illustrate the resource allocation process, right click on WBS 1.2.2.2 and select Assign Resources from the popup box. Figure 10.13 shows the resulting allocations for that activity and the Cost data field should reflect this total resource value (\$56,400) computed from these allocations.

Let us examine the allocation for the Mechanical Engineer resource. Note that 300% were allocated and the associated cost was calculated to be \$28,800. The 300% value indicates that three engineers have been allocated to this activity. Let us see if we can duplicate the cost calculation shown for the Designer resource. From the Gantt view, we can see the Duration for this activity is 35 days. Now open up the Resource Sheet view and see

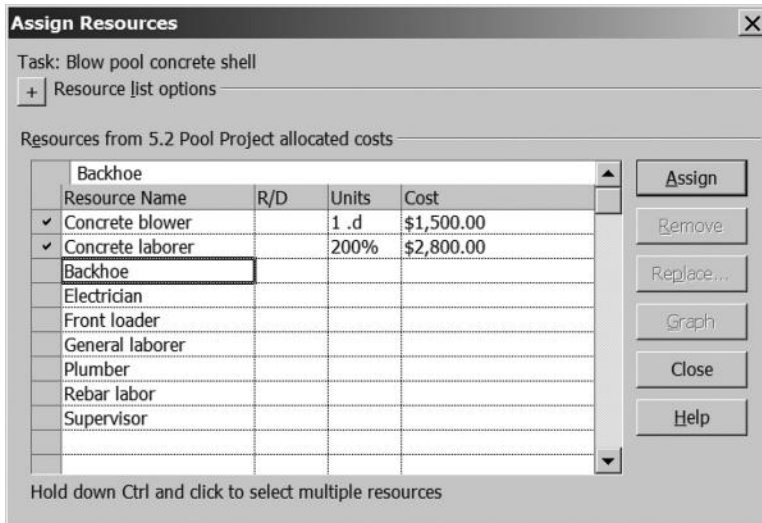


Figure 10.13 Resource allocations for WBS 1.2.2.2.

that a designer wage rate is \$75/h. The standard default work calendar is 8 h/day and 5 days/week. From these collective data items, the following calculation then computes the total activity cost for the Designer:

$$1 \text{ worker} \times 8 \text{ h/day} \times 30 \text{ days} \times \$75/\text{h} \text{ equals } \$18,000$$

One can see both the simple formula mechanics and yet a massive amount of related arithmetic performed in these calculations. It would be good to save this file version under another name and practice changing the resource allocations.

This version of the plan represents the base (or direct) WBS activities and it indicates that the direct project cost is \$1,252,920. Recognize that this is not the budget that would be presented to management for approval since various cost items are not yet included. We will see more specifics regarding these additional items in later chapters, but for now we will just summarize the major cost elements not specifically shown in this first cut view. These are

1. Various support costs that may be allocated to the project (i.e., computer tech support, equipment, facilities, etc.).
2. Verify how the material resource is cost. Is there an overhead allocation required?
3. Overhead related to labor rates.
4. Organizational overhead for the overall project.
5. MRs—unknown/unknowns.

6. Contingency reserves—known/unknowns.
7. Scope reserve—if this will be handled out of the approved budget.
8. Profit—if this project is being performed under contract.

Once the direct plan has been agreed upon, these cost categories would be added to represent the completed project budget.

Before we start thinking that the budgeting issue is basically resolved with the first cut view and these additional items, it is time to open up Pandora's box again. Two major management issues still lay in the path of a completed schedule and budget. First, the various stakeholders and sponsor have not agreed that this set of task and related parameters are approved. To simplify this discussion, let us assume that key stakeholders have approved the basic structure of this plan. We will do more with this topic in Chapter 11 and that activity will lead us back to a mechanical view similar to this example. The mechanical steps shown here are valid even though task definitions may change, total duration will vary, and the corresponding cost may change.

The remaining problem analysis is much more subtle than what has been shown thus far. Up to this point, we have behaved as though allocating resources resolved both the schedule and cost problem calculation. However, what happens if these resources are not available? The Resource Sheet defined a pool of such resources but at any specific point we might find that we had allocated more of these than were available, thus the plan is not viable as shown. MSP attempts to help with this situation by indicating overallocations with a red man icon in the left-hand Gantt view information column. Unfortunately, we see eight such icons here. The problem at this point is we do not know exactly what the exact overallocation is. This requires more detailed analysis and can be very difficult to resolve. For this introductory view, the allocation data will be explained, leaving more of the resolution mechanics to a future discussion in Chapter 19.

Resolving the overallocation issue is not a cookbook process, but a core element of that process is to first define which resources are overallocated, for what activity and in what time frame. MSP has three different resource analysis views to aid in this purpose. These are

Resource Sheet—the pool of available resources (supply).

Resource Graph—visual picture of each resource's allocated load through the life cycle.

Resource Usage—a detailed spreadsheet view by hours for each resource allocation through the life cycle.

Each of these views can be opened up from the View menu and each offers a slightly different perspective. Note that MSP has a wizard to help resolve this problem, but in some cases its solution is not what you

want. That level of discussion will also be saved for Chapter 19. For this introductory discussion, we will provide a brief tutorial to show the data views offered by the three resource option a focus on defining the overall location sources and locations.

Resource sheet

To access the Resource Sheet, go to the view menu and select [Team Planner/Resource Sheet]. Note that three of the resources shown here are highlighted in red and there is an information icon by each. Hovering over that icon shows the message “the resource is overallocated and should be leveled.” This simply means that the pool does not contain sufficient quantities of that resource at some point(s) in the life cycle to match the amounts allocated. We see resource overallocations indicated for Tester, Electrical Engineer, and Mechanic. That is the extent of information available in this view. One way of quickly solving this problem is to keep adding Max quantities to each resource until the color changes to black. That in essence says add more resources. Normally, this is not a viable solution but a good one if available.

Resource graph

The Resource Graph table is accessed similarly to other views, that is, [Team Planner/Resource Graph]. Navigation through this view is a little cumbersome but a couple of tricks will help deliver some insights into the resource problem.

Recall, the overallocations were *Tester*, *Electrical Engineer*, and *Mechanic*. Now, the Resource Graph view isolates all allocations by resource and time period. Use the keyboard down arrow or mouse wheel to scroll down through the various resources until the desired one opens—these are shown in alphabetical order. When the Tester graph appears, the next thing needed is to identify where in the life cycle the overallocation occurs. This search is made easier if you record the start and finish dates for the project because this is the scan range. In this example, the project life cycle goes from 2/13/2012 to 1/14/2014. Use the horizontal scroll at the bottom of the graph panel and move through the time range. Various blue bars will be visible, but as you move into the September 22, 2013, range red bars appear and this represents the overallocation periods. Figure 10.14 shows the overallocation for the Tester in the March time period.

At the bottom of these bars, you will see 500% recorded. That indicates five Testers allocated, but only two are available. The horizontal line at 200% shows the available capacity. So, the overallocation is three Testers for the time periods indicated. The second overallocated resource is the

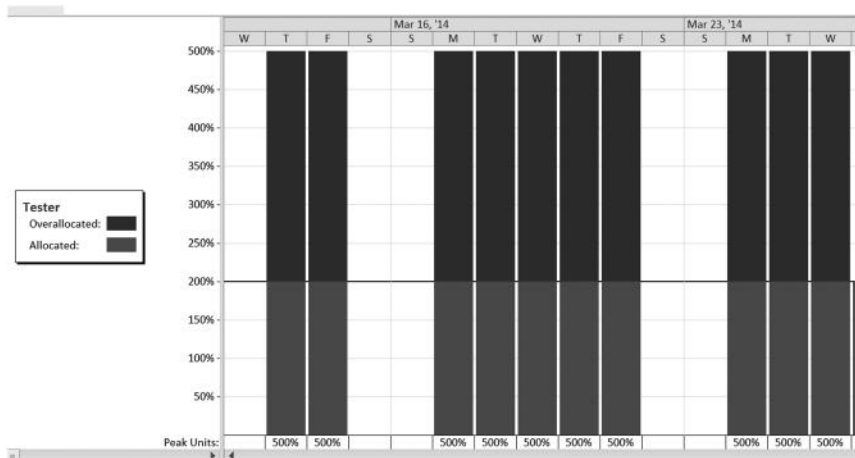


Figure 10.14 Resource graph view.

Electrical Engineer. In this case, the overallocation is found during the time range of December 24, 2012, through February 1, 2013. The indicated requirement is three, compared to a capacity of two. So, the overallocation is one. The third overallocation involves the Mechanic. This overallocation is more significant than the other two. Starting in the week of May 12, 2013, the overallocation level is three and that value increases to four in the week of May 26, 2013, and on into the week of June 9, 2013. Also, more overallocations are found in September 2013, month range.

As these examples illustrate, the Resource Graph view reveals more specific details regarding the overallocation levels for specific resources. From this, it is possible to quantify the overallocation level and time period, but it still does not provide details regarding which WBS activities are involved. Unless the resolution is to just increase the allocation of resources in the resource pool and therefore avoid the problem we have to know more specific data in order to decide how to deal with the issue. In the real world, simply adding more resource is seldom available as the option. This basically means that the PM has to go to a lower level of detail to decide how best to resolve the issue. That level of detail is found in the Resource Usage table.

Resource usage table

Access to the Resource Usage table is gained through the Team Planner view as described above. Format of this table is very similar to a spreadsheet and the level of detail shown here can be overwhelming, but necessary to understand how best to resolve the overallocations. In order to

help identify overallocation locations and specific detail levels, the following variables are added to the default table view:

- WBS is added to help map back to the Gantt view.
- Start is added to help show where to scan the timeline for data.
- Overallocated field is added to show which specific activity within the resource is overallocated.
- Overalloc option is added in the table view to highlight the level of overallocation. This is added by clicking on the Details field and selecting that option.
- More additional columns can be added to this view, but space becomes an issue. Figure 10.15 shows this modified format for the Mechanic resource segment of this table.

Once again, red colors in the resource details sheet area indicates overallocations and the “Overallocated” variable cells show specifically which WBS ID is overallocated. In this example figure, the Mechanic resource is overallocated and the Overalloc variable indicates that it is overallocated 8 hours in the days indicated. Below that cell, all tasks allocated to the resource are shown with their specific allocations. Figure 10.16 will expand the Resource Name view to show more WBS level details.

To show specific allocation details, some data views have been hidden. The important data displayed in this view is the overallocation of

WBS	Resource Name	Work	Start	Overallocate	Details	4				
						M	T	W	T	F
	Tester	656 hrs	3/13	Yes	Work	40h	40h	40h	40h	40h
					Overalloc.	24h	24h	24h	24h	24h
1.5.1.1	Electronic Compor	240 hrs	3/13	Yes	Work	24h	24h	24h	24h	24h
					Overalloc.	8h	8h	8h	8h	8h
1.5.1.2	Mechanic compon	160 hrs	3/13	No	Work	16h	16h	16h	16h	16h
					Overalloc.					
1.5.2	Test drive	128 hrs	3/27	No	Work					
					Overalloc.					
1.5.3	Safety test	128 hrs	4/8	No	Work					
					Overalloc.					
	Business Analyst	960 hrs	8/3	No	Work	8h	8h	8h	8h	8h
					Overalloc.					
1.1.1	Charter	80 hrs	8/3	No	Work					

Figure 10.15 Resource usage table.

WBS	Resource Name	Work	Start	Details	Mar 16, '14									
					T	F	S	S	M	T	W	T	F	
	Tester	656 hrs	3/13	Work	40h	40h			40h	40h	40h	40h	40h	
				Overalloc.	24h	24h			24h	24h	24h	24h	24h	
1.5.1.1	Electronic Compor	240 hrs	3/13	Work	24h	24h			24h	24h	24h	24h	24h	
				Overalloc.	8h	8h			8h	8h	8h	8h	8h	
1.5.1.2	Mechanic compon	160 hrs	3/13	Work	16h	16h			16h	16h	16h	16h	16h	
				Overalloc.										

Figure 10.16 Resource usage activity level expansion.

WBS 1.5.1.2 and 1.5.1.1 codes. Each of these is overallocated by 8 hours, or one Mechanic. The interesting issue in this view is to see that the total overallocation is 32 h and not the 16 h that was anticipated in looking at the individual tasks. The total work allocated for the mechanic in this time range is 48 h; however, the resource pool indicates that only two mechanics are available at 8 h/day, or 16 h. Therefore, the overallocation value is correct at 32 h. The skill to resolve this class of plan activity will take some time to acquire. It is clearly more than a cookbook set of instructions.

Techniques for resolving overallocations such as those described in this section are often quite complex and frequently ignored. Our goal at this point is to show that the plan is not viable because of resource deficits. For this phase of resource analysis, realize that the three plan resource views discussed contain the basic status information needed for this activity. From a pure mechanical point of view, realize that if the activity estimates and the resource allocations are accurate, the overallocations simply mean the plan will not be met. Our goal is to create a plan that represents an execution road map, so these issues must not be left in the state described here.

As a final comment before leaving this example, it would be instructive to edit the Resource Sheet by raising the Max values for the three overallocated resources and watch the red colors turn to black as the overallocations are technically resolved.

QUESTIONS

Review questions

1. How can scope creep affect the project plan in terms of time and cost? Comment on strategies to control this.
2. What are recurring costs in project cost management? Provide a real example of a recurring cost? Are recurring costs considered direct or indirect costs?
3. What change do you notice in the car problem duration if the "Schedule development" (WBS 1.1.4) duration is changed to 35 days?
4. What is the role of the WBS 1.7, Project Buffer (task 49) in the car problem example?
5. Resource overallocations were described in the chapter. Do you see allocation strategies that might work for the car problem other than adding more resources? Comment on these items.

In-class questions

1. Assuming that a work unit is accurately estimated, what is the most likely reason for the actual labor cost value to vary from its calculated cost value?
2. Describe the basic arithmetic in generating a work package cost.

3. Where is the project resource information stored?
4. Where in MSP can you find information about resource overallocation?
5. How would LOE-type costs be allocated to the project?
6. When a scope change occurs where does the additional resource to support this change come from?
7. Why do you need an MR?
8. Why do you need a contingency reserve?
9. Why does the organization add an overhead to the direct cost allocation for labor?
10. Where does the actual cost get collected for the project?

EXERCISE

Use the chapter practice example problem as a resource analysis exercise. Overallocated resources have been described in the chapter discussion. Using your knowledge of resource status, identify all tasks that contain a resource overallocation and then document the time ranges and resource names and overallocation levels for each. Use MSP to attempt to resolve each of the overallocations. (Do not be too concerned if you fail at this process as it only illustrates the complexity of the problem. Realize that removing tasks or adding resources will always work, but may not be a viable strategy.)

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chapter eleven

Introduction to risk

This chapter will offer a high-level overview of project risk concepts, saving the more detailed mechanics for Chapter 22. In today's fast-moving global marketplace, risk management is critical to business assets, jobs of employees, and ultimately an organization's survival (Liebig and Hastings 2009). Why is this so critical? Done properly, risk management provides a way to reduce project outcome uncertainty through providing awareness of risks that are present, thereby minimizing future threats, seizing opportunities, and achieving optimum results. It also identifies the degree to which a risk may occur and the outcome it could have in terms of impacting the project's success. Risk planning begins with a series of steps designed to help approach, plan, and execute the risk management activities, which constitute the first major step in risk management and is the first objective of this chapter. The second process step involves identification of risks through looking at a company's historical records to identify all previous risks encountered on past related projects, which is the second objective for this chapter. Risks are then further identified by various techniques designed to identify risks that have never been documented previously. This chapter and the supporting Chapter 22 serve a support goal and will provide tools and techniques for the PM to utilize in this endeavor.

Risk management

There are many uncertainties with everything in life but planning for uncertainties can prevent or reduce negative outcomes, thus bringing about the term *risk management*. Let us start with a clear definition for risk. Risk can be thought of as unplanned events in the future that could occur. Project risk management is both the art and science of studying identification, analysis, and response to risk events throughout the life of a project (Richardson 2010). The objective is to increase the probability and impact of positive events and to decrease the probability and impact of events considered to be adverse to the project. Some risks that are inherent in the project goal can never be avoided. Also, all risks cannot be fully mitigated because of financial and practical limitations. *Risk management* is formally defined as the systematic process of planning for, identifying, analyzing, responding to, and monitoring project risks involving processes, tools,

and techniques to help the PM maximize the probability of a predictable outcome.

When it comes to business risks, organizations may benefit from having a PMO. A PMO supports a flexible, end-to-end project management process, which balances rigor with overhead cost. It makes tools and techniques available along with formal training to improve PM competency. To be effective, the risk management process must be proactive throughout the project life cycle (Richardson 2010). Therefore, not only does a PM anticipate and plan for the event, but the PM must also monitor activities during the execution phase to minimize risk impact when the event does occur. The ultimate management vision of risk management is in understanding the realm of potential risks that can occur in the project as well as how each risk can affect project success.

As Benta et al. (2011) discuss, risks are potential events with a probability of less than 100% of occurring and the impact of the risk is measured in terms of how the risk event will impact the project objectives if it occurs. It is important to note that a risk occurring can pose as an opportunity or a threat. Most risks are viewed as negative but sometimes the event can be linked to a positive factor such as new technology being introduced. If successfully delivered, this can create a competitive advantage for the organization. Therefore, in some cases, a risk event can relate to a better approach, resulting in a better outcome that may not have been available when the project first began. Realize that a risk event relates to something that has not happened yet. The vocabulary term *trigger* is used to define an early warning sign that a risk event has occurred or is about to occur (Richardson 2010). Delivering a project successfully within cost, time, and quality does not typically occur without effective risk management and this is the reason the project planning process must incorporate risk considerations. Therefore, the definitional components of a risk event are the possible events itself, the probability that the event will occur, the impact of the event, and the frequency with which the event may occur.

Eaton and Little (2011) discuss how risks are ever present and although these can typically be significantly reduced, even the best risk management process cannot bring the total negative impact to 0%. Risks are divided into two broad categories, known risks and unknown risks, as described below (Richardson 2010):

- *Known risks* are risks that are logically expected to occur and for which some general probabilities and impacts can be estimated. These risks can be handled through risk management techniques and can be minimized by following those techniques.
- *Unknown risks* are not predictable events and are not generally anticipated in terms of the formal risk evaluation process.

The wise PM will realize that this management aspect of the project dynamic is a critical success factor and will treat it accordingly. For that reason, risk is becoming a topic of increasing interest.

Formal risk legislation

The Securities and Exchange Commission (SEC) in 2010 required publicly traded companies to begin providing in their annual proxy statements to shareholders disclosures that provide information on the board's risk oversight role, and the Federal Financial Reform Legislation mandates risk committees to be in place for boards of financial institutions (Beasley et al. 2010). Also, public bank holding companies with \$10 billion or more in assets are mandated by the Dodd–Frank Wall Street Reform and Consumer Protection Act of 2010 to form a board-level risk committee to focus on risks and strategies. This also mandates creation of a risk expert on the committee in the area of identifying, assessing, and managing risk exposures of large, complex firms (Reinhold et al. 2011).

Project risk management

A risk management process identifies tools and techniques to aid in minimizing uncertainty through understanding, assessing, and managing the uncertainty inherent in projects. This chapter and Chapter 22 address some of the key mechanics useful in the risk mitigation process. It is now recognized that formal processes related to this aspect of the project can have an effective impact on subsequent project events. As a result, a description of these actions becomes part of the content for the risk management section in the project plan and the basis to show how risk in a project environment is handled. These processes can include but cannot be limited to project planning areas such as cost estimation, earned value analysis, task allocation, and detailing how monitoring and control of the project is to be accomplished. Within the framework of a project and as referenced in the *PMBOK*® Guide (PMI 2008, 273), risk management consists of six major subordinate processes. This chapter addresses the first two model processes but the last four will be deferred to Chapter 22, which focuses more on risk mechanics. The six model processes are listed below and are also displayed in Figure 11.1:

1. *Plan risk management.* Consists of details outlining how to approach, plan, and execute the risk management activities for a project with the main output of this process being the risk management plan.
2. *Identify risk.* This process defines the risk events that are likely to affect a project.

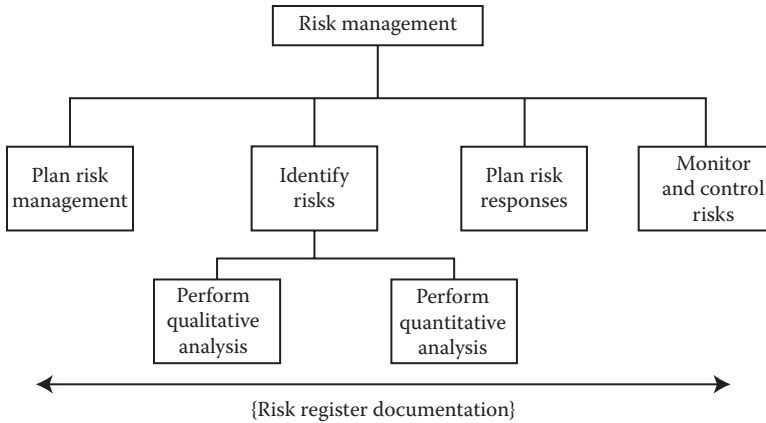


Figure 11.1 Risk management structure. (From Project Management Institute (PMI). 2008. Risk management structure. In *PMBOK® Guide*, 4th ed. Newtown Square, PA: Project Management Institute, Chapter 11.)

3. *Perform qualitative risk analysis.* Prioritizes the identified events for subsequent further analysis or action by assessing their probability of occurrence and impact with the main output being to update the risk register.
4. *Perform quantitative risk analysis.* Provides a quantification of the selected events to establish a measure of impact.
5. *Plan risk responses.* Develops options and actions to enhance opportunities and to reduce threats for the selected events. From the details resulting from the planned responses, various mitigation plans are established and a contingency reserve is established to handle the remaining potential events. All these details are recorded in the risk register.
6. *Monitoring and control risks.* This management process is designed to track both identified and unidentified new events. As these events are handled, the process monitors the effectiveness of the mitigation processes. This process' main outputs are recommended corrective and preventive actions, requested changes, updates to the risk register, and revisions to the project management plan.

Time spent in producing the risk management plan before execution allows those involved to not be in a crisis mode when identifying the best way to manage future project risks. Individual organizations and industries have varying perceptions and tolerances of risks, which are influenced by their various safety cultures, management commitment to safety, inaccurate risk assessment, amount of control over a particular risk, and varying criteria for determining which risks are acceptable

and past personal experiences with risks (Eaton and Little 2011). Beasley et al. (2010) suggest that there have been discussions related to organizations not spending adequate time on identifying, assessing, and managing the most important risks or being blindsided by unknown risks resulting in operational failures.

Risk identification

Risk identification involves the definition of potential risks affiliated with a project. These risks can be known risks for a potential project such as those identified by looking at company historical records to see which risk factors have occurred before on a related project. However, a brainstorming session is an often-used support process to further identify other risks that may have never occurred before but still pose a threat to the project. Vargas-Hernandez (2011) suggests categorizing risks using headings such as environment, technical, resources, integration, management, marketing, and strategy. The environment category is further broken down into government policy, exchange rates, weather, culture, and so on. Technical grouping could be new technologies or methods. Resource risks include people resources, monetary resources, and equipment or material resources. Examples of the integration category are risks affiliated with merging new with old systems. Management category items include corporate policies, project management techniques, and organizational structure. Marketing risks include customers and competitors. Competitors can also be further broken down into direct, indirect, and substitute (Sharp 2004). Direct examples are companies with similar products or services that sell to similar customers. Indirect examples are competitors with related businesses or capabilities. Substitute competitors are competitors who sell products or services that can replace (be substituted as) your company's products or services. Richardson (2010) adds in the category of "commercial risks," which includes financing, warranty, and vendor performance. These categories are listed in Figure 11.2, which displays a sample risk breakdown structure (Richardson 2010).

Identifying the root cause of risk events identified will also help in an organization's understanding of the potential for risk, identification of additional risks, and in making an informed decision to accept, avoid, mitigate, or transfer these risk(s). Let us take an example of a system that resides in Florida on a coast where hurricanes can hit, which therefore is classified as a known/unknown. Therefore, there is a defined probability that any particular section of Florida will experience a hurricane of some undefined magnitude. So, looking at historical records would provide insight into a method to help mitigate the negative consequences for this class of risk. Historical records from an organization or public records can help with this type of event quantification. This would initially alert the

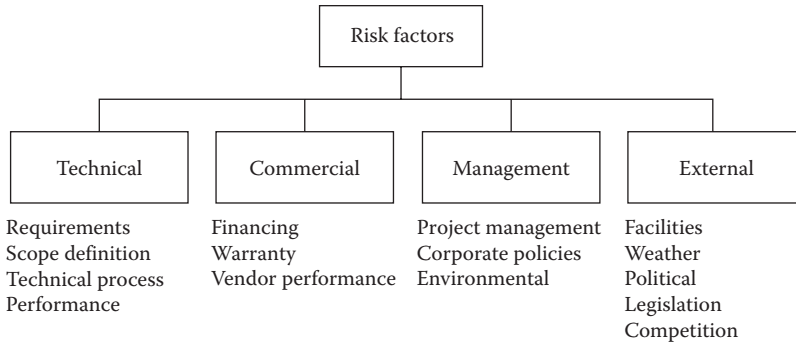


Figure 11.2 Risk breakdown structure. (From Richardson, G.L. 2010. *Project Management Theory and Practice*. New York: CRC Press, Taylor & Francis Group.)

project to make sure that there is a safe back-up system to handle potential operational downtime. At this point, since historical records from the organization only show the issue of temporary downtime, do we end the identification of risks stage or keep brainstorming other potential risk scenarios? The latter option is correct as the realities of life indicate that there are always new situations to consider. Realize that history may not be a complete educator for future situations. Therefore, the project team should be diligent in reviewing both historic and less obvious future situations in their identification process. The tough part of this is quantifying the likelihood and impact of any identified events.

Identification tools

A fishbone diagram (also known as an Ishakawa or cause-and-effect diagram) is a schematic map that is used to provide a logical method to list factors that may affect a problem or a preferred corrective outcome. Figure 11.3 displays a sample layout of this diagram and Figure 11.4 displays an example of a filled-out diagram relating to the car case study. This method allows a team to graphically identify and detail the possible causes of a problem. The box to the far right of the diagram is the “effect” or problem and everything to the left of the box is a *possible* cause of that effect. The

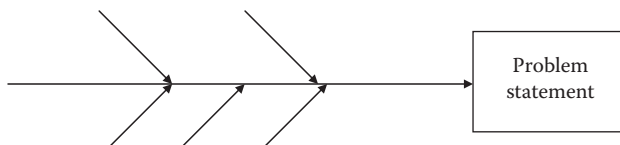


Figure 11.3 Bones (major cause categories). Note that there is no perfect set or number of “bone” categories—they can be modified to fit the problem.

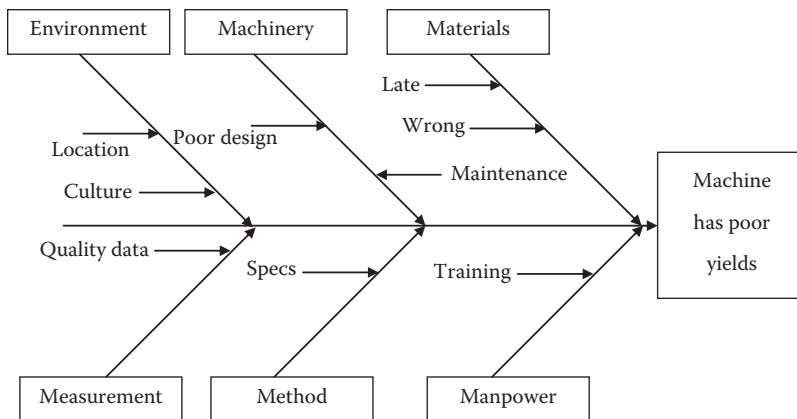


Figure 11.4 Fishbone diagram to examine poor process output.

possible causes are identified by SMEs from each technical area who come together to *brainstorm* the problem. Finally, fishbone diagrams are useful tools to help organize ideas and show interrelationships between ideas.

Table 11.1 focuses on the preliminary questions that should be discussed before accepting a project. Review the items indicated and modify the list if necessary. When more detail can be obtained about the project at the visioning stage, other documentation will be better such as defining the project scope, preparing a viable plan, and anticipating related risk events. The table will result in knowing where the project is weak in terms of where more information needs to be identified to enhance the probability of success.

Another tool is the risk assessment checklist displayed in Table 11.2, which should also be generated at the beginning of a project and updated on at least a monthly basis for comparison purposes to monitor the risk management process. This tool requires the use of the following guidelines in generating and updating the checklist:

- Update the items as needed. If the project does not use the item, delete it and add new items as required.
- Identify the correct weight appropriately and use the range for lows (L) as 1–3, for mediums (M) as 4–7, and for highs (H) as 8–10.
- For each item, enter the assessment grade in one of the three columns (low, medium, or high). Enter the same number in the R (risk factor) column.
- When completed, analyze what is happening over time and take corrective action (i.e., rank the top 10 risks and put a risk containment plan together with the project team).

Table 11.1 Probability of Success

	A		B		C		D		E	
	Weights		Example		Example		Project		Project	
	Success weight High = 5, Medium = 3, Low = 1		Answer Yes = 1, No = 0		Success value $A \times B$		Answer Yes = 1, No = 0		Success value $A \times D$	
Questions to ask about a specific project										
A project is part of the organization's business strategy	5		1		5		1		5	
A project sponsor exists	3		1		3		1		3	
The project schedule is reasonable	5		0		0		1		5	
Project processes are known by the team members	5		1		5		1		5	
Risks have been identified	3		0		0		1		3	
The project is well documented	5		1		5		0		0	
The project has a detailed communications plan	5		1		5		0		0	
Status meetings are held for the project team	5		1		5		0		0	
Is the project already started?	3		1		3		1		3	
All project documentation is accessible to the team	1		0		0		1		1	
Is the project to be completed offsite or is additional space needed?	3		0		0		0		0	
Total = Sum of the rows	43		7		31		7		25	
Probability of success^a =	C Total ÷ A Total = 72.1%				E Total ÷ A Total = 58.1%					

Instructions: Fill in the questions that apply to your project. Adjust the weights to what is appropriate for your organization and project as the below only displays weights as an example. Fill in the numbers for the specific project under columns "D" and "E" and perform the calculations.

^a Every organization will have to identify the desired probability of success as some organizations will be more comfortable than others with lower probability of success percentages. If the percentage falls less than the desired for a particular organization, then an action plan is needed to change the key "No" answers to a "Yes."

Table 11.2 Risk Assessment Checklist

Number	Areas	H	M	L	R
1	Requirements definition				
2	Requirements change				
3	System performance requirements				
4	Design level of detail				
5	Project planning				
6	Application complexity				
7	Experience with system application				
8	Hardware products				
9	Software products				
10	Telecommunications/network				
11	Interfaces with other systems				
12	Schedule				
13	Workload estimate				
14	Project management				
15	Project resources				
16	External dependencies				
17	Customer expectation				
18	Customer involvement				
19	Subcontractor involvement				
20	Statement of work				
21	Acceptance				
22	Terms and conditions				
23	Productivity rates				
24	Baselines				
		Totals			
		Last month's totals			
		Original totals			

Risk register

The primary documentation output of the risk identification phase is the *risk register*. This document is a formal repository source for capturing the project knowledge regarding risks and their status (Richardson 2010). Table 11.3 displays a sample risk register as a tool for documenting potential risk events and related information. The name of the risk is listed under the risk column along with a description (Descr.). A risk may fall under a particular category (Categ.) such as technology, facilities, and so on, and can have the category defined. Other information pertaining to the specific risk can be identified well such as the root cause of the risk or any triggers that can

Table 11.3 Sample Risk Register Format

Number	Rank	Risk	Descr.	Categ.	Root cause	Triggers	Potential response	Risk owner	Probability	Impact	Status
R6	1										
R43	2										
R21	3										

Source: Adapted from Richardson, G.L. 2010. *Project Management Theory and Practice*. New York: CRC Press, Taylor & Francis Group.

signal activation of the event. The term *trigger* is used and can be defined as an early warning sign that a risk has occurred or is about to occur. An identified item in the risk register is a risk event and its corresponding trigger (PMI 2008). A planned response to the risk can also be tracked in the risk register along with the risk owner, responsible person for handling the risk, and the probability and impact assessment. Last, the status column is used to signal the status of the event through the life cycle.

Summary

Risk planning begins with a series of steps designed to help approach, plan, and execute the risk management activities, which constitutes the first major step in risk management and was the first objective of this chapter. The second process step involves identification of risks through looking at a company's historical records to identify all previous risks encountered on past related projects, which was the second objective of this chapter. Chapter 22 will focus on risk mechanics that will address the four additional risk processes performing qualitative risk analysis, performing quantitative risk analysis, planning risk responses, and monitoring and controlling risks.

QUESTIONS

Review questions

1. Name and briefly describe the six steps in the project risk management process.
2. Describe how risks for a project can be identified and categorized.

In-class questions

1. Explain the value of documentation in the risk management process.
2. Select a specific industry such as health care or banking and brainstorm risks that may apply to the implementation of a new system within the particular industry selected.

EXERCISES

Using the car case study, produce the following:

1. Risk planning: Develop a risk management plan that the formula TwoProject Team can use throughout their project. Examples of risk management plans can be found in Appendix C.
2. Risk assessment—Risk identification: Log (risk register) identifying five risks affiliated with the car project. An example of risk logs can be found in Appendix C.

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chapter twelve

Creating a viable project plan

PROJECTNMOTION BACKGROUND LESSONS

See Section 3, Lessons 1 through 7 as relevant to this material. Note the lesson on Basic Keystroking as particularly relevant to this chapter.

Previous chapters have outlined the basic mechanics for constructing a first cut scope, time, and cost project plan. From this base point, we now need to introduce some additional planning issues that will have to be addressed. Earlier comments warned that there would be diverse areas of interest by different stakeholders. These different views manifest themselves in many different ways that collectively put pressure on the project to tweak the plan in an attempt to satisfy these concerns. The focus of this chapter is to illustrate various strategies that the PM has to embrace in customizing the initial plan to fit these various constraints or views, while keeping the bulk structure somewhat intact.

Plan tweaking strategies

One of the frequent decision scenarios that occur in the project, especially at the end of the first cut plan phase, is the need to change some aspect of the plan to fit stated constraints defined by key stakeholders. Based on these constraints, the plan will not be approved. Techniques to resolve such issues without destroying the integrity of the original plan are a management art. Each technique takes some aspect of the project work units and moves them around to eliminate or minimize the constraint. We will view these processes as the PM's magic toolbox of tricks to tweak a plan and attempt to satisfy various scope, time, and cost constraint issues. Seven common scenarios will be discussed as examples of this process. They are as follows:

1. The plan is perfect, except you have asked for more resources than are available—this problem is labeled *resource capacity*.
2. Resource commitment issues—the Achilles heel of a project matrix organization structure. In this case, you are informed that the needed resources are not available.
3. The plan consumes more time and cost than management is willing to allow—scope must be reduced.

4. You have been told to cut the project cycle time and hold the scope, time, and budget as is—fast tracking is the typical response.
5. You have been told to cut the project cycle time even further than fast tracking can accommodate, but more budget resource is made available for this activity—activity crashing is a possible option.
6. Project requirements are ok, but the technical staff believes that there is a better way to accomplish the goal—value engineering is a possible strategy.
7. After all of the “tweaking” tools above have been used, some lesser desirable strategies related to team resources, risk levels, quality, and change management can be invoked—these are the last resort.

Each of the events above represents different project issues and strategies required to “tweak” the plan. In each of these situations, the goal is to preserve as much of the initial base plan as possible while dealing with the stated constraint. Some of these options are more mechanical than others, but there is a fundamental process theme running throughout this set that needs to be understood. The sections below will discuss techniques for dealing with each of the seven scenarios.

Resource capacity

Simply stated, resource capacity is a situation where the plan specifies resources that are not available. Figure 12.1 illustrates this problem in graphical form. The lighter gray bar line represents the level of requirement

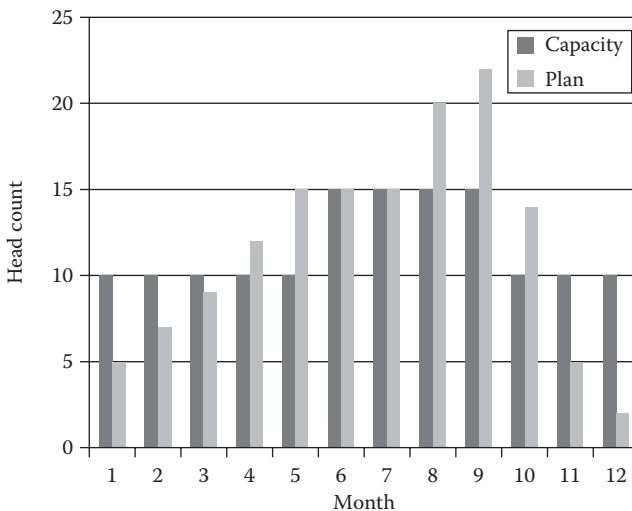


Figure 12.1 Resource capacity.

for some specific skill during the project life cycle as reflected in the plan, while the solid black bar represents availability of that skill. Differences in these two levels represent the resource shortfall for the time segments indicated.

A resource shortfall can occur for equipment, skill group, or even a broader collection of resources. Surprisingly, many project plans do not evaluate this situation and find later that it is impossible to generate the defined work with less resource availability. In the case of a software development project, there may be a defined need for generating 50,000 lines of code in the resource gap period, but the available programmer capacity can only generate 30,000 lines. Mechanically, the plan should be corrected to match planned versus actual resource availability. Assuming the estimates are correct, this gap will represent a time overrun for the project. There are six typical strategies to deal with this mismatch situation:

1. The easiest mechanical fix is to hire more workers to fill the resource gap; however, this may well negatively impact team productivity. Brook's Law says that adding resources to a project to attempt to correct scheduling issues may in fact slow it down because of the training required to bring the new team members up to speed (Brooks 1974). This action also puts an extra load on the PM in dealing with new team members. Realize that adding the required knowledge to the new members may be more involved than it appears.
2. Adding third-party contract resources may be a more desirable approach for resource augmentation than adding organizational staff since the former can be easily moved out of the organization after they are no longer needed. So, if the requirement is of short term, this is often the preferred approach.
3. One way to multiply resource capacity is to simply work the team longer so that more hours are generated per worker. This is the most frequent option employed because it is more under the control of the PM. However, use of long-term overtime can erode team productivity, morale, and turnover.
4. The best engineering approach and the one that will have the best chance of producing the desired quality is to simply expand the project schedule until it fits the available resource capacity. There will be external negative reaction to this option because of the added schedule.
5. Scope can be removed from the plan until the capacity gap is resolved. This is a reminder that initial requirements need to be not only defined, but also prioritized. In this case, the scope reductions would be made from low-priority work units.
6. It may be possible to move slack work units into other time slots without impacting the critical path. This essentially then moves the related resource requirement with the work and may then match

available resources. Assuming that the original plan had the preferred technical work sequence, this would compromise these changes, so it must be done carefully.

In summary, understanding the significance of resource capacity management is an important aspect of the PM's role. By applying these strategies to the plan, it is possible to overcome what appears to be a fatal flaw in the schedule. At any rate, regardless of the strategy employed, this is a variance situation that cannot be ignored as it represents an infeasible plan solution assuming that the original estimates are reasonably accurate.

Looking at this from another point of view, realize that scope change and task overruns during project execution can also create a resource gap and in fact this should be anticipated in the plan. This means that some unallocated buffer of available resources is needed to cover these events. Solving the resource capacity problem during planning is therefore only one layer of analysis that the PM must deal with. For this reason, it is necessary to quantify the status of this topic throughout the life cycle. Failure to have appropriate resources in place per an accurate plan will negatively impact the result just as much as a bad plan will.

Resource commitment issues

The idea of resource commitment arises when a plan has been created, but the supplier has not yet formally committed to that level or timing. This situation can also occur mid-stream when the resource provider does not supply planned resources on schedule. If there is a common issue in the project management environment, it is in this area. Too often the skills and quantity defined are approved in the plan and then not committed per the schedule. Just as in the resource capacity scenario, even with a perfect plan, a deficit of resources will cause the project to drift or force some other mitigation strategy to be used. To minimize this issue, it is important to obtain formal commitment for a resource supply plan and then track that closely through the life cycle. This is an area where the PM can be blamed for an overrun when in fact the cause is directly linked to the resource supplier. For this reason, it is important to keep these data visible and take corrective action quickly. Maintaining a match of actual resources per the plan is a major success factor for the project.

Reducing scope

Returning to an earlier metaphor, recall that a scope-related work unit was characterized as a box with dimensions of scope, time, and cost. All of these are then arrayed in the WBS hierarchy and then into the project plan

as part of the defined work. If there is a need to cut project time or cost, one of the most straightforward ways of accomplishing that is by cutting scope. Envision this through the WBS. Scope cutting is represented by either cutting boxes out of the structure or reducing the size of a box via lesser deliverables. Once again we see a need from the requirements definition process to indicate priority for each requirement to help guide these rationalization activities. If all deliverables are prioritized, the requirements related scope cutting can use this to yield the greatest resource decrease per requirement unit. In other words, keep as much of the project intact as possible while achieving the required resource reduction.

Fast tracking

Every project is under some level of pressure to shorten its overall cycle time. Sometimes this has to do with market delivery requirements, while in other situations it may be more weather-related (winter is coming) or some other delivery need. There are many instances where being first to market has significant impact on success and the organization is pressing the PM to look for techniques to accomplish faster delivery of the output. Fast tracking is one of the most popular of these because of its apparent zero incremental cost, although that may be more of an illusion than fact.

The term fast tracking has multiple meanings in practice. At the core, it means reducing project overall life cycle time. One typical definition of this term is ... *a duration compression is a technique to shorten the project schedule, usually to meet constrained target dates. Normally this will be done by overlapping or compressing some of the project activities or phases* (SPMF). This process is most often accomplished by taking two sequential tasks and overlapping them to some degree such that the duration sum is decreased. That is the mechanical process, but there really is more to this technique than overlapping work units as we shall point out.

The first point that has to be realized is that overlapping tasks that are not on the critical path will have no impact on the overall schedule. From another perspective, we may find that overlapping causes yet other tasks to become the critical path and therefore did not accomplish the desired result. In fact, the more iterations of this process, the more slack that will be taken out of the entire project network, so multiple critical paths will emerge and have to be dealt with.

Beyond the mechanical steps, this process often increases the potential for risk, quality, and management variables to be negatively impacted. Joel Kohler offers a very simple and realistic example of this (Kohler). If we have two sequential tasks to lay carpet and paint a room, we might try to allocate these resources into the same time by moving them parallel, thereby cutting the cycle time. The optimum technical sequence is to paint first and then lay the carpet. By doing these tasks in parallel, we risk

having paint on the carpet, resulting in lower quality, rework, management issues, and so on. In most cases, the original plan should have been constructed with an optimal technical sequence, so fast tracking is challenging that sequence.

Before deciding to fast track a project, it is necessary to evaluate the technical characteristics of the project. If it involves a new type initiative or high interaction between the tasks, the risk level is further elevated. If critical path time can be cut by overlapping, evaluate the value of that decrease compared to the increased risk and management effort involved. Recognize that there are many factors involved in the decision to fast track such that no simple cookbook approach can be produced here. Some of the major considerations to review are

1. Are the tasks involved on the critical path? If not, no value in doing this.
2. Are the tasks divisible? What happens to productivity if you do this?
3. Do the associated skill groups work together ok?
4. Would fast tracking create a resource capacity imbalance?
5. Can the management process handle these tasks in this modified format?

Carroll et al. (2004) describe a related tactic of reducing cycle times by decentralizing decision-making to aid in finding alternative methods of fast tracking. His study quotes simulation results from this strategy, indicating that decentralizing the decision-making in hopes of speeding up the cycle time did not work. There is also some belief that fast tracking itself is more complex than it appears, with the result being that cycle time is increased and not decreased. Regardless of the underlying complexities involved in selecting tasks for fast tracking and the potential negatives surrounding the action, it is a popular time compression technique primarily because it appears to be free from an additional resource point of view.

Crashing

The process of reducing task time by crashing simply means adding resources to a critical path task to finish the project quicker. Let us take a simple example to illustrate. Suppose we wished to manually dig a hole $10 \times 10 \times 10$ feet. We have estimated the work required to do this as 200 h and allocate one laborer to the task. Does not it make sense that allocating two laborers to this task would shorten it? How about three? What do you think would happen if we allocated 50 laborers to the task? Would the same time reduction occur with each new additional resource? Clearly no! We have to establish a minimum time for this and that is called the *crash*

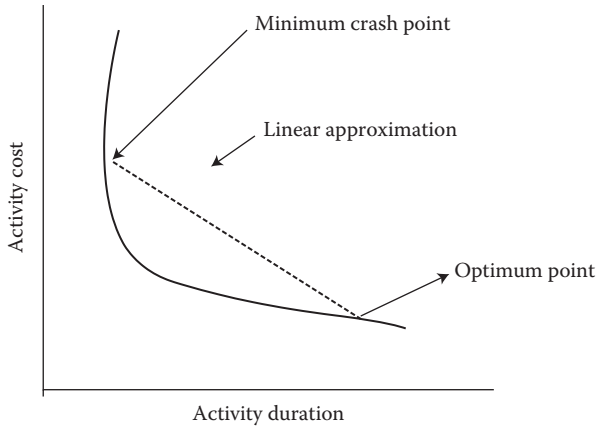


Figure 12.2 Time–cost tradeoff curve.

time. The incremental cost of adding an additional resource is called *crash cost*. Mechanically, crashing involves spending *crash cost* on a work unit to achieve *crash time*.

So, in order to perform the crashing process mechanics two time and cost estimates are required for each activity in the network—normal values and maximum crash values. The normal estimate is considered to be the optimum time and cost for that work unit, while the crash estimate is considered to be the absolute minimum time for the job and the added cost per each time unit from that optimum point (Stires and Murphy 1962). The primary concern in the crash estimate is the incremental cost to decrease the activity time. A graphical crash relationship for an activity is shown in Figure 12.2 as a time–cost tradeoff curve.

The time–cost tradeoff graph shows that each increment of time becomes more costly and eventually crashing will result in diminishing returns. At the minimum crash point, it is not feasible to try to shorten the activity any further. Note in the time–cost curve shape that an attempt to crash beyond the minimum crash point will actually increase both the time and the cost of the effort as overall productivity falls. Review the hole-digging example with this in mind. Envision the situation where too many diggers have been assigned and they are now in each other’s way. This is an example of allocating resources beyond the minimum crash point.

Simple crashing example

For this example, we will assume that crashing data has been derived for each activity on the critical path. Figure 12.3 will be the simple example

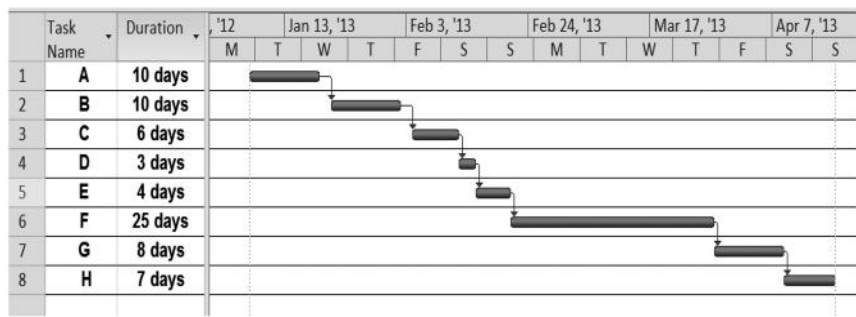


Figure 12.3 Simple crashing example.

used to illustrate the basic mechanics of network crashing. Since all tasks are on the critical path, any reduction will cut the overall project cycle time.

Table 12.1 contains the crash data necessary to execute the process. For sample crash data note that all tasks allow only one day of crashing and all except one have the same crash cost ($D\$/DT$). Given these data, it is then possible to cut one day out of the project for \$3 by selecting any of the tasks with that value (all except G). So we would proceed to select up to seven of these and thereby cut the cycle by 7 days and pay an additional \$21. If desired we can cut one more day from activity G for the remaining \$6. In a more complex network, each duration crash iteration would select the minimum crash cost, recalculate the critical path, and continue to iterate the process. The stopping would occur when the balance between time and cost had been reached. In other words, the stop point would be reached when the cost to cut another unit of time outweighs the benefit. Also, at some point the network cannot technically be reduced further regardless of how much money and resources are available.

Table 12.1 Crashing Task Definition

Activity	NT	CT	D\$/DT
A	10	9	3
B	10	9	3
C	6	5	3
D	3	2	3
E	4	3	3
F	25	24	3
G	8	7	6
H	7	6	3

Note: NT, normal task activity time; CT, minimum time that the activity can be crashed; $D\$/DT$, incremental crash cost per time unit.

Value engineering

The concept of value engineering (VE) was initially used in the early 1940s at General Electric as a technique to produce products under a scarcity of materials situation (Save 2007). In other words, they were attempting to engineer equivalent output using materials that were more readily available. A key part of this early process was use of a function analysis concept to help measure value of alternatives. This technique was later called value analysis. In the 1950s that title changed again to value engineering as the role of the process changed. As viewed today, it is the systematic application of recognized techniques by multidiscipline team(s) to identify the function of a product or service; establish a worth for that function; generate alternatives through the use of creative thinking; and provide the needed functions, reliably, at the lowest overall cost (WVDOH 2004). Stated in more simple terms this is a product or process analysis technique to create the same functional outcome at a cheaper price. It can be applied to both product and process-type projects.

The normal view of VE is a cost reduction tool; however, it is more appropriate to think of it as a value improvement tool, which may or may not include a cost reduction. The Department of Defense (DoD) uses this approach widely and reports savings in the range of \$1 billion annually (IDA). A synonym for VE is design-to-cost. Basically, what this attempts to do is evaluate various requirements as to cost/value. In the situation of project cost tweaking, we can see how this could be used to cut scope or restate a requirement that has less cost than the original. The DoD considers this process to be “one of the principal, established and proven tools for reducing cost and enhancing system performance” (IDA). The following seven basic steps are defined in this process (Save 2007):

1. Gather information—current status
2. Measurement—defining how the alternatives will be measured
3. Analysis—what is the requirement and what does it cost
4. Alternatives—what are the various ways this can be accomplished
5. Evaluate—select best options to evaluate further
6. Quantify options—develop cost/impact status for each option
7. Presentation—describe results to decision makers

The first part of the VE process is similar to the creative aspects of brainstorming and the latter part exhibits many of the quantification traits of the scientific method. Realize there are many dialects of this process and interested readers can gain more details on this from www.value-eng.org and several DoD Internet references.

Other plan compression strategies

Once the first six options described above have been used or eliminated, the remaining options fall into the category of *Court of Last Resort*. None of these choices is optimal, but may be necessary to invoke for overriding reasons.

One somewhat radical management choice could be to halt all changes to the project and focus on delivering the currently defined version. That decision essentially says that no more time or resources can be allocated, but what has been defined is still needed.

A second option is to make the decision to lower the quality level of the deliverable. One example of this is to cut out some testing. This obviously has major risk implications by leaving undefined design errors that were not uncovered only to surface later. In some cases, technical functionality can be reduced and costs cut.

A third example is to cut the project into smaller phases and focus on delivering smaller groups of requirements. This is a “stretching out” strategy and may in fact create more cost longer term, so is viewed as a tactical strategy rather than strategic. Obviously, if this is done during the execution phase, it could cause a major disruption for the project team and result in chaos as the team attempts to split the overall effort into different work groupings.

Summary

A classic IBM development project in the 1960s offers a classic example of plan tweaking gone awry. As IBM struggled to get its model 360 on to market with the goal of capturing the world computer market, it found that the software side of this project was running behind the hardware segment, so they decided to tweak the software portion by adding internal resources with the goal of speeding up delivery. At the initial point, there were about 50 software engineers working on the operating system. Multiple cycles of this strategy were used and in each case the result was not desirable. Before the software was actually finished some 2 years later, the software team size had grown to nearly 1000 and in years later there was a feeling that this process did not speed up the development and certainly did not help the final quality of the product. In essence, this was a massive crashing exercise. Frederick Brooks, the PM, later reviewed this process and surmised that it would have been better to have left the original team in place and not created so much confusion from the crashing process (Brooks 1974). This real-world example shows that the process of project tweaking off of what would be considered the optimal arrangement is not that simple to execute or straightforward in its predicted results. Nevertheless, PMs will have to utilize this tool kit of options as they are pressured to move their projects back into some desired scope, time, or cost state.

QUESTIONS

Review questions

Use sample car project plan titled *12 Car Project Case Discussion* from the publisher website to answer the following questions:

1. If you were able to cut any task in the car project by 10%, which task would you choose to cut?
2. Given historical project performance slippage do you feel that the “green” buffer in task 71 is adequate to protect the project schedule?
3. Do you see anything wrong with the recurring tasks?
4. Generate the WBS for this plan and comment on the logic of the structure.
5. Do you see an opportunity to fast track in this structure?

In-class questions

1. Describe the term *tweaking* as used in this chapter. What is the goal of this activity?
2. Describe the situation outlined in Figure 12.1. What would be the anticipated outcome of this?
3. What does the term “time/cost tradeoff” mean?
4. What is the difference in fast tracking and crashing? Where are these ideas used in the plan structure?
5. If value engineering were to be applied, when would it be most useful?

EXERCISE

The purpose of this exercise is to test your understanding of basic project compression techniques. This file can be accessed from the Publisher website (see Appendix F for instructions) under the title *Table 12.2 Compression Exercise.xls* (see Table 12.2). In order to get full value out of the exercise, it is recommended that this is performed as a group discussion to simulate how a project team would actually go about this. At the end of the exercise, describe what management and key stakeholders should be told about the revised plan? Assume that the basic goal is to cut time and cost as much as possible and then discuss the results with your management group. Use the discussion questions below as a guide for this activity.

The corresponding crash definition table outlines the time–cost trade-off data for this plan. All tasks shown in Table 12.3 are on the Critical Path.

Given the plan technical network specification data outlined above answer the following questions:

1. Clean up the initial network and show results for the following:
 - a. Original plan based on network specification

Table 12.2 Project Compression Exercise

WBS	Task name	Duration	Predecessors	Cost (\$)
1	Office complex	71 days		549,000
1.1	Determine budget	2 days		6000
1.2	Select architect	4 days	2	12,000
1.3	Interview architects	4 days		4000
1.3.1	Architect 1	8 h	3	1000
1.3.2	Architect 2	8 h	5	1000
1.3.3	Architect 3	8 h	6	1000
1.3.4	Select an architect	8 h	7	1000
1.4	Prepare first draft plan	1 day	4,8	4000
1.5	Review the plan	0.5 days	9	500
1.6	Finalize the plan	0.5 days	10	500
1.7	Obtain construction permit	0 days	11	0
1.8	Plan office layout	4 days		16,000
1.8.1	Prepare layout plan	2 days	12	8000
1.8.2	Estimate costs	2 days	14	8000
1.9	Buy materials	5 days		16,000
1.9.1	Rent tools and equipment	3 days	13	6000
1.9.2	Purchase materials	5 days	13	10,000
1.10	Prepare the site	20 days		140,000
1.10.1	Excavate foundation	8 days	16	56,000
1.10.2	Build the foundation	12 days	20	84,000
1.11	Begin construction	18 days		224,000
1.11.1	Build the pillars	10 days	19	70,000
1.11.2	Lay the roof	8 days	23	56,000
1.11.3	Build the walls	8 days	23	56,000
1.11.4	Flooring	6 days	23	42,000
1.12	Miscellaneous	12 days		126,000
1.12.1	Install plumbing fixtures	6 days	22,26	42,000
1.12.2	Install wires and cables	3 days	22	21,000
1.12.3	Plastering	4 days	29	28,000
1.12.4	Woodwork for doors and windows	3 days	30	21,000
1.12.5	Furnishing	2 days	31	14,000
1.13	Office complex complete	0 days	32	0

b. Critical path shown on the network

c. Finish dates on all tasks

- Discuss possible duration reductions that could be made without expenditure of additional resources. What do you feel are the date reductions that can be made on this plan?

Table 12.3 Activity Crashing Data

WBS	Task name	Duration	Predecessors	Cost (\$)
3	Select architect	4 days	3	0
15	Estimate costs	2 days	1	0
20	Excavate for foundation	8 days	6	5
21	Build the foundation	12 days	10	6
23	Build the pillars	10 days	7	7
24	Lay the roof	8 days	7	8
25	Build the walls	7 days	6	10
26	Flooring	7 days	6	10
28	Install plumbing fixtures	4 days	3	10
29	Install wires and cables	3 days	2	5

Note: NT, initial time estimate; CT, minimum time (same time unit as NT); D\$/DT, cost to crash the activity one time unit (\$000s).

3. Assume that your senior management has instructed you to take five time periods out of the plan described in Tables 12.2 and 12.3. You tell them that this might be possible, but will cost extra resources. As part of this exercise crash the network using the data provided and then answer the questions below.
- a. What is the logic that you will use to accomplish this task?
 - b. What task(s) will you crash and why?

Crash 1: _____
Crash 2: _____
Crash 3: _____
Crash 4: _____
Crash 5: _____

- c. How much extra will this add to the initial project budget?
4. Using the sample data above crash this project plan to 63 days and show the cost impact of that. Use MSP and crash one day at a time. Record the task selected and cost impact.

Duration	Task	Total cost
70		
69		
68		
67		
66		
65		
64		
63		

5. Using the modified (crashed) plan answer the following questions:
 - a. What is the earliest time you could reach WBS 1.13?
 - b. What is the latest time you could leave WBS 1.11.2 and not affect the CP?
 - c. What is the slack time at node WBS 1.12.1?
 - d. Write a formal description of the CP.

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chapter thirteen

Finalizing the project plan

The previous chapters have described the mechanics for creating, sizing, communicating, and receiving approval of the project plan. Recall that components of the project plan consist of schedule, budget, risk, and various nondirect items. At this point, the management and key stakeholders have signed off on the document and the project team is now gearing up to move into execution. From this base point, it is necessary to execute the final set of steps to formally terminate the planning stage and transition into the execution phase. Before jumping into this discussion, be aware that the material described to this point would be considered as basic planning in that it has been limited to only scope, time, and cost considerations. More aspects of the overall process have been reserved until later in order to establish the basic processes that form the foundation mechanics.

The concepts described to this point represent the core of basic management processes, but admittedly there are other supporting management issues that have not been covered yet. These relate primarily to topics such as change management, risk management, procurement (make or buy), quality, communications, and human relations. This omission is not to suggest that these additional topics are unimportant; rather that the initial goal was to simplify the initial view since the holy trilogy represents the framework upon which the other processes link. If we try to show this point visually, think of the project consisting of a large set of work units. All management processes operate on those entities in some form or fashion.

Reviewing the project plan components

A viable project plan serves as a road map for the execution process in the same way that a highway road map serves to guide a planned trip. In both cases, we realize that the map may not have identified all items along the way, but hopefully, the detours encountered will be minor and we will always be close to the defined target areas. Also, the plan can help us move back in the desired direction. To accomplish this goal, the project plan must accurately capture the stated requirements, map an appropriate technical work pathway to achieve those requirements, incorporate various necessary technical items into the plan to support the output, allocate required resources to work units, and integrate these together such that all necessary

components are in synchronization. At this stage, to the best of the team's collective knowledge, this plan if followed will achieve the defined goal. For the plan to function as a management and communication tool, it must be packaged in a format that supports the various management roles.

Another important role for a project plan is to serve as a control vehicle (plan versus actual) during execution. To do this, it is necessary to keep the plan contents up to date. This means that all of the currently defined work is in the plan, including all overruns, changes, and triggered risk events. The dual role of an approved plan versus dynamic work plan requires the introduction of another management process. That is, the original approved plan will be *baselined*, or frozen for use as the former item, which then becomes one of the primary performance measurement control tools. More details on the control aspects of the plan mechanics are given in a later section.

In the ideal case, the final approved plan would be so accurate that all that will be required of the execution team is to simply allocate defined resources to defined work units and the results would mirror the plan. That would make project management a checker of the completed task and there would be nothing else to do. Coming out of this dream state, we know that is not the upcoming environment, but still realize that the more accurate the planning effort, the less confusion later.

WBS control structure

The most important management infrastructure activity related to project control is the location and establishment of formal CAPs. This decision determines the level of resource visibility for the project. The higher up in the WBS hierarchy these are chosen, the lesser the visibility to lower-level performance details, whereas the more lower level they are placed, the more data administrative volume to deal with exists. The location selected for a CAP represents a trade-off decision is based heavily on the need for status visibility versus increased administrative work. There is no right or wrong answer regarding the location selection of CAPs, but they should be located low enough in the structure to aid in reasonable status tracking and variance analysis.

Enterprise accounting system

This system will most likely be the official point of origin for capturing actual resource costs. Moving accounting data into the project CAP structure requires a linkage between the enterprise accounting system chart of accounts and the project's CAPs. To accomplish this, the enterprise system will link its account codes to the CAP named project WBS IDs (or the equivalent of this). As resources are consumed on the project, time, and

cost charges will flow from the accounting structure back to the linked project WBS ID. This will supply the needed actual performance information by CAP. Within this linkage, there are also design issues regarding the granularity of data related to fund types (i.e., expense vs. capital), material, hours, and so on. Mature organizations will have formalized processes to perform this service so that the only project requirement will be to establish the linked internal project CAP codes. Without such a process in place, it would be up to the project team to convert raw accounting data into some form that can be used for status tracking, or to manually collect data internal to the project. Neither of these two choices is the most efficient resource collection process.

One interesting metaphor that helps one to describe the relationship between the organization and its internal project is to view the organization as a flowerbed and the project as a seed in that flowerbed. The more supportive the flowerbed, the easier it is for the project to grow its flower (output). A flowerbed supplies the sun (human resources), water (facilities), and fertilizer (processes) to support the project. If it is necessary for each project to create its own flowerbed, the project cost and time will be greatly increased.

The budget model proposed here is that the project schedule and budget are defined inside a planned envelope. The area within this management envelope defines the control limits that the project must stay within. Project actuals cannot exceed the envelope values without formal management review (with good explanation to go with it). Any time a performance value exceeds its outer envelope value, the project is vulnerable to shut down. The concept of the outer envelope of control is the full budget, schedule, and resources outlined in the plan. This means that all anticipated growth for the project needs to be recognized as the plan is approved. It would not be viewed positively to have a plan approved and then come back later to say that some variance had not been anticipated or some risk had been not considered. That may happen but is not considered to be a good career event for the PM.

Some of the most difficult items to plan are the various reserve items surrounding change, time variances, risk, and MRs (in that order). Showing any of these is often viewed as padding (Richardson 2010). For this reason, budgets seldom show the breadth of reserves as outlined here and management reviewers often think that they do not represent real events. It is true that scope change, triggered risk events, and MRs are not real work yet, but some form of them certainly will occur as the project unfolds. Each of these items cannot be defined as clearly as the defined work units at this point in time. However, to reject these as valid categories is ignoring the real world. Too often, the reaction to this is to hide these categories in various lower-level work units and that action greatly clouds the control process integrity.

Recognize that the reserve items outlined here do not represent padding; rather, they represent events that need to be considered as part of the planning and control process. The previous discussions have outlined some of the background as to how scope change, risk, and estimating variability occur. The point has also been stressed that none of these has occurred and therefore should not be included in the direct plan, but handled in separate reserve categories to cover them when they do occur. Mature organizations try to understand these work categories and attempt to deal with them.

Reserve funds

An indirect aspect of budget control involves controlling the movement of funds from reserve categories and the authority to make decisions regarding these reserves. In most cases, reserve funds are not readily controlled by the PM, but this can be delegated to him in some fashion. Buried somewhere in the budget maze must be three equivalent reserve funds whether they are so named or not. These are planned contingency reserves for risk, scope change, and management. For this discussion, we will assume that all three of these funds have been estimated and set aside for the project execution phase. These events are real and simply cannot be ignored from the resource obligation.

Let us examine what happens when these reserve classes are buried within other budget categories. When the related events do occur, they are not linked to predefined work units, so the process of covering the event would be to move the resource out of some other work unit. As subsequent scope, risk, and estimating errors began to surface, their impact would be absorbed with these padded work units, even though the placement of the padding would not fit the reserve event. This means that when the project is completed, the actual charges would not reflect where and how they actually occurred. Obviously, resource traceability is lost in this process. Not recognizing the discrete role of reserves in the overall management process will hold an organization back in its move to higher operational maturity.

The proper view of reserve pools is to estimate their respective future impact on the project, set aside a resource to fund that impact, and then develop a mechanism to allocate resources from those reserve pools to cover the future events. As the event is funded, visible work is recognized and the reserve pool decreases by the allocation. If all goes as forecasted, each reserve pool will be exhausted at the end of the project. More importantly, the overall budget will be protected by the pools. Many projects do not follow this approach, but burying reserves in specific work units complicates the management process and conceals the actual performance.

Not only has the organization not learned from the various events, but it has also succeeded in confusing itself by hiding the source of these

variances. A more logical approach would be to estimate the future impact of these items and then develop a mechanism to compare what actually happens in each category compared to the plan. Noting where the variances actually occurred would provide additional insight for future reference. To implement this, some defined reserve components in the budget structure are needed. Basically, this involves making the reserve pools visible and then defining a process to move resources from the pools into the various WBS work units to balance the observed variances. The sections below describe some specific control issues related to reserve components and nondirect work elements.

Scope reserve

Some level of scope creep is normal for a project and must be recognized as part of the approved plan. A formal change control process is established explicitly to manage and control the level of such activity. However, we must recognize that scope work units were not part of the original requirements-based planning process, and hence are not shown in the WBS view and therefore not defined in the project work schedule, budget, or resource allocation level. When a scope change is later approved by the project board, that amount of additional project resource will be needed to execute the new work (Richardson 2010). This is the basic role of the scope reserve. One straightforward method to handle this would be to extract the approved change amount from the scope reserve and move that into the WBS structure as a newly defined work activity. It would then become part of the regular project plan. More importantly, the overall budget for the project would not have changed since the resources were extracted from a defined reserve pool and this controlled flow of funds fits our management control requirement. In this case, the project board is the approval authority and the PM could serve the role of the reserve custodian and be delegated to actually manage the fund flow. One controversial related issue for this is the impact of a scope change on the project baseline. Conceptually, all changes in scope represent changes in the approved project baseline, but in most cases, this is not done unless the change is significant. The normal baseline definition method is to keep the originally approved value for status comparison purposes.

Risk (contingency) reserve

Risk (contingency) reserve is defined as "... allowances for unplanned but potentially required changes that can result for realized risks identified in the risk register" (PMI 2008, 177). This reserve fund is initially evaluated during the planning risk assessment process (reference Section VI for more details), but monitored throughout the life cycle. Even if there was

not a formal risk assessment process performed during planning, some budget reserve should be set up for this class of event based on history, gut feel, or whatever technique the organization wishes. The movement of funds from this reserve pool should also be under the approval control of the project board much in the same fashion as a scope change. In many ways, the risk event acts in much the same form as a change dictated by some natural event—that is, weather, technology, and so on.

Management reserve

MR is defined as "... budgets reserved for unplanned changes to project scope and cost" (PMI 2008, 177). This reserve category is defined to handle "unknown/unknowns." The most common examples of this would be the normal variances found in individual work units. This group is different from the risk contingency or scope reserves because MRs are not anticipated as part of the planning exercise. One could argue that many of these are simply risk events, but a risk event is generally viewed as something other than normal work unit variations.

There is a certain amount of management mystique surrounding this reserve type. Some organizations do not admit that such a thing exists and basically just ignore this source of budget overruns so long as an explanation is supplied. As stated multiple times previously, we believe that the budget should be able to show the level of activity for each of the resource types and that holds for this category as well. In many cases, the level of MR is unknown to the PM and he seldom has direct control of allocating this class of resource. There are multiple ways in which this class of project resource can be budgeted and controlled. One way is for management external to the project to hold the reserve funds and require explanations of all associated variances. That is not a practical solution and would invoke many poor behavior traits within the project. This level of oversight is also a poor use of the management's time. A more practical approach is to allow some percentage of the PMB to be delegated to the PM to cover undefined overruns. These variances would be managed by the PM without external oversight up to the defined limit. A second component of this fund type would be kept at some higher level and managed by that entity. This segment of the fund might well not even be known as to size by the project. Holding portions of this fund away from the project and hidden is not the recommended approach, but it seems that the real world project often uses this strategy.

The recommended approach for the MR category is to delegate some segment of it for control by the PM. This first-tier allocation would then serve to handle normal variances in WP cost, but related overruns would be tagged to the specific WP showing its variance from the plan value.

In this fashion, the normal level of *unknown/unknown* class of variations would be protected by the tier one reserve amount. At the end of each account reconciliation period, all variances not attributed to risk would be covered by reductions in the MR fund. In theory, when a WP overruns its planned level, that amount should be extracted from the reserve and tracked accordingly. Lack of formal recognition of this budget category places the PM in a tenuous position in that a work unit overrun would be viewed as a budget overrun when in fact it is a normal operational event. With no recognition, these variances would give the flavor of poor management to outsiders. In a professional trust relationship, both parties should understand these dynamics and provide the proper operational environment for the PM to do his job.

Regardless of the method used to balance work variability, strong consideration should be given to delegating the PM some fraction above the direct budget plan to handle this class of variability and to protect the plan from an apparent overrun. At the same time, there should be an increased emphasis on developing work unit cost estimates that do not include padding. If that could be achieved, the role of this reserve class takes on a new meaning.

Yet another format to handle project variances is through the use of a visible buffer in the plan. An example of this was shown in Chapter 10. In both the described cases, this reserve would protect the budget from normally occurring variations without padding those events during the planning cycle. The buffer acts just like a reserve pool, except that it is visible as a phantom work unit. Management often views buffers as extra padding, but if the padding can be kept out of individual work units, it simply represents a central location to measure the reserve level and status as the project unfolds.

As indicated earlier, most MRs are not visible even though the concept of unknown/unknowns is real. Lack of formal recognition of this budget category places the PM in a tenuous position when the project budget begins to overrun because of these events, they occur as budget overruns. Often, this will force asking for more budget resources from the sponsor when the actual variances are small and expected in any project environment.

On the basis of this interpretation, the MR concept becomes a split responsibility between the PM and his sponsor who has funded the effort. Both parties understand that the items in this category are not anticipated, but some of them will occur. The management philosophy is that it is better to encourage honest work unit estimates and manage the resulting potential overruns rather than to bury resource padding in all such units and ignore the problem. If we look at this issue politically rather than technically, the real problem is how to show it on the visible budget, not

the concept itself. For that reason, it may be necessary to keep the management of reserve groups out of visible view, but make them known in some format as generally described here. It is primarily up to the PM and his project board to ensure that these funds are properly managed as the project moves through the life cycle.

The final budget structure including all the categories described here is a formal document that will live with the project through its life cycle and it basically represents the scorecard performance master template for the project. Specific methods to deal with the dynamics related to scope, risk, and unanticipated overruns have been covered in this model view (this is not always so in the traditional budget). At this point, the PM and the project board are committing to the organization that they will produce what has been shown in the plan and to report their performance in a manner described here. They now have to ask senior management for the resources to pursue this venture. The sponsor and the project management delegation level for this class of reserve signify the enterprise's willingness to commit some amount of the total resource pool for allocation by the internal project. In this view, the PM must be looked at as the primary control agent who is charged with managing the variances that occur.

A final comment on budgets—tracking a total budget plan value versus actual resource consumption—does not satisfy the planning or control requirements of modern project management. However, a budgeting and control structure similar to what is described here needs to be considered as the appropriate planning and control view.

Level of effort

Project support resources often come from various parts of the organization and either their charges will be part of the general overhead or they will be charged more directly in some form. These charges are difficult to map to WBS work units since they are not based on the actual work performed. One approach to handling this class of resource allocation is to charge the total fee to the project and then reallocate to lower-level units as they request specific support. A second method is to negotiate a fixed cost arrangement to supply the required support when and where it is needed. If the support resource charges are directly linked to the specific work unit, we can then simulate the regular work task cost allocation approach. For the sake of management control, it does seem reasonable to show this class of charge under a line item with a defined name. Control of this class of account would simply be comparing actual with plan because the concept of work completed does not fit the activity. These items can be shown as one or more defined lines in the budget (i.e., help desk, desktop support, office space, copycenter, documentation department, etc.).

Overhead

Projects frequently show at least some segments of the budget as overhead. This class of resource cost elements come from various sources and represents the external cost of support. Organizations own buildings, have executives and managers, supply various support organizations, incur employee benefit costs, supply basic infrastructure, and so on. The normal accounting allocation goal is to match costs in proportion to their actual resource consumption, so a full budget view would have to show these costs. Some overhead items fit into the WBS structure and some do not. For example, the team personnel have benefits beyond their salary, so rather than simply showing a lower direct salary we would likely reflect the full cost of the employee directly in the WBS structure. In this case, the overhead amount would be directly embedded in the work structure. Other items are not so easy to link to specific work efforts (i.e., cost of facilities or senior management). In those cases, the budget might simply apply a factor, called a burden rate, to some portion of the budget to cover these expenses. These items need to be categorized on the budget structure outside the performance measurement segment of the project because they are not controlled internal to the project.

Profit

Inclusion of this budget segment is only applicable when the project is being pursued for an external third party under contract. Similar to the MR issue, showing profit on a budget is often avoided or visible only to certain management levels. Profit targets are often established by the senior management, so this number would be derived from previous conversations with them on this topic.

Budget structure and format

The organization of the project budget may require that internal resource data descriptions be translated into formal accounting line items, which are dictated by the enterprise accounting system. In the ideal case, that would have been done during the initial plan preparation, but it must be verified now as future actual costs from the accounting system will likely be delivered back in this code format. Resource codes are standardized within an enterprise to support the formal regulatory reporting structure, or other internal financial requirements. Items such as capital versus tactical funds represent a typical example of how dollars can actually be divided into multiple groups. Funds could be identified by the allocation year or a host of other methods. Just recognize that there are many such code designations that might need to be reflected in the budget presentation. When

presenting the budget to the senior financial management, it may be necessary to reformat the project view into the enterprise financial format. During the earlier planning process, these were not the paramount concerns, but they must be resolved before formal approval is given.

Management control structure

After all the budget components and machinations described above are properly formatted into the plan, the final item to review is how the various budget categories will be controlled. For example, the PM needs to understand what types of formal financial and other decision-making flexibility he has within each budget category or group. A common term for this is *delegation of authority*.

Projects will generally be monitored and controlled based on planned resource status versus actual resource status. The planned value will most often be a defined baseline using the WBS structure for aggregation of the components. For financial resources, this control strategy would simply be the total resources consumed versus the baseline value; however, for nonfinancial resource management views, this comparison might have a more complex status interpretation. For example, analysis of a labor variance has a completely different meaning than a material resource variance. Similar interpretive differences would exist for reserve fund status, level of effort activity, and third-party procurement activity. The key point in project control is that there are a myriad of events that might be tracked in describing status. Section VI of the textbook will discuss the various project control aspects further.

Budget categories

Each budget line item or category may have a different level of delegation and this is an official constraint limit for the PM and the team. It is important to understand what each of these categories involve and abide by them accordingly.

Human resources

Some of the most complex control issues are related to the human resource component. Much of this is related to the fact that the failure to achieve the planned resources here will certainly pass through to other aspects of project performance. Since a common form of project organization is the matrix form, resources are essentially borrowed from the functional organizational groups. Given the related dynamics of moving resources in and out of the project team, some PMs believe that this is the most mismanaged aspect of a project and therefore is a significant control item.

Quantities, skills, and productivity are all part of this issue, and for this reason, significant monitoring and control efforts are required.

Project repository

During the planning and execution stages, many documents are created to support the project activity. These documents have a significant value for both the current project and others who could learn from their contents. To support this role, there is a growing recognition that a formal approach for archiving and storage has a significant value. Some repository items will be extracted and compiled into the formal project plan, while other items may have more internal technical value. In any case, think of the repository as the place to look for any data related to the project. Not only will the item be available, but it will also be controlled. So, when you extract a project plan from the repository, you will know that it is the latest version. In this role, it could be considered not only a repository, but also a configuration management (CM) system repository.

The key items to consider for inclusion in the repository are summarized in the following list:

1. Project charter (formal management approval for the project).
2. High-level assumptions and constraints.
3. Project objectives.
4. Scope statement.
5. WBS.
6. Labor and time estimates with background notes.
7. Work unit estimates with background notes.
8. Resource allocation notes.
9. Network diagram showing the desired technical sequence of tasks—may be multiple versions as the plan is updated.
10. Schedule—may be multiple versions as this is updated.
11. HR management plan (staffing, skills, and training issues).
12. Staffing plan—showing how the project team will be staffed and relocated.
13. Communications management plan—outlining the who, what, when, and how communications will be delivered.
14. Risk management—see risk chapter for more details on this area.
15. Procurement management plan—detailing how procurement will be executed.
16. Quality management plan—quality objectives and approach.
17. Budget/spending plan—this can be in various forms, but it should outline the project cash flow by major categories.
18. Testing plan—processes for component testing, system testing, stress testing, and so on.

19. CM plan—depending upon the project type, the control of various configuration items can be very rigorous. In any case, develop an appropriate document and product control strategy for the project.
20. Baseline plan—this may be only the initial baseline, but could also be multiple baselines approved through the life cycle. Baselines can be set for time, cost, quality, technical performance, or any other project variable.
21. Performance analysis plan—KPIs are to be used in tracking the project performance.
22. Document the archival structure—describes the timing for how documents will be archived or destroyed.
23. Documentation plan—defining the overall repository structure.

Final project plan format

While the raw data components are stored in the project repository, a formatted collection of this data is prepared as the final project plan that will be viewable by external sources. Local organizational processes will dictate the format of the final plan, but in a pure model view, the project plan consists of a subsidiary plan for each knowledge area (i.e., scope, time, cost, risk, procurement, quality, communications, and HR) and a summary high-level overview outlining the key aspects of the overall plan. This plan should outline how the work will be performed and it should define a performance measurement plan describing the control process that will be followed during execution. Additional data could also be included depending upon the underlying technology related to the project goal.

The summary plan overview section outlines issues of greatest interest and concern to the key stakeholder review groups. The core of this would certainly include time and cost information, as well as a restatement of the approved scope (which could have changed from the initial version based on the tweaking process). Many readers will only be interested in the summary view, while other groups may be primarily interested in only one of the subsidiary documents. Regardless, this collection of plan documentation becomes the face of the project and becomes essentially a performance contract for the PM and his team.

Communicating the plan

Packaging of the project plan documentation for external presentation must be sensitive to the communication focus and value of this activity to specific subgroups. For this reason, the presentation material will require multiple versions to focus on the needs and interest of a particular audience. For example, the senior management typically wants a summary version of project objectives, schedule, and budget, with major milestone

dates. Cost is often a main focus, although showing how the project will contribute to some aspects of organizational goal alignment is always a good communication strategy. Future user group presentations should focus more on the projected deliverables functionality and related schedules—how is it going to make their life better? This audience will want to see how the original requirements or vision statement was translated, particularly if some original requirement was deleted through a rationalization process as a result of some resource, cost, or time constraint. Third, if there is a PMO in the organization, they may well want to review many of the plan details as a central management agent. Finally, a fourth communication audience is the newly formed project team. Once formed, a kickoff session for them provides a good opportunity to go through the work plans in detail and describe all the technical details they need to be familiar with and how the project has a value.

The key requirement in presentation packaging is to communicate topics that are appropriate for each audience. This exercise should actually be more than a one-way discussion. Now is the time to deal with requirements changes that were made during planning and the logic behind those changes. If requirements changes did occur, be prepared to discuss why they occurred and, in some cases, be prepared to go back to the management and report concerns that surfaced. The user presentation process should also outline how they can best help support the project as it moves through the execution cycle. Activities such as design reviews, product prototype reviews, test acceptance, user manuals, and training are typical interface points that could profit from their involvement.

Planning stage close

It may be surprising to learn at this point that the complete project planning process has not yet been completed. The final structure of this document is both financial and political. The financial components are somewhat deterministic, but the method of showing these becomes more of a political process.

At this point, the plan has now been formally approved and communicated. It is time to move the project into the execution phase. These last steps fall into the category of planning stage closing and preliminary execution stage activation. One activity that takes on new life at this point is change control. Up to this point, changes to the plan have been relatively easy since no real work had been performed on any deliverable. However, from this point onward, the plan details are baselined and all changes will be processed through a formal change control process. As the team is formed and starting work, there will also be other support organizations linked to the effort. These could be third-party vendors, internal support groups, or a host of others. Many startup logistics issues will pop up at

this point as their groups try to understand what is needed and how it is to be delivered. This phase has been named “storming” to signify the level of confusion found during the startup phase. Communication channels now increase exponentially and everyone needs to be instructed as they crystallize their roles. This can be quite time-consuming if the project team is fragmented across wide geographic areas. Good PMs will need to be thinking ahead and trying to anticipate what will be needed before the project has to stop and wait.

The last formal steps before leaving the planning stage are to be sure that the lessons learned to date are documented, stored in the repository, and reviewed for improving ideas. Finally, it is also important to remember to deal with an often forgotten step regarding the individuals that were involved with the planning process. These individuals need to know how much you appreciated their contribution and this should be transmitted both personally and formally to their home manager. Part of this process should be to find some suitable nonwork activity to celebrate the successful completion of this step. A lunch or dinner (whichever is more appropriate) is often used for this purpose. If the planning team has had to work long hours to finish the effort, it is also nice to include the significant other in this celebration. A gift, bonus, or other memento is appropriate. All these gestures are part of building a positive team culture now and into the future.

QUESTIONS

Review questions

1. If a project plan is a road map, what happens when the project gets lost?
2. Explain the decision logic for defining a control account level.
3. What is the role of the enterprise accounting system in project management?
4. What types of reserve funds were defined in the chapter?
5. What is the basic role of a reserve fund? Do you think it will be easy to show these in the plan and have them accepted? Rationalize your answer to this.
6. How do you control an LOE?
7. Why would a project budget contain more than just the total costs of the material, labor, and dollar cost required for execution?
8. What is often a major stakeholder communication issue in regard to the project plan?

In-class questions

1. Describe some of the data that emerged during the planning process that needs to be communicated and to whom?

2. Do you agree with the level to management for the level of planning detail outlined in this section of the text? What issues do you see with this model theory versus taking a less formal approach to plan development?
3. What would you do if you were instructed by your project sponsor to move into the execution phase before you were comfortable with the plan status?
4. How would you react to receiving a significant negative stakeholder response to the plan during the external communication phase after you had received a formal approval from management as outlined in this chapter? Discuss your strategy and actions.
5. What is the purpose of a project baseline? Do you think that all the approved scope changes represent new baselines? Where does the additional budget resource come from for changes after the budget is approved?
6. Given that most real-world projects do not create the level of planning or budget documentation outlined in this chapter, what would you guess to be the rationale for shortening this process?
7. Most PMs say that they have never seen the visible reserve pools used as outlined here. Do you agree that these reserves are valid entities and should be managed this way, or do you see another option that would work better? What real-world management culture do you think has an impact on not making such reserves visible?
8. How would you sell the idea of building a common project document archive for the organization? Name two or three life cycle processes that this would aid.
9. How would you approach communicating the car project plan to management? Do you see this project as being difficult and why?

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section five

Project execution

This section of the textbook contains a collection of tools and techniques that aid the PM in successfully carrying out the project. The learning objectives for this section are listed as follows:

1. Understand the difference between metrics and measures to track project performance.
2. Describe the earned value (EV) suite of status evaluation techniques to provide the PM with sophisticated tools to examine project performance.
3. Identify different types of project status reports to be utilized by the PM to successfully track the project progress.
4. Understand techniques that influence the outcome of a project from the aspect of planning or control as it relates to scope, project, and scheduling management.
5. Implement changes to the project while managing the project scope.
6. Demonstrate the mechanics related to resource leveling through the Microsoft Project view while learning how to resolve resource constraints.

A brief goal statement for each topic is included below.

Key performance indicators

Chapter 14 provides the PM with different metrics and measures used to track project performance. This chapter provides the PM with knowledge of what constitutes a metric versus a measure. A simple example of a metric is the speed of the car. The measure for this metric is the actual value of the metric, such as different cars' actual speed limit. You cannot manage what you cannot measure. Therefore, the performance indicators provide the PM with examples of how to adequately measure and manage a project.

Earned value

Chapter 15 on EV is a contemporary project management cost and schedule analysis technique that has gained broad industry acceptance over the past few years. Originally introduced into the project management sphere in the late 1960s, this topic lay essentially dormant for over 40 years before the commercial world began to embrace its usage. There is now broad evidence to indicate that EV provides one of the most effective and meaningful project status analysis tools available today to measure and report cost, schedule, and performance. EV has the unique ability to combine cost, time, and scope completion measurements within a single integrated methodology.

Status tracking

Chapter 16 is on project status tracking reporting which should be defined at the start of any project by the PM as part of their communications plan, which describes the information needs of the stakeholders and the project team. This overall plan should cover who needs to know, what and when they need to know, and how they should receive it. This chapter discusses different kinds of project status reports that can be utilized by PMs to help them become more successful in tracking the progress of their project for the stakeholders and project team. The more popular ones to use are the Action Logs, project plan, and pivot visual reports for weekly project status tracking and reporting.

Influencing project outcomes

Chapter 17 is on influencing project outcomes. Projects that are completed often end up having fewer features and functions than originally planned to save development time and/or costs. Therefore, PMs need to be equipped with numerous techniques in their toolbox to help in influencing the project outcome in a positive manner. The examples discussed represent techniques to accomplish an aspect of planning or control for the project and is divided into three major areas—scope, project, and scheduling management.

Integrated change control and scope management

Chapter 18 is integrated change control (ICC) and scope management. The focus of this chapter is on managing the project scope while changes throughout the project occur. The charter is the envelope of the project in terms of identifying its specific time and cost requirements. The project execution and specifically changes that occur with the project will go through an ICC board. This board has authority to only make changes

that fall within the envelope. Change requests (CRs) may result in a cost to the project. If the project budget does not have money for the scope changes approved, there are different approaches to seek the budget. This chapter also addresses when a scope change has been made in violation with the board.

Resource leveling

Chapter 19 is on resource leveling. The purpose of this chapter is to demonstrate some of the mechanics related to resource leveling through the Microsoft Project view. In some cases, overtime is used to bridge the gap between the plan and actual resource availability. This is actually a way to stretch resources, but there are negatives related to what looks like a universal solution. While this is a temporary solution, it is never a long-term solution as an ongoing need for overtime results in the need for a better solution whether it requires the approval by the management to hire additional resources, change tasks within the schedule to a different time period that does not conflict with tasks on the critical path, change tasks to other team resources, and so on. The area of resource leveling represents a common gap in the planning process and one that can crater the value if not recognized.

Summary

Collectively, these chapters complete our overview of tools and techniques to help the PM successfully execute a project. The section addresses a portion of the project life cycle. The tools and techniques discussed better equip a PM with the managing the project performance, cost, schedule, outcome, scope, and resources.

chapter fourteen

Key performance indicators

Introduction to KPIs

Key performance indicators (KPIs) are a very broad area and therefore interpreted differently, making it somewhat difficult for companies to develop KPIs that are meaningful and useful (Enoma and Allen 2007). However, simply stated, a KPI is an indicator to the organization or the PM that some specific area is below, above, or on track. Therefore, a collection of these is used to indicate the performance of the project or organization (Chan and Chan 2004).

Not only is it difficult to develop meaningful KPIs, but it is also often a mistake by organizations to define too many KPIs, resulting in the generation of too much data beyond what is needed to collect and interpret (Carlucci 2010). This chapter outlines some of the well-defined KPIs that will support a better understanding of project performance. It will also highlight the common confusion between the difference in KPIs, metrics, and measures.

KPIs help to ensure that project results are in alignment with organizational goals (Shahin and Mahbod 2007). For instance, a company that has a goal of being the most profitable in their industry will have a KPI that measures some related attribute of that goal. KPIs are very helpful for organizations seeking to achieve continuous improvement (Kaskinen 2007). Another performance example from Shahin and Mahbod (2007) is that a university might have KPIs that measure employment rate after graduation as these are in alignment with an organizational goal of providing valuable curriculum. Overall, the purpose of measuring a project or organization is to assess progress, identify issues and the root causes of the issues, and monitor the completion of work.

Developing KPIs and KPQs

Prior to developing KPIs, it is important for an organization to identify key performance questions (KPQs) such as what is the end-goal of the project or organization (Nixon et al. 2012). Identification of KPQs better equips an organization to develop relevant and meaningful KPIs. Too often, KPIs are developed without first having an understanding of what we want to know. Once there is understanding of what the higher-level goals are, we can then begin to develop specific KPIs to measure progress

in that area. Another important characteristic role for a KPI is that it plays an important role in monitoring past achievements, present planning, and present controlling. However, KPIs cannot be generic across an organization as they must be applicable to the specific project or organization to be useful (Harris and Mongiello 2001).

There are different categories of KPIs that can be developed. Lavy et al. (2010) defined four common ones. The first category is a financial KPI set that relates to costs and expenditures. The second category is a physical set that relates to the physical shape and condition of something tangible such as a facility, hardware, and so on. The third category relates to function and relates to how well something is working. This could be a technical capability measure of speed, rotation, vibration, or the like. The fourth category relates to qualitative measures from respondents (i.e., customers, users, etc.). This last category is useful to measure factors such as environmental and psychological aspects, with examples being customers' satisfaction with a product or service, or appropriateness of a classroom for faculty and students.

Operational examples of KPIs for a university were developed by Chen et al. (2009). These examples include facilities expense as an example of a financial KPI, dropout rate as an example of a functional KPI, student/teacher ratio as an example of a physical KPI, and student satisfaction as an example of a survey-based KPI. Haponava and Al-Jibouri (2009) discuss process-based KPIs that fall under the third category described above. An example of process-based KPIs that is similar to a functional KPI is stakeholder's involvement and communication such as the quality of relationship between stakeholders having an effect on a project's success. Other categories of KPIs identified by Practical Software and Systems Measurement (2012) relate to schedule and progress, resources and cost, product size and stability, product quality, process performance, technology effectiveness, and customer satisfaction. Examples of some typical project KPIs are basic status attributes, product testing and verification, teamwork and personnel, requirements analysis, process improvement, defect prevention, and various KPIs focused on employees and customers. Others can be defined to assess risk status, reserves and baseline comparisons, buffers for time and cost, completion forecasts for schedule and costs, and EV parameters. More specifics related to EV parameters will be discussed in Chapter 15.

KPIs should be easy to calculate, clearly defined, easy to compare (actual versus estimated or comparable from month to month), and focused with regard to their purpose (Hursman 2010). One of the tests of a good KPI is that it is specific, measurable, attainable, realistic (relevant), and time-sensitive (Hursman 2010; Shahin and Mahbod 2007). The first letter of each of these characteristics makes up the acronym SMART. Therefore, the SMART method for evaluating a particular KPI is a useful guideline. Indicators need to be *specific* and clear where no two individuals would

interpret the indicator differently. Indicators also need to be *measurable* so that it is easy to gauge the trend performance of increasing, decreasing, or no change. The *attainable* attribute serves to make certain that the indicator is something that can be obtained with reasonable effort. The indicator must also be realistic, which is slightly different than attainable as *realistic* means that the cost of collection is within constraints (Shahin and Mahbod 2007). Without resource support, some indicators are not realistic. The realistic criteria can also be referred to as relevant as it must be relevant in terms of measuring something of value, but also relevant in being able to measure performance where the KPI applies (Hursman 2010). In other words, does the metric actually relate to a valid area of concern? All indicators should be *time-sensitive* in regard to having a period of time in which the indicator is reviewed and measured (Shahin and Mahbod 2007). Using these criteria as guides, the steps in KPI development are to define the goals in terms of what the KPQs indicate as time, cost, functionality, and so on. KPIs should also focus more on tracking output versus input. As an example, milestone-based targets for a project or organization are useful for KPIs. Finally, the number of KPIs tracked is an important constraint which is discussed in the next section.

Metrics, measures, critical success factors, and KPIs

Metrics represent defined attributes of a process or product whose possible values are numbers or grades, whereas a measure is a value of a metric (Parth and Gumz 2003). Metrics potentially influence project activity and therefore need to be relevant, straightforward, and quantifiable. Failure to define and analyze measured results and adjust project direction can lead to less than desired results. Metrics are then able to be translated into vision and strategy to form tangible targets and focus work activity on formal critical success factors (CSFs) (Richardson 2010). CSFs are related to activities that need to occur for the project to successfully produce its deliverables. Examples of CSFs are measures indicating adherence to schedules, budgets, specific process values, product quality, and so on (Kerzner 2011).

A simple example of a metric is the speed of the car. The measure for this metric is the actual value of the metric (e.g., 55 miles/h or 200 km/h). Therefore, a measure contains some defined standard unit of measurement (The International Function Point Users Group 2012). In some cases, a metric is defined as a combination of two or more discrete measures such as using hours per function point as the productivity metric. Note that a metric “measures” something and a KPI “indicates” an interest in some attribute. A KPI is a snapshot of the progress a project is making in some specific area toward its targets (Kerzner 2011). KPIs are used to draw

attention and evaluate a particular situation such as a flag or deviation outside predetermined tolerances or control limits.

There is a common management adage that says “You cannot control what you cannot measure.” Another common management adage is “What gets measured gets done.” Recognize that it is also difficult to improve something that cannot be measured, so KPIs provide an organization with a way to measure current performance against benchmarks to learn of strengths and weaknesses (Kaskinen 2007). Once a particular weakness is identified, an organization is in a better position to evaluate corrective actions such as assigning more resources, improving the operational process, and so on to correct the deviation. If a positive outcome is identified, the project team can use this information in different areas of the project or company. KPIs provide the PM with a way to measure and manage a project and provide the management with ways to measure and manage a company’s performance too.

Selecting KPIs

In selecting KPIs, the focus needs to be on a small set of metrics (Richardson 2010). Albert Einstein said “Not everything that can be counted counts” Therefore, focus should be given to those factors key to the success of the project and organization. The frequent tendency is to collect too much KPI data, which becomes unmanageable to analyze. Just because a company or project measures a high number of KPIs does not mean that these provide useful information to justify their collection expense. Reh (2008) recommends a limited number of standard KPIs because too many KPIs may become overwhelming to manage and over time become ignored. Each project can then support this by defining three to five specific KPIs that support the organization’s overall KPIs. Generally, project or departmental KPIs help to align the organization focus by rolling up the information into the overall organizational scorecard KPI (Richardson 2010).

Let us take the example of the organizational KPI of “increase sales” and translate it downward to lower-level units into one or more KPIs that contribute to that higher-level goal (Richardson 2010). For example, a customer relationship management (CRM) development project could contribute to this organizational KPI of “increase sales” through improvement of the linkage between the sales force and customer. In this case, a CRM development project metric would also fit one or more departmental goals that might in turn be translated across multiple business units, which are indicated below:

- Product department KPI—“new product time to market”
- Sales department KPI—“number of new customers”

- Marketing department KPI—"number of telemarketing calls completed"
- IT department KPI—"online website up-time"

Organizations are tempted to revolve their KPIs around items relating to cost and schedule since those are of common interest to management. However, these do not address the output side of the project very well such as the quality or performance of the deliverable. The KPIs selected need to be balanced and not focus only on one or two areas of interests. Also, ensure that KPIs are for different segments of the project life cycle so that all the focus again is not in one area. If the KPIs are unbalanced, it could unintentionally affect and drive the project toward undesirable behavior. Too much focus on any one area is not good as it may cause an unbalance with another area, or a lack of concern in those areas.

Analytical hierarchy process

Shahin and Mahbod (2007) established a process resulting in KPIs that are most relevant to the goals of an organization. The SMART criteria discussed above is used to measure each KPI using their analytical hierarchy process (AHP) to identify which KPIs are best for an organization. AHP is a way to model complex problems in a simple way, which assists decision-makers in the selection of different decisions ranging from selection of projects for an organization to even selection of KPIs. AHP allows for weights to be assigned to the different criteria such as the SMART criteria as each criterion may be more or less important than other options. In this instance, AHP combined with the SMART criteria helps to establish priorities among options as well as identify KPIs that measure the progress of achieving those goals most important to the organization. To have a successful KPI program, it should have buy-in from the stakeholders who are charged with their collection or use, as well as higher-level management, or receive these measures (Kaskinen 2007).

KPIs as individual performance measures

KPIs are also linked to individual performance. Therefore, compensation decisions related to salary or bonuses for an employee performing well should be considered (Hursman 2010). Motivation for employees to continue to make progress toward improvement of KPIs can occur through a bonus or alternate reward system. Those individuals responsible for gathering the KPI data, using the information and working in the area affiliated with a KPI, need to be part of the KPI program (Kaskinen 2007). Consulting these individuals on a regular basis will help one to ensure that the KPI remains an important focal point for everyone. It will also

assist in providing meaningful feedback to employees and management on the progress of the KPI target and ideas for continuous improvement. It is helpful in the development of KPIs and the measurement highlighted if there is knowledge of the business processes and environment where the KPI is affiliated (del-Rey-Chamorro et al. 2003). Therefore, involvement by those closest to the area being measured should be involved in the development of the KPI and measurement. If a KPI measure does not have an impact on improvements in processes, resources, and so on, then continuous improvement will not occur and there is suspicion that this metric is not worth being collected.

Data collection

The data collection step should be as simple and automated as possible. Also realize that the data collection process may not be perfect or even arithmetically accurate to accounting standards. However, any data that helps identify trends in a timely manner is better than not having any data as it will aid in better decision-making. Reasonable data now is better than perfect data later when it becomes too late to influence the decision process. The cost of data collection must be reasonable too or it will not be supported long term. The data also need to be consistent and directionally accurate. Realize that the term *accurate* must be measured in regard to its usage and audience. For long-term KPI success, there should also be designated times and schedules for the data collection. Without reliable timelines, the measure will decline in usage and value. The data should also not include excessive qualitative measures as that can create invalid results. One of the more common examples of this is asking a team member to define percentage complete for a work unit. Unless this is based on some objective criteria, that result may be worthless.

KPI graphics

Collection of a KPI measure over time produces output as illustrated in Figure 14.1. This example displays estimated costs compared to actual costs over a 10-week time frame. Graphics of this type provide a way to present the KPI data in an easy-to-understand format.

Visually displaying KPI information is a powerful tool as it provides the PM with a quick way to see trends in data and outliers. It makes it easy to view the data collected over days, weeks, months, and years. Visually displaying the data also lets those individuals collecting data see how the data being collected is actually used within organizations that further sends the message of the importance of collecting the data, which keeps employees focused on continuing to collect data since it will be viewed as value-added.

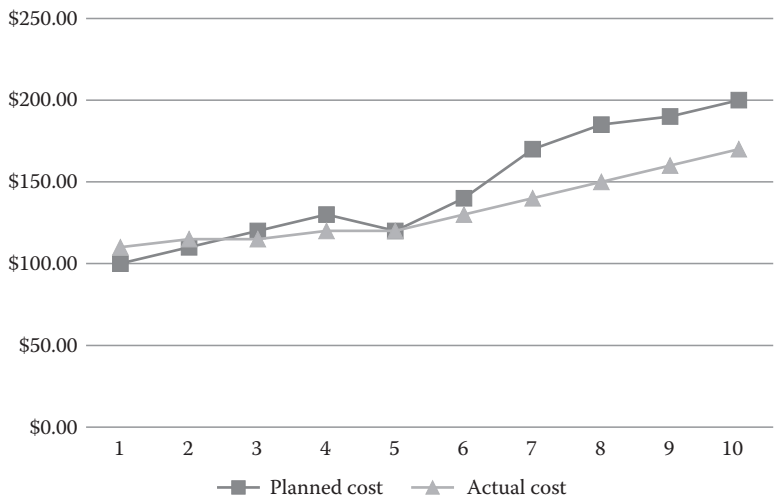


Figure 14.1 Composite.

Summary

Metrics will not replace management, but are a vital support element to that process. A KPI indicates to an organization or the PM that some specific area is below, above, or on track with regard to performance. KPIs, when effectively used, provide data about potential problem areas and therefore help focus management attention on the right targets. KPIs help the project team perform their role more effectively and present data to company management outlining how the project is aligning with the organizational goals defined for that effort. Therefore, KPIs measure the overall health of the project in how well it is meeting company goals. Status reports to management should include not only the KPI, but also their current and approved baseline values so that a true performance picture is being communicated. In essence, the KPI collection is used to measure achievement in alignment with a company’s strategic target (Chen et al. 2009). In addition to KPIs, a comprehensive performance management system will also have other factors such as cost, productivity, quality, employees, supplier-specific issues, and strategic alignment (Kaskinen 2007). While metrics will provide performance information, the metric does not provide a solution to resolve a deviation from the approved baseline. Therefore, it is incumbent on management and/or the PM to actually define the necessary corrective action to resolve the problem. We will illustrate more mechanics related to metric performance analysis through earned value management (EVM) in the next chapter.

Table 14.1 Defect Data

Week number	1	2	3	4	5	6	7	8	9	10
Estimated defects	34	24	20	15	12	10	8	6	4	2
Actual defects	50	42	30	21	18	17	14	10	5	1

QUESTIONS

Student review questions

1. What is the difference between the terms metrics, measures, CSFs, and KPIs?
2. What is the difference between a KPQ and a KPI?
3. How does a company develop a KPI?
4. How can a company keep employees interested in making progress toward a KPI target value?

In-class questions

1. Perform a search to identify a metric along with the affiliated measure used by a company.
2. Identify two examples of a project KPI.
3. Using the data of Table 14.1 showing the number of estimated versus actual defects in a factory for a new product, create a status trend chart similar to Figure 14.1. What does the chart indicate?

EXERCISES

1. For the car case study, identify a metric and measure to track project performance.
2. For the car case study, identify three useful KPIs.

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chapter fifteen

Earned value management

PROJECTNMOTION TUTORIAL LESSONS

Section 5 of the video library contains several relevant tutorials regarding status tracking and earned value (EV). Basic lesson topics include:

- Reviewing status
- EV basic parameters
- EV theory
- EV mechanics
- EV dog pen problem
- Book solution to the dog pen problem.

Introduction

Earned value management (EVM) is a contemporary project management cost and schedule analysis technique that has gained broad industry acceptance over the past few years. Originally introduced into the project management sphere in the 1960s, this topic lay essentially dormant for about 40 before the commercial world began to embrace its usage. There is now broad evidence to indicate that EV provides one of the most effective and meaningful project status analysis tools available today to measure and report cost, schedule, and performance. Stratton (2012) reports that "... use of EVM increased in 2011 by 13% over 2010." Also, this growth is occurring well beyond the boundaries of the USA. EV has the unique ability to combine cost, time, and scope completion measurements within a single integrated methodology.

During the initial definitional stage in the late 1960s, the Department of Defense defined 35 supporting management capabilities (criteria) to be used by their contractors. Given the contractor level of management process maturity, these requirements were found to be overly onerous; however, over the next 40 years internal management process maturity evolved and eventually the value of the EV status parameters began to be accepted as a way of life. In 1987, the PMI added reference to EV in their *PMBOK®* Guide and expanded that discussion in subsequent editions. Also, an ANSI/EIA-748 standard was released in 1998, which further stimulated a

broader formal recognition of the technique to the nongovernmental project environment (Fleming and Koppleman 2006). Continuing efforts to simplify and implement EV gained further momentum in the early 2000, and to date, there is now a recognized body of research data that validates it as an effective tool to support management of projects of any size and risk (Christensen 1998, p. 13). In the hands of a trained technician, EV represents the most robust tool available for evaluating project cost and schedule status and completion forecasting.

During the middle evolutionary stage (1970–1990), EV was often viewed as requiring excessive overhead compared to its value and rejected based on that belief. This attitude still exists in some project management circles, but the author's opinion is that it is the best method available to assess project status. For that reason, it is a mandatory tool for the PM to understand. EV techniques are now widely used internationally in governmental projects, construction, information technology, and more. An important support driver for this acceptance level is the modern suite of computerized tools that makes the computational overhead related to this process well within reason for even large projects. However, as in many cases using a computer to generate numbers can lead to misuse as much as it helps perpetuate the process.

Basic EV principles

On the basis of its underlying modeling constructs, EV principles deal with many core project management areas, including formal scope definition, resource analysis, schedules, budgets, resource accounting, status analysis, reporting, and change control. EV's specific mechanics favor the use of WBS, formal performance measurement baseline, and defined set of work unit performance measurement rules. Before delving further into the computational methodology, it is important to review the role of one framework support concept critical to EVM implementation, that is, the WBS.

As previously described in Chapter 7, the WBS is a fundamental technique for defining and organizing total project scope into a hierarchical tree structure. Through this structure the WBS is defined as a set of approved project deliverables and related work units that collectively represents 100% of the approved project scope. Arrayed through this structure is a collection of boxes into which planned work and related resource allocations are defined. The EV model then uses this structure mapped to an approved project schedule to evaluate the status of project time and cost. Once the WBS has been approved it is baselined, or frozen, to represent a control framework for the project. These baselined work units are time-phased into an approved schedule and budget. From this view, actual work completion and resource consumption are compared to the approved plan in order to assess how the project is performing. The

major difference between EV and the more traditional simple plan versus actual resource consumption status method relates to how EV also evaluates work accomplished instead of just resources consumed.

Figure 15.1 shows a trend curve of a project's planned versus actual resource consumption. This display shows that the project is using less than the planned level of resources, and therefore, one could conclude that all is going well, right? Maybe not! Too often a curve such as this is used to suggest that a project is doing well. However, the missing ingredient in this scheme is "what has been accomplished during this period?" If half of the budget has been consumed but only accomplished 25% of the required work the project is obviously not doing well. EV offers parameters to properly evaluate this situation in quantitative terms.

A third dimension included in the EV status measurement problem is the concept of *earning*. Basically, earning is measured by completion of defined work prior to the status point. In the examples used here, work is defined by boxes in the WBS. So, the project status measurement simply becomes a two-way comparison view between baselined and earned box measurements, versus actual resources consumed and work accomplished (earned) earned values. At a defined status time point, the following three sets of performance status data would be collected:

- Actual cost (AC)—The actual cost incurred for the planned work packages up to the status point.
- EV—A measure of completed work units and partially completed portions of work units up to the status point. For example, a 50% complete work package would receive 50% of the planned value (PV) as earned.
- PV—The sum of planned baseline cost for all or partial work units scheduled to be accomplished up to the status point.

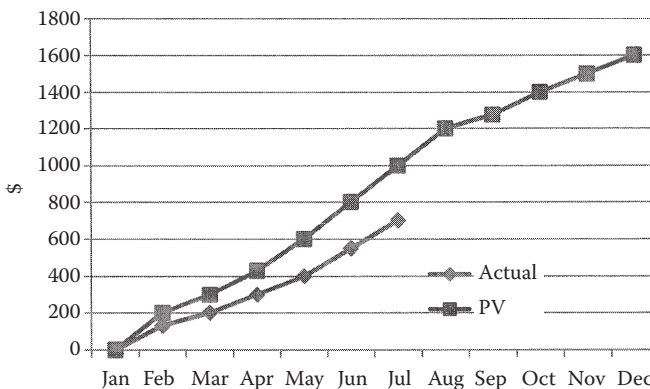


Figure 15.1 Traditional status report.

A mental model view of this is shown in Figure 15.2 with three “cans” of data. This data view is valid for both the entire project and down to the lowest point at which actual data are collected. Recall the term CAP that was defined in Chapter 7. Here, we see that term come into play. The EV evaluation scheme requires that plan and status data be collected into these three groupings. Note the alphabetical sequence (A, E, and P) of the three data categories shown as this will be important later to help remember the cost and schedule relationships.

With the addition of a third evaluation variable, it is now possible to produce three separate measures of project status. A typical project EV trend curve as shown in Figure 15.3.

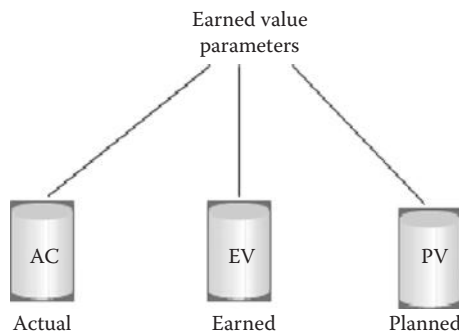


Figure 15.2 EV parameters.

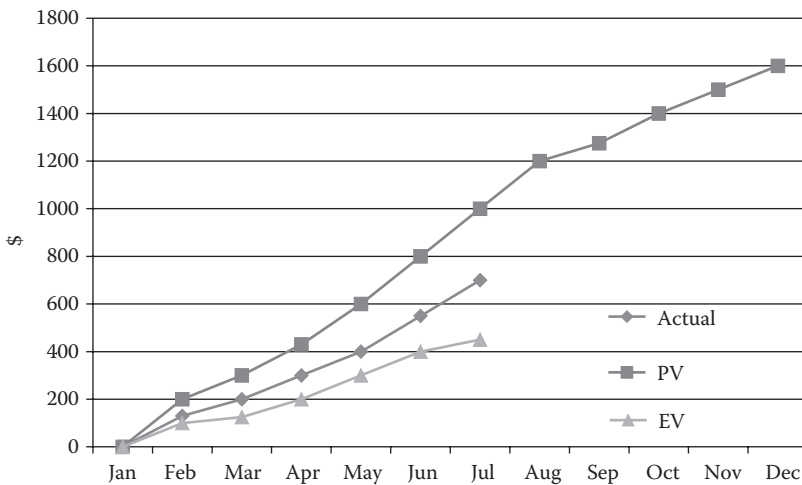


Figure 15.3 EV graphical status view.

Unfortunately, as we will see shortly, this typical curve suggests that the project is behind schedule and has spent more than planned. Using these three relationships, EV status parameters can be calculated to help the PM identify key problem areas and help focus on project areas that need corrective action. The three trend views offer insights into how the project is doing, but this raw data needs to be converted to more quantitative terms for true analysis. Both schedule and cost status measures can be derived from this data.

Beyond revealing specifics about historical performance, these same data relationships can be used to forecast final outcomes of the project based on various assumptions. One typical forecasting assumption is that the project will continue to exhibit the same trends in the future that it has up to the current status point. Of course, every PM hopes that the future will be less bumpy, but there is research evidence that this is not the norm. Trained manipulation of these data relationships offers very sophisticated insights into project performance now and into the future. Learning to use these data for these purposes makes the EV process a most important monitoring and control technique for the PM. Multiple examples will be shown in this chapter to illustrate how EV parameters can be produced at various levels of detail and plan formats.

EV framework

When viewed from its raw theory state, the framework and mechanics required to support EV project tracking seem very complex. However, when broken down into fundamental project, process elements that are suitable to support the majority of projects it is much more understandable and reasonable to accomplish. Fleming and Koppelman (2006) studied the fundamental control requirements contained in the EV ANSI/EIA-748 standard and from this review distilled 10 basic management steps necessary to implement a reasonable set of procedures that will satisfy control requirements for most moderate-to-small projects in any industry. These basic management process steps are summarized below:

- Step 1—Define the scope of the project. One of the most useful framework tools available to the PM is the WBS and its Dictionary, which fit into the fundamental scope definitional requirements for EV quite well.
- Step 2—Define the project work units and related allocated resources. Through this process, the relationship of required work to its associated resources can be evaluated. To obtain a valid work status, the project must be able to measure the current level of accomplishment of a work unit against the actual resources consumed for that work.
- Step 3—Estimate the required resources and formally authorize the budget. Once the project scope has been fully defined and subsequently

planned and scheduled, the next step is to estimate the resource requirements (budgets) for all the defined work units. Each defined WBS element must have a resource value estimated for its specified work. Management will then approve this in the form of an authorized project budget. *Individual WBS work units will not contain contingencies or management reserves in the EV analysis portion.* These two reserves are held separately.

Step 4—Plan and schedule defined work. The EV methodology requires a resource management system that is capable of tracking authorized resources (budgets) through the approved schedule. The comparison plan must reflect a time-phased budget mapped to the authorized schedule. From this time-phased formal baseline, work completion status is measured as work is accomplished. Evaluations are made at defined status points.

Step 5—Define a project Performance Measurement Baseline (PMB). EV requires the formal definition of an integrated project baseline containing defined work units, baseline schedule, and related time-phased budget. Calculation of EV status parameters focuses on comparative measurement between baseline and actual values for each of the selected WBS elements referred to as control account plans (CAPs). A CAP can be best described as an arbitrary point in the WBS where actual cost and status data are collected (refer to Chapter 7). In some projects, the total baseline cost may include such things as indirect costs, and even profits or fees to match the total authorized project commitment. The cost baseline must include whatever executive management has authorized for the project, but realize that the *EV analysis only applies to the direct work portion and is not so much useful in evaluating items such as level of effort tasks and material.*

Step 6—Record all direct costs consistent with the authorized baseline work units. This criterion requires PMs to have access to current resource expenditures at the level of detail required. It is essential that direct costs be tracked to a CAP. In order to employ EV metrics on a project, the actual costs must be aligned with the baseline budget. For instance, work accomplished must be relatable to actual resource consumption by work unit in order to determine the related EV parameters. This is the single most important EV performance process evaluation step.

Step 7—Convert the work unit status into EV status parameters. The status measurement challenge here is to identify a viable method to quantify work unit completion status. There are various methods used to measure work unit accomplishment and the most respected ones use some type of discrete physical completion measurement; however, this is not possible in all situations.

- Step 8—Continuously monitor EV parameters against the authorized baseline values throughout the duration of the project. Primary management focus should be on work unit variances, particularly those that fall above defined control tolerance levels. In this role, EV is a management by exception concept. One of the most important aspects of employing EV is its ability to monitor ongoing cost and schedule status of the project at CAP levels of detail.
- Step 9—Forecast the final project status. EV is the most sophisticated project management tool currently available to forecast cost and schedule status based on current work performed.
- Step 10—Manage authorized scope. The project Performance Measurement Baseline (PMB) is defined by the approved plan and is used as a control benchmark value. A formal change control process is required to manage the project baseline. Recognize that approved scope changes often represent new work units added to the WBS and this can complicate the EV computation mechanics; however, once added to the baseline the process remains essentially the same.

By utilizing these 10 operational process steps, the PM is provided with a reasonable mechanism to satisfy most basic schedule and budget evaluation requirements. If the scope and complexity of the project dictates, these abbreviated steps can be expanded to satisfy the more rigorous 32 criteria contained in the ANSI/EIA-748 Standard (NDIA 2005); however, the more simplified structure outlined above should be satisfactory for most small-to-medium-sized projects.

EV notation

The original 1960's four-letter acronym notational definition for EV parameters was viewed as cumbersome. During the 1990's evolution period, this was simplified to a three more obvious and easier to understand basic two-letter status acronyms. Unfortunately, during the earlier period, extensive documentation and training of the technique occurred mostly in governmental sectors. As a result of this, there is now a vast set of published literature with two different notation. This dual installed documentation base creates some user confusion that is not likely to resolve in the near term. Realize the cost and effort involved for the older implementations to translate all of their training and documentation into the newer simplified notational forms. As a result of this historical dichotomy, it will be necessary to translate terms across both notation sets. The newer notation has been used in this chapter up to this point, but we now need to cross-reference both formats. One of the primary reasons to highlight this point is to warn the reader of this and also to note that MSP still uses the older notation. Table 15.1 summarizes the comparative core EV parameter terms.

Table 15.1 EV Dual Notional Terms

New	Original	Meaning
PV	BCWS	Current baseline cost value to status point
EV	BCWP	EV calculation up to status point (work performed)
AC	ACWP	Actual cost of planned work performed up to status point
BAC	BAC	Total direct work unit cost for full project
EAC	EAC	Estimated direct cost of total project at completion
ETC	ETC	Estimate of incremental direct costs from status point

It is important to note that both notation deal with the same concepts, so it is simply a matter of recognizing the dual naming convention. As the use of EV techniques continues to mature, there is high probability of additional notation to emerge. However, the embedded nature of the governmental documents and training may inhibit that aspect of change.

EV core status formulas

Before simply listing a set of formulas to show status, it seems worthwhile to show a simple memory schematic that helps produce the core formulas and avoids the need to memorize them. This memory device will structure the key variables in such a way as to produce the cost and schedule index and variance formulas.

Magic box formula generator

The first step in this memory structure is to remember “AEP” in alphabetical order. Remember, these are the first letters of the three required measurement parameters (see Figure 15.2), that is, AC, EV, and PV. With this as a starting point let us introduce the “EV Magic Box” in Table 15.2.

This is a visual memory schematic that will produce the core status formulas from the box design. First, note that the top columns of the box contain AEP in alphabetic order, which are the three core EV data

Table 15.2 EV Magic Box

	AC		EV		PV	
						
CV	?	---	?	---	?	SV
CPI	?	/	?	/	?	SPI

variables AC, EV, and PV. To finish populating this view, we add the two status variables for cost (C) and schedule (S) in alphabetic order going from the left to the right-hand sides, respectively. From this five-symbol structure, the basic EV formulas are essentially defined. The four core formulas we are trying to produce from this are as follows:

$$CV = EV - AC$$

$$CPI = EV/AC$$

$$SV = EV - PV$$

$$SPI = EV/PV$$

Most would agree that these relationships are not easy to memorize. However, if you can arrange the raw data into the logical magic box structure, the formulas are easily derived. The process of producing the cost and schedule formulas can be summarized as follows:

Each of the core formulas are generated by moving from the center EV cell outwards left and right as indicated by the arrows toward a target parameter (cost or schedule). Moving to the left would generate cost parameters, while moving to the right would do the same for schedule. Generation of variance parameters CV and SV require a negative operator sign between the two data items, while the index parameters CPI and SPI require a divisor.

Follow this explanation and note how the formulas “fall out” of the process. The reader should practice this data organization box structure as we illustrate the EV mechanics. This same structure and mechanics can be applied to any project situation into which the three variables can be defined.

Gantt bar example

As a starting example, let us illustrate the basic EV quantitative mechanics with a simple project Gantt chart plan as shown in Figure 15.4. It will be instructive to compare the process described here with the previous 10-step minimal process outlined earlier. One would certainly categorize this example on the low end of complexity, but it is useful for illustrating how the data are collected and used.

The hatched Gantt bars represent planned work and the solid black embedded bars represent actual accomplishment for their respective task. Each bar is labeled with the planned cost (PV) and actual percentage completion. A dashed vertical line indicates the status review point (time period 30).

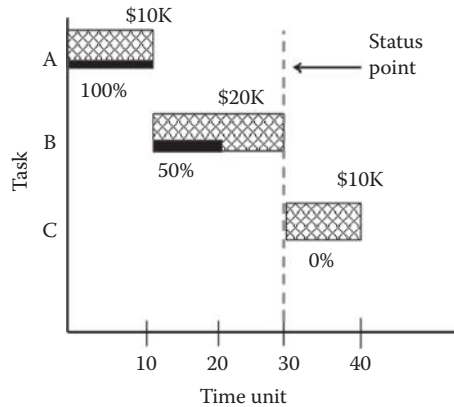


Figure 15.4 Gantt bar example.

First, note that EV performance is measured using only planned base-line task values prior to the status point, so in this calculation only Tasks A and B will have status values. The project status data for the two active project tasks is as follows:

Task A—PV = \$10K and 100% complete

Task B—PV = \$20K and 50% complete

Task C—Not active, therefore, not included

The basic status question for this data is “how is this project doing?” In this case, we can see that the actual work accomplishment is less than planned, but we do not yet see actual costs provided. That data will be added soon. About all that can be concluded with the existing data is that the project is running behind schedule. Even if actual cost data were provided, there is not much quantitative that could be produced regarding whether the project is only behind schedule but still on cost target, or even further behind on both than indicated. Let us use this to show how EV mechanics can provide a quantitative set of measures for both cost and schedule, plus the ability to forecast completion under some defined assumptions. The next step will generate that set of parameters.

EV solution for the Gantt problem

The first step in the evaluation is to move the required data into the magic box structure. For this, we simply fill in the cell values under the named columns. Review the Gantt chart model shown in Figure 15.4 to see if you can identify actual, plan, and EVs from that visual picture—this calculation is often confusing for a new EV user. The value for PV can be derived

directly from the Gantt bar status. Note that for the status point tasks A and B planned to complete, the project PV would be \$10 + \$20 or \$30. EV calculation is a little trickier. The rule says that you can only earn what you plan. Assuming the %Complete values are correct, EV would be \$10 for task A and \$10 for B (half of the plan value). So, the project EV would be 20. We now have defined two of the three required parameters.

The last variable needed is actual cost. The question in your mind at this point might be “where would one find actual costs for the project?” Going back to the material in Chapter 7, recall that the WBS had special tags for key points in the project where actual resource costs would be collected. These points were called CAPs and the enterprise accounting system would be linked to these points to deliver that data. Let us assume for this example that the accounting system returned the total actual cost value for work units A and B as \$35. This completes the required cell values for the magic box and the EV parameters can be produced from this point. In this example, we are only illustrating the mechanics for the total project, but in a real-world example it would be more beneficial to have EV parameters calculated for each task as well. Keep that thought in mind as we move forward.

The resulting data are now shown in the EV schematic boxes in Table 15.3.

Using the memory box logic explained above, the calculated core parameter values are

$CV = 20 - 35 = -15$
 $CPI = 20/35 = 0.57$
 $SV = 20 - 30 = -10$
 $SPI = 20/30 = 0.67$

As this example illustrates, generation of EV core parameters is not that difficult to produce once the three-driver data items are computed. A more important goal is to understand what these results mean and use that information to help take meaningful corrective action.

Remember, the design concept of EV is to create a formalized work unit structure against which work measurement and resource consumption are matched. The parameter values above accomplish that

Table 15.3 EV Parameters

	AC		EV		PV	
						
CV	35	---	20	---	30	SV
CPI	35	/	20	/	30	SPI

goal, but we now need to understand what the values mean. That is our next step.

Interpreting EV core parameters

Working definitions for the basic EV performance parameters are defined below:

Schedule variance (SV)—The difference in the dollar value of work that should have been completed in a given time period compared to the work actually completed.

Cost variance (CV)—The dollar value by which the project is either overrunning or under running its baselined cost plan as of the status point.

Cost performance index (CPI)—The ratio of budgeted cost of work performed (EV) to actual cost (AC). A CPI greater than 1.0 indicates work is being accomplished for less cost than planned or budgeted, while a CPI less than 1.0 indicates the project is running above the planned cost.

Schedule Performance Index (SPI)—The ratio of work accomplished (EV) versus work planned (PV), for a specific time period. SPI indicates the time rate at which the project is progressing. This index value has the same numerical interpretation as CPI, except it now represents schedule performance.

In summary, the basic quantitative interpretive meaning for the core EV status parameters is as follows:

Negative variance values are bad (below plan efficiency)

Positive variance values are good (better than plan efficiency)

Index values > 1.0 is good (better than plan performance)

Index values < 1.0 is bad (below plan performance)

The variance parameters are reasonably straightforward as to their interpretation; however, the index parameters deserve more comment. CPI for the example program was computed to be 0.57. That says the project is only running at 57% cost efficiency compared to the plan. The inverse interpretation says that the project will overrun its budget by 43% if it continues at the same rate. Obviously, both interpretations are valuable status indicators. For large projects, Christensen (1998, p. 10) found that CPI values tended to stabilize by the 20th percentile point into the project life cycle to within $\pm 10\%$ accuracy. This means that CPI is a valuable project predictive completion parameter once the project reaches this point. In other words, a project develops an environmental,

cultural, and technical profile that is not likely to suddenly change after this point.

SPI for the example problem was 0.67. This status interpretation is similar to that of the CPI with one slight difference. In this case, the project is running at 67% efficiency compared to the plan and if it continues at this rate the project will overrun its schedule by 33%. However, there is one important warning related to this parameter. Recall that the SPI formula is EV/PV . By definition, EVs cannot exceed PVs. So, as the project moves past around the 70th percentile point in the life cycle this formula begins to become misleading in that it will begin to migrate toward 1.0 regardless of actual project performance. As a result of this idiosyncrasy, calculations for SPI after the project midpoint will indicate improving results when in fact that is not necessarily the case. For this reason, care must be exercised in interpreting SPI values after the mid-point. We will review an alternative approach for schedule evaluation later in this chapter. For now, the key is to understand the basic interpretation of the values.

Critical ratio

There is one additional parameter that is occasionally used to evaluate the combination of cost and time. This term is called the critical ratio (CR). Its value is computed by $CPI \times SPI$ and represents the overall time/cost status of the project (Cable et al. 2004). This metric can help evaluate whether the project is drifting negatively in both time and cost, or possibly one is counteracting the other. For instance, the use of higher cost resources might make CPI less than 1.0, but the corresponding SPI values could be better than planned. Conversely, if both parameters are below plan the standard one variable EAC calculation may not fully reflect the corresponding time drift. The critical ratio helps one to interpret the interaction between cost and time performance, both good and bad. In some situations, the CR is used in the denominator of the cost forecast formulas for that reason. This is yet another evaluation tool that brings insight into the overall status.

Performance evaluation and forecasting parameters

Working definitions for the rest of the EV performance parameter set are defined below:

- Budget at completion (BAC)—Baseline budget for the project. Components such as reserves, overhead, profit, significant material costs, and more are included as part of the total project cost budget, but they should be removed from the EV status analysis since they are not “productive” in the sense of the work package delivery performance.

- Estimate at completion (EAC)—Completion forecast for the project is based on the computed value of CPI. Similar time forecasts can be produced using valid SPI parameters. Four other alternatives for forecasting the project EAC are described below:
 - Standard budget forecast for EAC—Used when *future progress is predicted to be similar to previous history*. The estimation formula for this assumption would be $EAC = BAC/CPI$.
 - Flawed estimating forecast—Used when past performance is not believed to represent future plans *and the existing future plans are not felt to be valid*. In this case, $EAC = (\text{Current actual costs}) + (A \text{ new estimate for all remaining work})$.
 - Poor startup—Used when current actual cost variances (CVs) are seen as atypical, but the project management team expectations are that *the remaining plan is valid* and similar variances will not occur in the future. In this case, $EAC = (\text{Current actual costs}) + (\text{Remaining planned work unit budget})$.
- Critical ratio estimate—Offers insights into the interaction of these two parameters. If both values are less than 1.0, this can indicate a more serious overrun than the standard EAC formula would indicate. Even if one of the parameters is significantly below 1.0 and the other is above 1.0, there might be reason to question the existing plan structure. More typically, both indices are less than 1.0 which means major issues with the current plan. From this view, a pessimistic estimate can be generated from the formula $EAC = BAC/(CPI * SPI)$.
- Estimate to complete (ETC)—A forecast cost estimate for the remaining period of the project from the status point. It is calculated as the difference between EAC and AC. Senior management and financial groups are the ones most often concerned about this number.
- Variance at completion (VAC)—Represents the difference between budget at completion (BAC) and estimate at completion (EAC). VAC represents the forecast variance compared to the baseline.
- Performance measurement baseline (PMB)—The sum of all PV work packages/units aggregated by time period for the total duration of the program. The PMB forms the time-phased budget plan against which project performance is measured. This curve is often called the S-shaped cost curve and may include a management reserve buffer. Be careful in interpreting the role of the reserve funds in project evaluation.
- TCPI—A computed parameter that provides an indication for how efficiently the project would have to operate from the status point to finish on budget. Values of 1.2 or higher typically mean that the project cannot recover. This parameter is a measure of the work remaining compared to remaining budget. No attempt will be made in the examples to interpret this term as research on this topic is still incomplete, but do recognize what it is suggesting.

Let us now go back to the initial example Gantt chart and illustrate the EV interpretation of these variables. It is worthwhile to visualize what the quantitative values represent. The EV input data and related status parameter results are summarized below:

Core EV status values explained earlier:

$BAC = 10 + 20 + 10 = 40$ (review Gantt chart for these values)

$PMB = BAC = 40$ (same value since no reserve is defined)

$PV = 30$

$EV = 20$

$AC = 35$ (see Table 15.3)

$CPI = 0.57$

$SPI = 0.67$

Derived forecast parameters:

$EAC = BAC/CPI = 40/0.57 = 70$ (projected completion forecast—basic option)

$VAC = EAC - BAC = 70 - 40 = 30$ (projected overrun)

$ETC = EAC - AC = 70 - 35 = 35$ (amount forecast to finish project)

$EAC(\text{time}) = 40/0.67 = 59.7$ (forecast schedule duration)

Note that the EAC (time) calculation violates the rule on percentile completion, but is shown here to demonstrate the mechanics.

Collectively this set of parameters outlines the current and forecast time and cost status of the project. There is a lot more in usage of the EV model in terms of user techniques, but this overview will offer a good starting point.

MSP mechanics

The next stage of the mechanics discussion involves converting a simple manual example into MSP and let the software take over the mechanical calculation details. With this step comes an important warning. *As is true with any reasonably complex software, if the user does not understand its internal assumptions the answers that are produced may be wrong.* This is certainly the case here. EV mechanics in MSP must be performed with more discipline than most other process to obtain arithmetic accuracy.

Assuming that proper discipline is followed, the good news is that most of the EV calculation complexity can be taken over by the software and the parameters are essentially created as a by-product of basic project status mechanics that have already been discussed. A second significant advantage offered by utilizing a software approach is the ease of repeating the process at each project status point. One of the early and maybe existing

reasons for not using EV was the perceived mechanical overhead related to this process. This part of the argument is now no longer valid, but the process discipline required to generate the underlying data remains an issue.

Garbage in—garbage out

There is a well-known adage regarding the use of computers in decision-making roles—*“To err is human, but to really screw up requires a computer.”* This point is very relevant in this section. MSP has many built-in default assumptions that may be used to generate task-level costs and therefore the resulting EV parameters. In some cases, these built-in assumptions may not be appropriate. The basics of this issue will be outlined here, but local usage may create even others. *Mishandling the driver data will result in EV parameters that are inaccurate for the defined role.* When the derived data do not represent what actually happens, confidence in the value of the tool is compromised. To mitigate this outcome, it is up to the PM to make sure that the correct data are used to produce the parameters. Simply generating an EV parameter and saying that it always means something is clearly erroneous. *Warning number two*—MSP is somewhat picky in the data input sequence leading up to producing EV parameters and it will require some practice to generate accurate values. The mechanics outlined here have been found to be the most manageable and accurate for normal situations, but care must be taken to not just retrieve values blindly without manual review.

MSP calculation steps

To generate an accurate set of core EV parameter values, it is critical to follow the sequence outlined below. Consider this list to be a checklist that should be followed in the order shown. The steps are as follows:

1. Be sure to produce a plan backup copy before starting this process.
2. The project plan should generate its internal work unit costs by allocating resources from the Resource Sheet into individual tasks. If planned costs are manually entered without linking them to work unit resources, default rules are used and are often not appropriate.
3. Explicitly define the EV calculation option. Go to [File/Options/Schedule] in the Calculations options section; uncheck box for *“Actual costs are always calculated by Project.”* This means that you are going to manage actual costs for each work unit in the plan—this simulates the accounting system delivering costs to the project. Second, review [File/Options/Advanced] EV section for measurement and baseline. The typical options here are %Complete and Baseline.
4. Make sure that the plan has a set baseline [Project/Set Baseline]—without this step, no EV parameters will be calculated.

5. Open up data fields for desired output items, that is, BCWS/PV, BCWP/EV, CPI, SPI, EAC, and so on. Recall the earlier note related to old versus new notation. If the new notation is preferred, the label titles can be edited by right clicking on the column and selecting *field settings*. The normal practice would be to create a periodic status set and develop trend values over the life cycle.
6. Set status date by [Project/Project Information]. Be sure to check the calendar year value carefully as projects often flow across year boundaries and it is easy to set the wrong year—without a valid status date, no EV parameters will be calculated.
7. Set a red gridline at status date by [Format/Gridlines/Gridlines/Status Date]—if this line does not show on the Gantt bar sheet at the defined status point, check the Project Information Status box for date error or gridline format color.
8. Use Gantt Chart Wizard to define the initial plan bar formatting—one useful wizard option is [Other/Baseline: Style 3].
9. From this starting format, use the standard bar format commands to add any other custom format features, that is [Format/Format/Bar formats ...].
10. Set actual durations for work accomplished task units and change any other future planned task durations as needed.
11. Set %Complete measurement values for tasks in the status range.
12. Open the Actual Cost field and input that data—this simulates data from the external accounting system.
13. EV driver data fields are Actual Cost, BCWP/EV, and BCWS/PV. EV parameters should now contain nonzero values. If no values appear, the most likely error sources are no baseline or status date set. Also, check location of the status gridline to confirm the status date is properly placed.
14. Project status interpretation can now be determined from the derived EV parameters. Note that the same parameters shown earlier for the Gantt example are now available, not only for the whole project, but all levels down to the lowest CAP.

Before moving forward into the next section, it would be worthwhile to review mechanics required for the MSP keystrokes. Also, if necessary review the ProjectNMotion website (ref Appendix F) tutorials for more theory and mechanics on this topic.

MSP example setup (checklist steps 1–3)

The Gantt chart example from Figure 15.4 will be used to illustrate the mechanical steps described above. To map the Gantt example into MSP, the only data item needed is the addition of a generic “Worker” with a

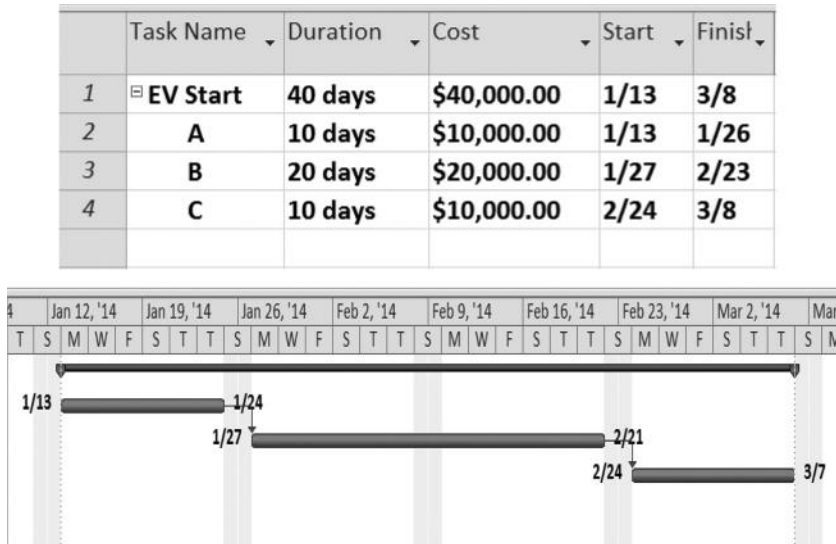


Figure 15.5 EV setup (steps 1–3).

standard rate of \$1000/day. That worker is defined in the Resource Sheet view and then allocated to each task to create the desired cost. This single resource and rate are designed to make the resulting task costing arithmetic easier to follow. All values shown in Figure 15.5 should now be matched as closely as possible to the earlier graphical Gantt model. Do note that the software has a more sophisticated calendar than the manual Gantt chart, so there is now additional reference to planned calendar dates based on the resource's work schedule. In this case, the project is defined to start on January 13 with a standard 5-day per week work schedule. Task duration is the number of work days shown and for the task with a cost of \$1000 for each day. Figure 15.5 shows the initial output split into two separate segments (table and Gantt bar views). This view essentially mirrors the earlier manual Gantt model.

Generating the EV parameters (steps 4–9)

This set of steps sets up the desired table format to make the desired EV parameters visible (Figure 15.6).

To generate this view, the following instructions were executed from the initial base plan view:

Step 4. Set project baseline—[Project/Set Baseline].

Step 5. Column formatting for selected EV parameters. Header titles were edited manually using the *Field Settings* option.

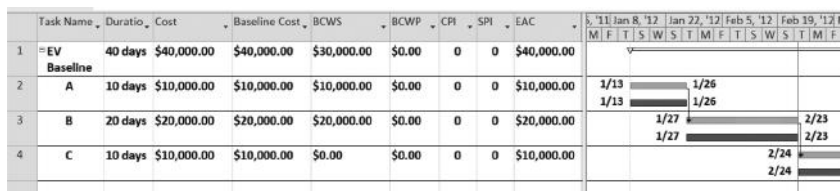


Figure 15.6 EV parameters (steps 4-9).

Step 6. Set status date to 2/22/2014 at [Project/Project Information].

Step 7. Display gridline at status date by [Format/Gridlines/Gridlines/Status Date]; enter line type (solid) and color (red). The vertical line should now appear at the defined status point. If it does not, you have made an error in either status date or gridline definition.

Steps 8 and 9. This is a cosmetic step to convert the default bars into a desired format. The recommended sequence for this is to first use the Gantt Chart Wizard to initiate the formatting process. This icon can be found in the Commands section. See the MSP checklist (Appendix D) for more details regarding how to make the wizard option visible on the menu ribbon panel.

Use the Gantt wizard option “Other/Baseline Style 3” for a starting bar format point. Then go to [Format/Format/Bar Styles] menu to finish any other item formats desired for the display, that is, dates, colors, bar sizes, and more.

Note that the Baseline column data field is now populated as a result of the “Set Baseline” command. However, no EV parameters yet have values. Remember, EV calculations are driven by measuring performance and we have not provided that data as yet. The following section will add the accomplishment data.

Measuring status with effort-driven logic (steps 9-13)

Steps 9-13 represent the highest EV calculation complexity area of the process. Resulting EV parameter values will vary depending upon how actual cost data and measurement values are generated. For example, in Option A, we will use the MSP default approach for producing actual task costs, which is called effort-driven. *Realize that this means the check box for letting MSP calculate actual cost is left checked (see [File/Options/Advanced]).* In Option B of this example, the box will be unchecked to show the impact that it has on the calculation. As subtle as this point is, this checkbox is a major key to get accurate EV values and also important to conceptually understand.

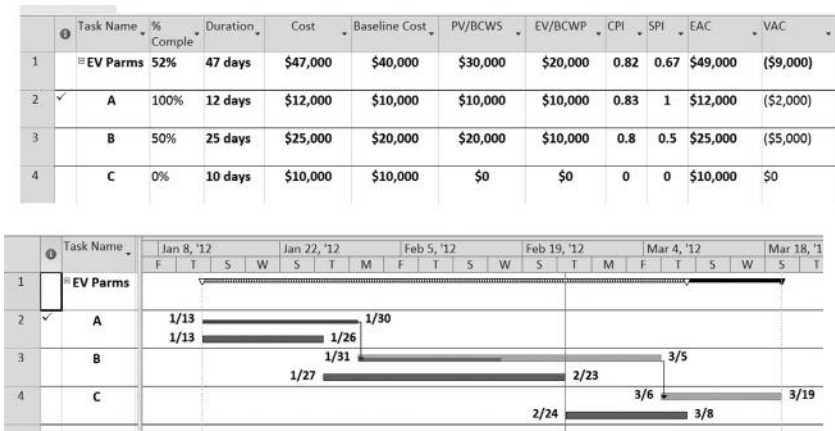


Figure 15.7 EV calculated parameters (Option A—effort-driven).

Note in the table data values shown in Figure 15.7 that both tasks are overrunning baseline planned time. As a result of the default MSP, effort-driven cost calculation assumption task costs are calculated as overrunning at the same rate as the duration. In this example, Task A overruns from 10 to 12 days and the projection for Task B is for it to overrun from 20 to 25 days. Both of these revised duration values are shown in the duration column. Note that the cost of each task overruns accordingly as per the effort-driven assumption. Second, %Complete values are added for Tasks A and B. These decisions generally mirror the original manual Gantt example. A revised table and Gantt bar result for this can be seen in Figure 15.7.

In comparing the previous manual Gantt bar example with Figure 15.7 (option A output), we note that the same values for SPI (0.67) are produced, but the computed value for CPI is significantly different at 0.82 compared with 0.57 from the original manual Gantt calculation. *This is the example you must remember!* Inspection of the table data shows where this difference is produced. MSP decided that the cost was \$37,000 and not the \$35,000 defined in the manual example. If the assumption that these tasks overran because the resources could not finish them on schedule, the \$37,000 might be a reasonable assumption, but if the actual resources utilized on the task was in fact \$35,000 but spread out over a longer duration this method creates an error. There are many similar reasons why generating duration cost with the effort-driven assumption is not valid, so the calculation rule should be to not let MSP calculate its task cost based simply on duration of the task. Therefore, the guideline is to always set the calculation option as described in checklist step 3.

Figure 15.7 clearly shows how the actual progress varies from the baseline. One analysis point to consider in this view is to decide if the early tasks

have overrun by 20% do we anticipate the rest of the project to suddenly start fitting the baseline plan durations? Research says that projects tend to develop a culture early in the cycle such that by this time the project has established its normal behavior for the rest of the life cycle. Once this issue is decided, it is time to either modify the rest of the plan accordingly or assume that it will go as planned from this point forward. If the same trend continues, one has to start dealing with how to forecast completion values. In any case, the current project plan should represent the latest views on both current and future status. As the project repeats this analysis through multiple status cycles, forecast value ranges will become more well defined.

It would be an instructive reader exercise to reproduce this example and manually follow it through to observe the software behavior as data values are added. This will provide more insights than seeing the static view shown here. It would even be instructive to change some of these sequence steps and see what happens to the calculated values.

Option B. EV status with manual entry of AC (steps 9–13)

Option B follows the same calculation path as Option A; however, in this case, specific control of actual costs values used are external to MSP defaults. This means that the “MS Project will Calculate Actual Costs” box is unchecked. Note in Table 15.8 the actual cost is now shown as \$35,000, as does the task cost for units A and B (these were manually entered with the desired values). As a result, the original manual values for CPI and SPI are accurately calculated. *Note: Compare the EV calculation values shown in options A and B to see the significance of the step 3 checkbox and its impact on the output values (Figure 15.8).*

Figure 15.9 summarizes the basic EV parameter set for option B. At this point, all of the column headings and data meanings should be understood.

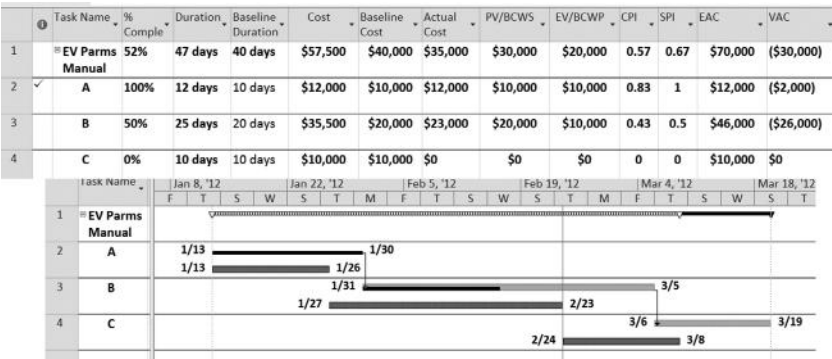


Figure 15.8 EV calculated parameters (manual actual costs entered).

	①	Task Name	Baseline Cost	PV/BCWS	EV/BCWP	CPI	SPI	EAC	VAC
1		EV Params Manual	\$40,000	\$30,000	\$20,000	0.57	0.67	\$70,000	(\$30,000)
2	✓	A	\$10,000	\$10,000	\$10,000	0.83	1	\$12,000	(\$2,000)
3		B	\$20,000	\$20,000	\$10,000	0.43	0.5	\$46,000	(\$26,000)
4		C	\$10,000	\$0	\$0	0	0	\$10,000	\$0

Figure 15.9 Final EV table values.

Final EV parameters (step 14)

The final step in this example process is to interpret the various derived status parameters. Option B has accurately recreated the manual output originally shown for the manual Gantt example. More importantly, the required set of steps to produce that answer has been shown. This same set of steps will produce EV parameter output for any project plan with minimal additional data entry.

There are two EV parameters that are not native to MSP. That is, ETC and EAC (time) parameters are not automatically calculated by the software. ETC can be easily produced by creating a custom formula to show the difference in EAC and AC; however, a forecast time estimate remains undefined in the software as it should be based on the calculation characteristics of the SPI parameter model.

Using a spreadsheet plan to calculate EV parameters

Industry data suggest that many project plans are created using traditional spreadsheets. One typical argument from this segment is that EV will not work for that model. This example will show that the same mechanics will work, but admittedly with a higher-level status view. The spreadsheet shown in Figure 15.10 illustrates a summary level project plan that could actually be extracted from MSP or just created at that level without going through higher-level software. The key with all EV calculations is to follow the basic steps outlined.

Note that the major spreadsheet project plan segments are scheduled into monthly time boxes. This example can be extracted from the publisher website as Chapter 15.

The first setup step required is to map this data format into the EV model. Note that the plan structure shows PV by summary activity level and month grouping (January through December). The solid vertical line at the end of May signifies that to be the status point for this evaluation.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	PV	% Comp.	EV
2	Plan and staff project	4,000	4,000											8,000	100	8,000
3	Analyze requirements		6,000	6,000										12,000	100	12,000
4	Develop ERDs			4,000	4,000									8,000	100	8,000
5	Design database tables				6,000	4,000								10,000	100	10,000
6	Design forms, reports, and queries					8,000	4,000							8,000	50	4,000
7	Construct working prototype						10,000							10,000	-	-
8	Test/evaluate prototype						2,000	6,000						8,000	-	-
9	Incorporate user feedback							4,000	6,000	4,000				14,000	-	-
10	Test system								4,000	4,000	2,000			10,000	-	-
11	Document system										3,000	1,000		4,000	-	-
12	Train users											4,000	4,000	-	-	-
13	Monthly Planned Value (PV)	4,000	10,000	10,000	10,000	12,000	16,000	10,000	6,000	8,000	4,000	5,000	5,000	100,000		42,000

Figure 15.10 Excel spreadsheet for producing aggregate EV parameters.

Column “N” contains the cumulative PV data for each work unit. This is calculated as a row total. Column “O” contains %Complete measurements for active work elements up to the status point. So, the product of columns “N” and “O” computes a value of EV for each active work unit. From these data sources, it is possible to derive the project values for PV (\$46,000) and EV (\$42,000).

A good conceptual question to ask at this point is “what additional data is now needed” to produce the core EV parameters? If you remember the AEP magic box structure, we need actual costs to complete the required data. Let us assume that the aggregate AC value is \$53,000 as delivered from the accounting system. Using these data values, we can define the values for CPI, SPI, BAC, EAC, and VAC. All required elements are available in the spreadsheet cells if you know where to look. The answers appear below, but try these calculations on your own before you read on.

Let us now expand this table view to show the rest of the story. Figure 15.11 contains the full data view and resulting EV parameters.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	PV	% Comp.	EV
13	Monthly Planned Value (PV)	4,000	10,000	10,000	10,000	12,000	16,000	10,000	6,000	8,000	4,000	5,000	5,000	100,000		42,000
14	Cumulative Planned Value (PV)	4,000	14,000	24,000	34,000	46,000	62,000	72,000	78,000	86,000	90,000	95,000	100,000			
15	Monthly Actual Cost (AC)	4,000	11,000	11,000	12,000	15,000										
16	Cumulative Actual Cost (AC)	4,000	15,000	26,000	38,000	53,000										
17	Monthly Earned Value (EV)	4,000	10,000	10,000	10,000	10,000										
18	Cumulative Earned Value (EV)	4,000	14,000	24,000	34,000	44,000										
19	Project EV as of May 31	44,000														
20	Project PV as of May 31	42,000														
21	Project AC as of May 31	\$ 53,000														
22	CV=EV-AC	\$ (9,000)														
23	SV=EV-PV	\$ 2,000														
24	CPI=EV/PV	83%														
25	SPI=EV/PV	105%														
26	Estimate at Completion (EAC)	\$ 120,455	(original plan of \$100,000 divided by CPI of 83%)													
27	Estimated time to complete	11.45	(original plan of 12 months divided by SPI of 98%)													
28																

Figure 15.11 EV spreadsheet data expanded.

This spreadsheet format illustrates how the various EV data items can be captured in a different format and then used to provide at least a high-level status view. In some situations, this approach is easier to manage and a preferred starting option to get familiar with the data issues. Review this format until you are comfortable that all of the core parameters are either shown or could be developed from this set of data. With Excel's graphing capabilities, it is also possible to use this same data source to create a visual view of the status. One major disadvantage of this high-level approach is loss of a task-level view in evaluating individual work unit performance; however, recognize that this is still a worthwhile starting approach for any project. Also, if status values were saved at each monthly status point, it is possible to create various time-oriented trend views, which add visual insights into whether the project is improving or declining.

EV earning rules

Previous examples have used the term “%Complete” to represent work accomplished and this value then drives the EV calculation. This is the most controversial and problematic variable in the EV model. Recall that the design goal is to measure what has been accomplished and experience suggests that individuals are not always accurate in creating this measure.

There are several considerations that impact the appropriate selection of a measurement approach. A few operational rules to consider when making this selection are summarized below:

Work package size—A general rule of thumb for a work package size is “2/80,” meaning that it will be sized in the general range of 2 weeks elapsed time and 80 hours of associated work effort. Other values can be used as local guidelines but it is important to keep the size moderate since large work packages can hide overruns.

LOE—This class of work package can cloud the project status analysis since related resource charges are independent of accomplishment.

Productivity studies should be done without these included in the mix.

Material costs—As with level of effort, material costs can hide labor productivity and variance trends. If material costs represent a significant percentage of the total work unit cost, then it should be extracted from the analysis of team performance.

Work unit accomplishment rules—There are several options for recording work package accomplishment. The list below summarizes the implications of the most used measurement techniques.

- 50/50—This rule gives a 50% credit once the work package is started and the last 50% is withheld until the unit is completed.
- 0/100—This rule penalizes work in progress since no credit is given until the unit is completed.

Table 15.4 Measurement Option Pros and Cons

Approach	Pro	Con
%Complete	Easy to implement; fits calculation model	Human bias can affect accuracy; subjective
Units produced	Accurate measurement	May not be granular enough
Weighted milestones	Visible measure	May create inaccurate measure, that is, 0/100 granularity
Apportioned	Typical for support	Does not measure accomplishment
LOE	Work unit often is support-oriented and hard to link to direct output	Another method should be used

- Percentage of work completed—This is the most accurate mathematical calculation of accomplishment if one can make the assumption that the measurement can be done accurately and honestly.
- Level of effort—This class of resource charge is normally either allocated to the work package as defined in the support agreements or as billed to the project based on actual charges. In the former option, the work unit should be taken out of the mix for performance measurement purposes.

Other techniques that may be appropriate to consider are:

- Internal work unit milestones—key events within the work unit.
- Weighted milestones—allocating completion credit for various key events.
- Units complete—if the work unit produces physical items, measurement of these could be used for %Completion. As an example, drawings completed in the work unit could be counted as a measurement unit.

Pros and cons for the major measurement options are summarized in Table 15.4.

As one can see from the pros and cons listing, each method has both advantages and disadvantages. The goal is to select the method that best measures work accomplishment. This selection should be documented as part of the project control management plan.

Labor efficiency and rate analysis

Stratton (2007) suggests that EVM for labor-intensive projects should also include analysis of labor related to the work activities. The relationships

shown below can be used for such analysis and can help reveal additional insights into project performance.

CVs can be broken down into two components to compute rate and use variances—also known as efficiency (Shulte 2005). The bid and rate variance formulas are as follows:

Bid rate = EV Cumulative Hours/EV Cumulative Dollars
Actual rate = AC Cumulative Hours/AC Cumulative Dollars
Rate variance = (Bid rate – Actual rate) × AC (cumulative hours)
Use variance = (EV hours – AC hours) × Bid rate
CV = Rate Variance + Use Variance

Table 15.5 shows example hours and cost data for a WBS element at a specific point in time. The earned and actual hours support rate and use variance calculations as illustrated.

Recall that a negative CV indicates that work is more expensive than planned. Calculation of a labor CV provides an additional view as to the separation of this value into two components: labor rate and productivity variances. The process outlined below shows how the estimated labor rate versus actual rate variance can affect the overall CV value and result in a quite different interpretation for that factor. Think of a bid rate as the initially planned resource rate, either for internal or external labor. Using the sample data in the example above, a labor rate analysis can be calculated as follows:

Bid rate = (\$75,480/680 h) = \$111.00/h
Actual rate = (\$90,000/960 h) = \$93.75/h (actual rate is cheaper than bid)
Rate variance = (111.00 – 93.75) × 960 = \$16,560
Use variance = (680 – 960) × 111.00 = –\$31,080
CV = \$16,560 – \$31,080 = –\$14,520

From these calculations, we see that the labor rate (rate variance) is cheaper (positive) than originally estimated (111.00 – 93.75) and the productivity (use variance) is below PV (negative). So, about half of the aggregate CV value is related to productivity loss and half is gained back by a favorable lower labor rate. The actual labor rate values are less than forecast, so this has a positive impact on CV status variables. However, the opposite can also be true. In some situations, we might find a perfect

Table 15.5 Example Work Unit Labor Data

	Earned value (EV)	Actual cost (AC)	Cost variance (CV)
Cumulative hours (h)	680	960	–280
Cumulative \$	\$75,480	\$90,000	–\$14,520

work forecast indicating a negative variance when in fact the only issue causing this is the charge rate of the resources. Recognition of the rate and use factors variance calculations are important to review. Also, this type of analysis can help isolate resource issues and root cause factors. Understanding the interrelationship of this type of data can support an interesting conversation with resource providers.

In addition to examining the rate and use variances for a single period, trend charts can be used to examine how the parameters change over time at various stages of the project, by work unit, or organizational skill group.

Earned schedule

Walt Lipke, who is one of the outstanding pioneering conceptual thinkers in the field of project management, has derived an insightful contemporary model to evaluate project schedule status. This technique is labeled earned schedule (ES) and it is a time-based view of EV (Lipke 2009). ES is now being broadly accepted in the industry and the only operational complexity with its conversion to a simple formula; however, there are MSP add-ins available to assist in this calculation. The concept is much easier to visualize in graphical form rather than to try to understand it algebraically, so that is the way it will be described here. The interested reader should pursue some of the Lipke sources outlined in the chapter additional reference section for more details on this topic.

Recall the earlier statement that the SPI parameter formula will fail as a forecasting parameter around the 70th percentile point in the project life cycle based on its formula definitional structure. ES offers a general method to overcome this shortcoming and will work all through the life cycle. It is simply defined by reviewing the project's performance measurement baseline (PMB) S-shaped curve and evaluating the EV at a particular status point, then comparing a point on the PMB for that ES value. As Mr Lipke says *"The idea is to determine the time at which the EV accrued should have occurred."*

The graphic in Figure 15.12 provides a very easy-to-understand explanation of the ES concept. Graphically, ES is determined by projecting current EV status horizontally to the equivalent PMB baseline curve. For this example, the project status point is period 7. The current schedule performance gap can be determined by moving from the current EV value at period 7 and evaluate at what time period the PMB/PV has that same value. The horizontal line labeled C connects these two points. Moving horizontally from the EV curve along line C intersects the PMB curve at time period 3. This indicates that the current planned EV should have been reached at time period 3 rather than 7. So, the project has a current time variance of 4 time units (7-3) and an ES value of 3. Both these values should be obvious from the schematic.

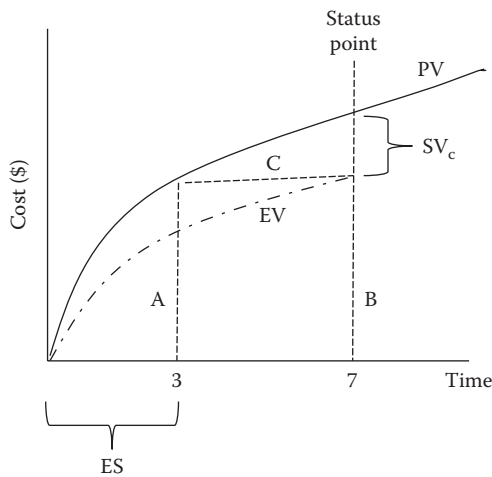


Figure 15.12 ES schematic.

Figure 15.10 also graphically shows two methods for defining schedule variance. The traditional EV cost-based view is labeled SV_c as the gap between the PV and EV curves, while the newer ES time-based view is represented by the ES value on the X-axis. During project execution, both measures should be evaluated and tracked as a check and balance review.

EV work unit component interpretation

This chapter has highlighted the analytical value of EV and the topics covered are accurate if the user understands what the internal components represent. However, failure to understand the internal work package resource characteristics in this analysis can lead to erroneous use of the parameters. For instance, labor resource performance provides insights into team productivity, while material and dollar expense components do not. Let us illustrate this point with the following hypothetical data for a single work unit:

	AC	EV	Baseline
Labor	2400	1000	2000
Material	1500	1000	2000
\$	1200	1000	2000
Total	5100	3000	6000

Assume that this work unit is evaluated at 50% complete. The respective component EV parameter calculations are shown in the table values.

For this example, we will show what happens when we look at each resource separately and compare that to the traditional total work unit value. The calculations are as follows:

$$\text{CPI (Total)} = \text{EV/AC} = 3000/5100 = 0.59$$

$$\text{CPI (Labor)} = 1000/2400 = 0.42$$

$$\text{CPI (Material)} = 1000/1500 = 0.67$$

$$\text{CPI (\$)} = 1000/1200 = 0.83$$

Each of the internal items indicates a different cost performance status for that specific segment. Reviewing each individually gives a measure of performance for that component. However, if the goal is to forecast the EAC for a project, is it correct to say that the proper formula would be BAC/CPI (Total) , or $6000/0.59 = \$10,169$. In other words, is it anticipated that the CVs for material and dollars will remain the same for the rest of the project? If so, this might be an accurate forecast. Certainly, there is no reason to suggest this, so a better way to look at forecasting the future project budget is to consider each variance independently. Using this logic, the labor portion would be estimated as $6000/0.42 = \$14,286$ and the same logic could be used for forecasting material and dollar costs. The key point in this decomposition approach is that project work performance is dictated independently by the labor component. Depending upon how the trends are anticipated for material and dollar expenses, a quite variable result could occur. When forecasting the future project cost and outcomes, it is necessary to evaluate the impact of these differences before blindly using the EV total parameters and assuming the group average is relevant. The initial EAC formula discussion described multiple ways of forecasting EAC and these concepts are also relevant to this discussion as well. For this example, the assumption is made that the various component trends will continue through the life cycle as these parameters indicate. Given this assumption, a combined EAC calculation would be developed as follows:

$$\text{EAC (Total)} = \$14,286 (\text{labor}) + 1000/0.67 (\text{matl}) + 1000/0.83 (\$) = \$19,681$$

Note that this forecast is nearly double the original forecast using a single bundled view. This simply highlights the sensitivity regarding what the forecast assumption can do to the resulting estimate if one does not understand the implications of the various resource types.

Included below are a few resource rules to consider in using EV for team productivity analysis or outcome forecasting:

- Material variances do not impact either team performance or labor forecasting. These should be reviewed as to the consideration of how to interpret material forecasting outcomes.

- Dollar resource category has the same interpretation as material regarding team productivity and outcome forecasting.
- LOE and recurring activities are typically fixed allocations in regard to %Complete and possibly actual cost allocation. These typically should be removed from team analysis and forecasting parameters if these resource allocations are of significant size.
- Contractual labor charges should be reviewed for proper allocation in team productivity or outcome forecasting activities.
- Task padding clouds both the team productivity and EAC forecasting calculation as described in this chapter.

Once the various resource groups are segregated, decisions related to how each group should be manipulated follow the guidelines outlined earlier. The key aspect of this decision is to evaluate likelihood that the current trends will continue. If so, the standard formulas can be used to evaluate current status and forecast future outcome. If not, other choices would be more appropriate. From a data viewpoint, recognize that MSP does not easily extract the resource groups into the categories supporting this discussion. It is left for the reader to evaluate a specific situation and decide on the best analytical techniques for that scenario.

Project operational data repository

Management artifacts created in projects consist mostly of paper files or fragmented computer-based files. These include various items related to schedule, budget, design documents, human resources, vendor items, status reports, and a host of other support materials. In more recent times, computer-based document management software has emerged as a viable media to house what would be defined as multimedia-type class of material. Also, database technology is replacing fragmented file views. The PM needs to understand both the present and future values related to the ability to efficiently retrieve selected project data. On the basis of this premise, the concept of a common data repository becomes a very important project management support tool. That requirement is even more important when dealing with the need for detailed granularity of data analysis as described here.

A flexible method, for manipulating work package data elements, is needed in order to facilitate a more in-depth analytical approach to EV-based parameter calculation. In the ideal case, this repository would be a formal database or document management tool which could be accessed in various flexible ways, but regardless of approach work package level planning and status data is useful throughout the life cycle. This section has illustrated some of the key data elements that outline what such a capability can yield for monitoring and control activities.

The initial view of project data evolves from work package level estimates developed in the planning phase. This is heavily oriented toward the scope definition process related to the WBS and its companion dictionary data. In many ways, a formalized WBS Dictionary could inherit much of the data storage role described here.

Basically, the structure of project data falls into two broad categories: planning and execution/control. Planning data evolve from the processes leading up to the approved baseline, while the latter subset deals with actual performance status tracking of those work units. Much of the data element definition links are achieved using the WBS ID as a common reference code. In some cases, it makes sense to capture collections of data through time under higher-level aggregate names such as status report, lessons learned, designs, and so on. For our focus here, we are looking primarily at operational analysis support, but the role for a formal data repository is broader than that. Data are most useful when it can be easily retrievable, manipulated, and distributed. As a project team becomes distributed geographically, the communication process increases in complexity. If one believes in the value of having such data, a project repository should be an organizational goal and not one pursued by a single project. In this environment, each project would just utilize the common repository and not have to deal with its design or operational support.

Data definitions

The specific data definitions outlined in this section are primarily oriented toward planning and control aspects, but recognize that this concept should be expanded into other project management analysis and communication areas as well.

Table 15.6 summarizes a sample core set of planning data that is required to support a reasonable level of EV creation and analysis. There is one other subtle but important point outlined in the table. Note the column labeled “MSP.” This implies that the associated data element contained within the MSP data environment is therefore capable of exporting that data for other uses. Recognize that much of the value of project data lies external to the PM software and using its data for broader management provides a wealth of analytical and communication information. The evolving Enterprise level architecture for MSP has recognized this concept and it is moving in the general direction outlined here.

Regardless of the underlying project management methodology, the data types described here should be similar. This also means that this is common for the planning role, even though various local needs may supplement this view. Strategies regarding how to collect, store, and distribute project data and information are beyond the scope of this chapter but failure to recognize the value of a formal project data management

Table 15.6 Project Data Repository (Planning Work Units)

MSP	Work unit	
	Item	Comment
*****	WBS ID	
	Baseline parameters	
*****	Short name	
*****	Type	WP or CAP, summary, PP or CAP
*****	Duration	Baseline plan
	PV /T(E)	Direct work
	Work rate est.	Estimated labor rate for work unit
	Optimistic (a)	Direct work
	Most likely (m)	Direct work
	Pessimistic (b)	Direct work
*****	PV	Material cost
	PV	Other
	PV OH allocated	OH defined at work unit level
*****	PV total	Sum of PVs
*****	Start	Planned
*****	Finish	Planned

Note: ***** indicates that this is an existing defined MSP data variable.

strategy would be a major shortcoming in our description of a best practices environment. Use the table description as a starting point to examine this idea.

Logic for the data granularity level shown here is to not only produce aggregate EV parameters, but also to eventually drill down to a sufficient detail level to support identification of root-cause variance issues. The inability to manipulate project data and sort out task-level issues such as overhead allocation, material, labor rates, and LOE can hide the underlying variance root issues. Experience is gained with an analysis repository such as this, more data detail could be added as it was found useful. There is a management adage that says “you can’t control what you have not defined.” So, the remaining question is “what else needs to be analyzed for control purposes?”

As the project moves into execution, details related to actual status begin to emerge. The typical control model compares actual performance to the corresponding baseline values. Our database design issue then is to define what actuals are needed to perform the desired status reporting and analysis. As we have seen in previous examples, EV parameters can be created from internal MSP data, but even more robust analysis versions of these parameters could be generated from a flexible database containing the same raw data. With this thought in mind, Table 15.7 defines a more

Table 15.7 Project Data Repository (Execution/Control Work Units)

MSP	Item	Comment
Current status		
*****	%Completion	Current status measurement
*****	Current plan start	
*****	Current plan finish	
*****	Actual duration	
	Actual cost direct \$	"if CAP"
	Actual cost material	"if CAP"
	Actual cost other	"if CAP"
*****	Actual cost total	"if CAP"
*****	Actual start	
*****	Actual finish	
	EV direct labor	
	EV material	
	EV other	(LOE and other)
*****	EV total	Combined view
Other possible data item categories		
	HR staffing	Quantities by skill type
	Risk contingency	References to risk register

analytical view of this data. This level of granularity is designed to support manipulating selected items for more detailed analysis. This capability represents the core value of such a data store over the more fixed views embedded in the PM software.

A major ingredient of project management is structure and organization. That view has been reflected in much of the discussion throughout this chapter. Think of a project data repository as embodying this idea. In most organizations, cost and resource data are likely kept in central systems. However, the format of that data may not fit the analytical needs described here, so some extraction from those source may be justified to fit the project needs. One philosophical view of the project repository is the "one place to search for the truth." In any case, it is envisioned as the one place for project stakeholders to access data about the project.

Summary

EV analysis is based on previous project performance trends that are developed by comparing current actual project accomplishments to the approved baseline. To accurately evaluate project performance, the PM must understand not only what created the past variances, but also his assumptions

regarding what will drive future predictions and challenges. One objective of EV is to assist in the process of understanding project quantitative variances; however, strictly focusing on past performance does not yield a complete picture. The EV model defines key data elements needed to evaluate aggregate project performance, but more granularity of these evaluation parameters is often needed for detailed root-cause analysis. In addition to the historical evaluation role, derived EV status parameters can be used to create completion forecasts. A third phase of this discussion illustrated how to use work unit data for analyzing rate and work efficiency.

By utilizing this suite of status evaluation techniques, the PM is provided with very sophisticated tools for use in examining project performance. Collectively, these methods contain some of the most sophisticated quantification analysis available for status reporting, evaluating work unit progress, and identifying variance sources. The ability to isolate specific casual issues for performance variance is a fundamental success criterion for the PM. Through the identification of work unit time and CV, the project team can better identify how to influence the project back toward its baseline direction.

The examples used here are simple in order to focus on the underlying mechanics of the processes. Obviously larger projects would create additional data manipulation and interpretation complexity for this process.

We will leave the review of this topic with these key summary learning objective review points:

- The EV “magic box” is a good way to structure EV core driver data into a simple format that easily leads to the core parameter formulas.
- MSP is capable of producing numerical EV data as a by-product of its basic status tracking, but one must be very careful about the process steps used in order to achieve accuracy of the derived results because of the software tool internal calculation rules. Also, be aware of how the parameters are created and use them appropriately.
- The MSP EV checklist supplied in this chapter should be used in executing the EV calculation process.
- A spreadsheet summary level plan can also be used as a high-level method to generate summary task-level EV parameters. This is a reasonable method to use for initial testing of the concept since the data values used can be more easily controlled.
- Exercise care in using CPI and SPI parameters for cost and time forecasting. The appropriate method depends upon assumptions about the future work compared to the past. A standard CPI formula-based forecast is only valid if it is assumed that the future will progress the same as the past. Also, note other possible assumptions provided in the chapter.

- The standard SPI formula is *invalid* as a time status predictor after around the 70th percentile of the life cycle. Use only the ES formula after this point and always compare the standard SPI value with ES for consistency. Monitor trends in this forecast category for further validation.
- At 20% through the project execution life cycle, the CPI will normally not change more than 10% (Christensen 1998).
- When a project falls behind baseline plan by 15%, it will not recover. TCPI parameter values above 1.15 indicate a low probability of budget recovery.
- Organizations with higher process maturity can deal with the EV process cheaper than those with lower maturity because of their existing support processes.
- If a project has significant material costs embedded in the work structure, those cost components should be separated for evaluating team productivity and completion forecasts. Also, realize that LOE, labor rates, and overhead elements may distort EV parameters.
- Review labor data for rate and efficiency variations. The rate variance is often outside the PM's control and needs to be assessed as to its impact on the CPI calculation.

QUESTIONS

Review questions

1. If current project actual cost expenditure is less than the baseline plan at the status point, can we assume the project is doing well? Why or why not?
2. After reviewing the material in this chapter why do you feel it took so long for the EV concept to catch on in general project management practice?
3. What are the key driver variables for EV? Draw the EV "magic box" and show how this leads to the core formulas.
4. Is EV calculated from Work Package or Cost Account data?
5. If CPI is 0.5, what is your expectation for future project performance? Why might this not be the case?
6. If SPI is 0.9 at the 80th percentile stage of the project can you assume that this project will finish within 10% of its baseline schedule? Why or why not?
7. What does the ES model add to the EV parameter analysis set?
8. What is the role of the critical ratio (CR)?
9. List the key steps necessary for using MSP to generate reasonably accurate EV parameters.
10. What is the 20% rule?
11. What is the major EV issue with %Completion?

- 12. Where can rate and use variance help?
- 13. Assuming that you have accurate raw data why might an EAC forecast be wrong even if it is assumed that the project will continue as it has?

In-class questions

- 1. This simple Gantt chart plan contains three activities. PVs for each activity are shown in bold font on each bar. Task completion estimates are shown as a percentage and time period two is the status point. The accounting system has collected actual costs for the three activities as 6, 12, and 6, respectively. Compute the EV parameters for this model. What is your prediction for cost and time completion of this project (ignoring the SPI formula flaw)? (Figures 15.13 and 15.14).
- 2. EV Dog Pen Exercise. Assume that you are the PM for the Dog Pen project. The goal is to build a four-sided dog pen. Each side is budgeted to cost \$200 to complete and require 1 day of your time. As the project progresses the following results are recorded:
Day 1: Side A completed; spent \$200
Day 2: Side B completed; spent \$240

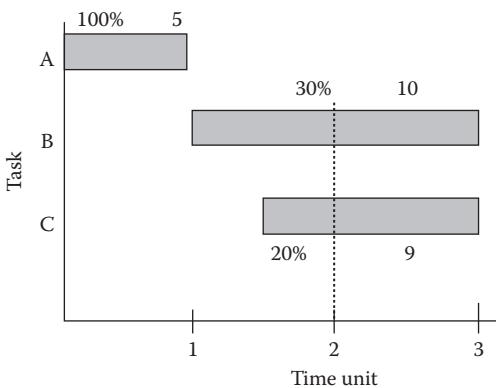


Figure 15.13 Gantt chart problem.

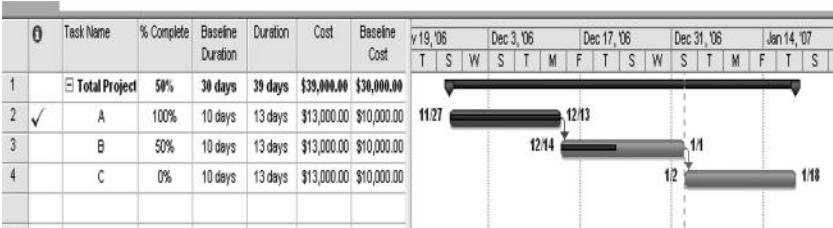


Figure 15.14 MSP baseline problem.

Day 3: Side C 50% completed; spent \$120

Day 4: Side D not started; spent \$0

- a. By inspection and without resorting to EV formulas what is our perception regarding the general status of this project? Estimate cost and schedule percent completion by inspection of the raw data?
 - b. Calculate the following EV parameters and compare your answer with part A:
PV =
EV =
AC =
BAC =
CV =
SV =
EAC =
ETC =
 - c. Use your knowledge of EV to interpret the status of this project.
3. What are the essential steps in producing valid EV parameters using MSP?
 4. If a project is approaching the 70th percentile point what method should be used to evaluate schedule status.
 5. Name three task cost element types that can distort a project team efficiency analysis.
 6. One of the more common methods to compute EV parameters is through the use of a spreadsheet. Create a 12-month spreadsheet summary level plan with planned cost for each month (a sample data set can be see in Table 15.4). From this base, add the following data parameters:
 - a. Set the status date at the end of month 6
 - b. Provide %Completion values for all active groups
 - c. Add actual cost information for each monthUsing your EV knowledge, answer the following questions.
 - a. Translate this table data into core EV status parameters.
 - b. What is the condition of the project based on these metrics?
 - c. What is the estimated cost and schedule at completion?
 - d. Use the Excel trend graphing utility described in Chapter 14 and create a trend chart for CPI and SPI (make up the data for the chart).

EXERCISE

Using the familiar car problem, extract file *15 Car Project Start* from the publisher's website (Appendix F). This file contains an MSP baseline plan. Use the current %Complete and Duration status information shown in Table 15.8 to update the project status. From the results generated by MSP, answer the EV-related questions outlined below.

Table 15.8 Car Problem Status

Task name	% Complete	Duration (days)
15 Car problem first cut	39	283
Planning and project initiation	88	70
Charter	67	15
Stakeholders identification	50	10
Scope definition	100	15
Schedule development	100	15
Risk assessment	100	5
Budget definition	100	15
Management charter approval	100	5
Set baseline	100	5
Engineering	40	147.5
Body/engine draft design	100	22.5
Initial draft	100	17.5
Integration analysis	100	5
Mechanical engineering	87	124
Engine design	100	104.5
Mechanics design	65	60
Electrical engineering	0	77.5

CAR PROBLEM STATUS QUESTIONS

- How is this project doing in regard to planned cost and time?
- What is the projected duration overrun?
- What is the EV predicted cost overrun at completion?
- Why are the values of SPI and CPI the same? Do you see a potential flaw in this calculation?
- What is the MSP predicted date of completion and how does this compare to what you would estimate from the EV EAC calculation. What would cause this difference?

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chapter sixteen

Project tracking status

Introduction

PMI (2008) states that 90% of a PM's time should be spent on of internal and external communications. Communications management is a model process outlining how PMs should manage the communications related to a project. Project status tracking and reporting processes should be defined at the start of any project as part of the communications plan, which describes the information needs of the stakeholders and the project team. This overall plan should cover who needs to what, when they need to know it, and how the information should be received. There are many ways of reporting weekly and monthly status of a project (i.e., Microsoft Project 2010, Excel, Visio, email, and/or your imagination). This chapter will cover useful project status reporting techniques that can be utilized for tracking progress.

Status reports

Status reports are snapshots of the project's progress made since the last reporting period, which covers the schedule status, what was completed during the period, task completion dates, progress expected for the next reporting period, risks, and issues. One of the major reasons for having periodic status meetings is to provide a forum for stakeholders and the project team to discuss issues and resolutions to implement with the least negative impact to the project. The later sections of this chapter will highlight examples of status reports.

Issue log

Issues will crop up which will need to be researched and resolved. The PM needs to be sure that the appropriate team members understand these issues and identify who is responsible for their resolution. Table 16.1 displays an example of an issue log. The format of this table could also be used for tracking problems and questions.

Project plan communications

Before commencing project status tracking, a project plan has to be generated and approved, which consists of a WBS, discussed previously in the

Table 16.2 DR Test Project Plan

% Complete	Task name	Predecessor	Duration	Start	Finish	Resource names	Cost (\$)
100%	GSI Group SAN to SAN SAP DR test		148 days	12/31/10	7/25/11		3015.00
100%	Project start-up		127 days	12/31/10	6/24/11		750.00
100%	DR instance verification		5 days	7/4/11	7/11/11		920.00
100%	Test start-up (8 AM PDT)		4 days	7/11/11	7/14/11		970.00
100%	Open <i>sumtime group chat</i> if any issues		0 days	7/11/11	7/11/11	Pawan	0.00
100%	Confirm the beginning of SAP DR with email to the IBM team/GSI Group client		0 days	7/11/11	7/11/11	Pawan	0.00
100%	Activate PEM suppression for DR instance—Starts 8:00 AM PDT	16	30 min	7/11/11	7/11/11	James	25.00
100%	Take drive layout screenshot for all the drives	17	30 min	7/11/11	7/11/11	Prasanna	15.00
100%	Disable all communication from QA to PRD data center	18	30 min	7/11/11	7/11/11	CJ	15.00
100%	Bring the QA applications down and set services start to Manual (Shutdown Prod Systems)	19	60 min	7/11/11	7/11/11	Dhaliwal James	30.00
100%	Unmap all existing drives other than E: and I: drives. The E: drive has the SQL system database files and is needed for SQL and the I: drive has Temp DB	20	45 min	7/11/11	7/11/11	Prasanna	20.00
100%	Present the DR LUNs to the QA systems	21	30 min	7/11/11	7/11/11	Mukesh, Rakesh	15.00
100%	Redo the Drive Letter and map the LUNs to the drives	22	60 min	7/11/11	7/11/11	Prasanna	30.00

continued

Table 16.2 (continued) DR Test Project Plan

% Complete	Task name	Predecessor	Duration	Start	Finish	Resource names	Cost (\$)
100%	Rename the hosts file in C:\	23	30 min	7/11/11	7/11/11	James, Prasanna	15.00
100%	Open SQL studio and attach the DB PE1	24	90 min	7/11/11	7/11/11	James	45.00
100%	Validate the PRD host names are pointing to QA	25	15 min	7/11/11	7/11/11	James	10.00
100%	Start the PRD systems on the DR(QA) servers	26	30 min	7/11/11	7/11/11	James	15.00
100%	Notify that the client server is ready for login with an email to the team	27	0 days	7/11/11	7/11/11	James	0.00
100%	Client verifies the data that is within RPO	28	30 min	7/11/11	7/11/11	Client	15.00
100%	Client performs DR testing	29	3 days	7/11/11	7/14/11	Client	720.00
100%	Confirm test completion		0 days	7/14/11	7/14/11	Client	0.00
100%	Test results	14	1 day	7/15/11	7/15/11		150.00
100%	Test recovered systems for operation	31	60 min	7/15/11	7/15/11	James	30.00
100%	Define the corrective action for DR procedures		60 min	7/15/11	7/15/11	James	30.00
100%	Document DR metrics defined in the DR recovery plan		60 min	7/15/11	7/15/11	James	30.00
100%	Define the areas of improvement for future tests		60 min	7/15/11	7/15/11	Pawan, James	30.00
100%	Create a test success statement		60 min	7/15/11	7/15/11	Pawan, James	30.00
100%	Test close-out		7 days	7/15/11	7/25/11		225.00

Project statistics and baselining

Project statistics provide high-level overviews of the project status. This includes the various cost and schedule information as well as other defined KPI values. To open a snapshot of the project’s plan time and cost status, choose Project/Properties/–Project Information and Statistics. In Figure 16.1, the dialog box shows NA and 0d for the baseline fields because the baseline was not set yet. Also, the other fields such as start, finish, current duration, work, and cost are defined through the plan development process.

The dialog box in Figure 16.2 now shows that the baseline was set to indicate an approved project plan. All the other statistics are the same as illustrated in Figure 16.1.

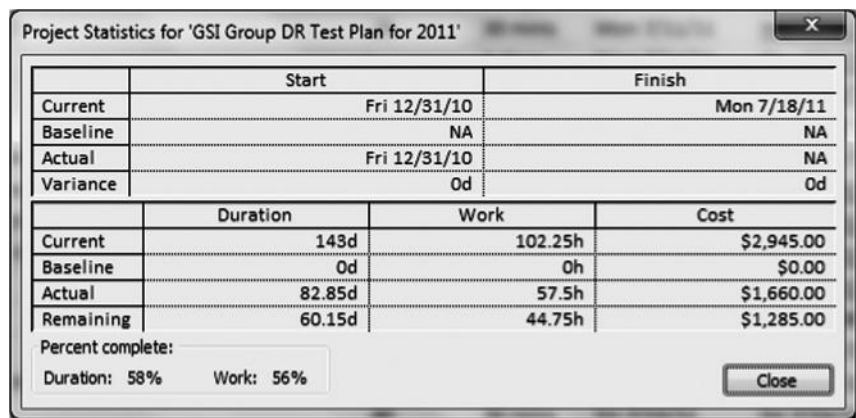


Figure 16.1 Phase I of project statistics—no baseline.

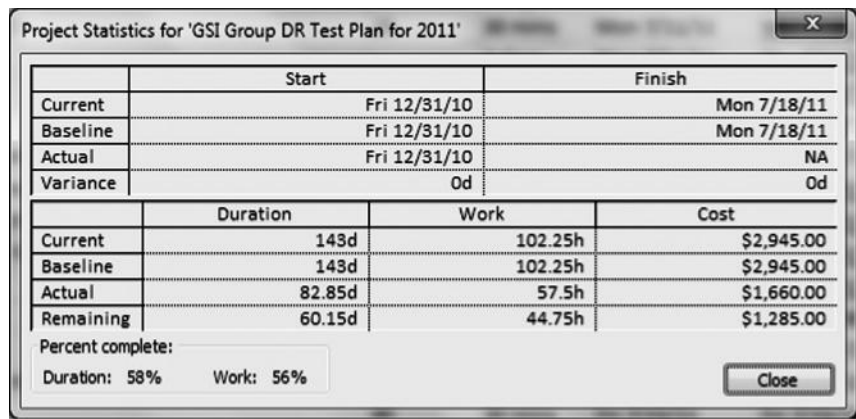


Figure 16.2 Phase II of project statistics—baseline set.

	Start	Finish
Current	Fri 12/31/10	Mon 7/25/11
Baseline	Fri 12/31/10	Mon 7/18/11
Actual	Fri 12/31/10	NA
Variance	0d	5d

	Duration	Work	Cost
Current	148d	200.75h	\$3,015.00
Baseline	143d	102.25h	\$2,945.00
Actual	56.83d	57.5h	\$1,660.00
Remaining	91.17d	143.25h	\$1,355.00

Percent complete:
 Duration: 38% Work: 29%

Close

Figure 16.3 Phase III of project statistics—post baseline.

It is typical for the project performance statistics to drift away from baseline values during execution. For example, Figure 16.3 indicates a five work day variance in the finish date from 7/18/11 to 7/25/11. The same duration variance is indicated between current duration and baseline duration (or 148d–143d).

The bottom-half of the dialog box indicates changes to most of the nonbaseline fields. The current field data items are related to the current plan values and these are compared to the approved baseline values. It is important to note that the work hours increased by 98.5 (or 200.75–102.25) and the costs increased by \$70 (or \$3015–\$2945).

Baselining is a method for analyzing a project's performance. This method compares the current performance to a historical metric or "baseline." Microsoft Project 2010 allows for the comparison of the baseline values to the actual or current values to calculate variances and other performance measures once the project is underway. Ultimately, baselining is a significant component of the overall project management plan (Biafore 2010).

After the stakeholders have approved a project plan, the PM should save that version in MS Project by choosing Project/Schedule/Set Baseline/Set Baseline (Biafore 2010). If changes to the baselined plan are approved later on, then a second baseline such as "Baseline 1" can be saved for the ongoing comparison. Up to 11 different baselines can be saved for a project, but if this many occur, it indicates that there are serious scope creep problems (e.g., new requirements) occurring and a strong possibility that the project should be canceled.

If a new task is added to the project plan after the baseline is generated and the PM wants to baseline it, then highlight the new task and choose Project/Schedule/Set Baseline/Set Baseline/Selected tasks (Biafore 2010).

Project does not automatically update all summary tasks, so a check has to be made for “To all summary tasks” and/or “From subtasks into summary selected task(s)” in order for the new task to be “rolled” up. When a task is deleted, the baseline numbers of the other tasks do not change and this can reduce the overall summary of the actual numbers or dates such as cost, duration, start, and finish dates, for example.

If the PM is not ready to save a complete project baseline but for some good reason want an interim partial baseline of the plan, the PM has the choice of doing this, which only saves the start and finish dates, not duration, work, or cost (Biafore 2010). To do this, choose Project/Schedule/–Set Baseline/Set Baseline and select the “Set interim plan” option. From the Copy: drop down list, select the start and finish fields desired and then select the start and finish fields from the Into: drop down list. Then, select Entire project or Selected tasks. Later on, it will be necessary to clear the interim plan by selecting Entire project or Selected tasks from the Set Baseline pull-down menu.

Finally and fortunately, there is a large growing trend within organizations to start using or assigning Project’s cost fields by utilizing data captured in the enterprise accounting system to keep a more accurate track of project costs and variances. One way of doing this is to link the accounting system codes to the project WBS Control Account codes. This may require that the project WBS codes be modified to better fit the accounting coding structure. There are many ways of summarizing task costs related to their different accounting codes and doing analysis on these projects costs. One of the ways to do this is to merge the project and accounting data sources into a common data file.

Text-based reports

Text-based reports are adequate if the stakeholders prefer that type of format. This format can be created out of MS Project 2010 by choosing Project/Reports/Reports. Figure 16.4 summarizes the six different categories of reports available.

There are over 20 standard MS Project predefined reports to choose from within these categories. In addition, it is possible to define a new report or edit a current report. Table 16.3 shows the types of standard reports available for each category.

Visual reports: Excel

Visual reports are more robust because they bring the value of graphics to view and allow presenting a project’s performance from many different angles (Biafore 2010). In MS Project 2010, if you choose Project/Reports/Visual Reports (uncheck the Visio box if you do not want to see those



Figure 16.4 Text-based reports by category.

Table 16.3 Text-Based Reports

Category	Project reports
Overview	Project summary (shows high-level overview), top-level tasks (tasks at the outline’s top level), critical tasks, milestones (typically appears after producing a deliverable in a plan and has zero duration), and working days (great for planning)
Current	Unstarted tasks, tasks starting soon (may include tasks that have started after you give date range), tasks in progress, completed tasks, should have started tasks (need to enter the start date), and slipping tasks (tasks that have started but will be completed after their baseline finish date)
Costs	Cash flow, budget, overbudget tasks, overbudget resources, and EV (EV is covered in Chapter 15)
Assignments	Who does what (tasks assigned to each resource), who does what and when, to-do list (is similar to who does what and when for a specified resource selected), and overallocated resources
Workload	Task usage and resource usage
Custom	Edit a current report or create a new report

formats). Figure 16.5 summarizes the different kinds of Excel reports that can be produced. These pivot table templates can be edited to customize the output format. The reports have a bar graph look. Also, the time period can be selected (days, weeks, months, quarters, or years) under “Select level of usage data to include in the report.”

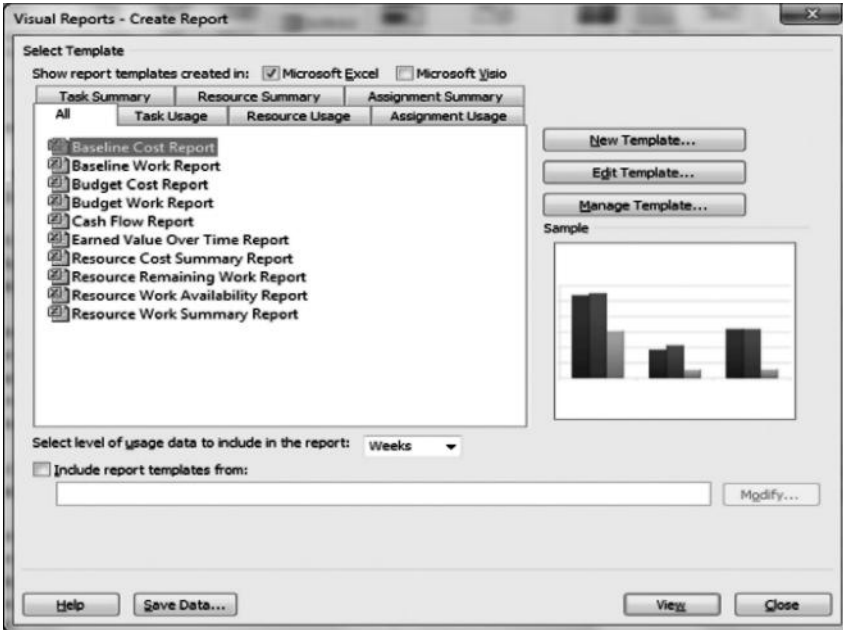


Figure 16.5 Excel visual reports.

Visual reports: Visio

A similar report option is available for Visio by selecting Project/Reports/Visual Reports (uncheck click Excel if it is not desired to have the options listed). Figure 16.6 shows a listing of the Visio reports that can then be accessed. These templates can then be edited or a new template created. Also, these reports have a hierarchical thumbnail graph as shown in the sample. As in the previous case, the time period (days, weeks, months, quarters, or years) can be defined under “Select level of usage data to include in the report.”

Both Excel and Visio report options take advantage of the pivot table concept, which is a data utility tool found in data visualization programs such as spreadsheets or business intelligence software. This type of tool allows for the data to be looked at from different angles/rotations or “pivots.” The raw information driving these reports are saved as a specialized database format called OLAP (online analytical processing) cube. The nice feature of the data cubes is the ability to support very flexible data organizations, thereby allowing the ability to filter, sort, change calculations, create new calculations, or populate the cube with other categories of data. It is for the user to decide how this data is to be presented. Pivot tables are a very powerful and flexible tool for analyzing project data

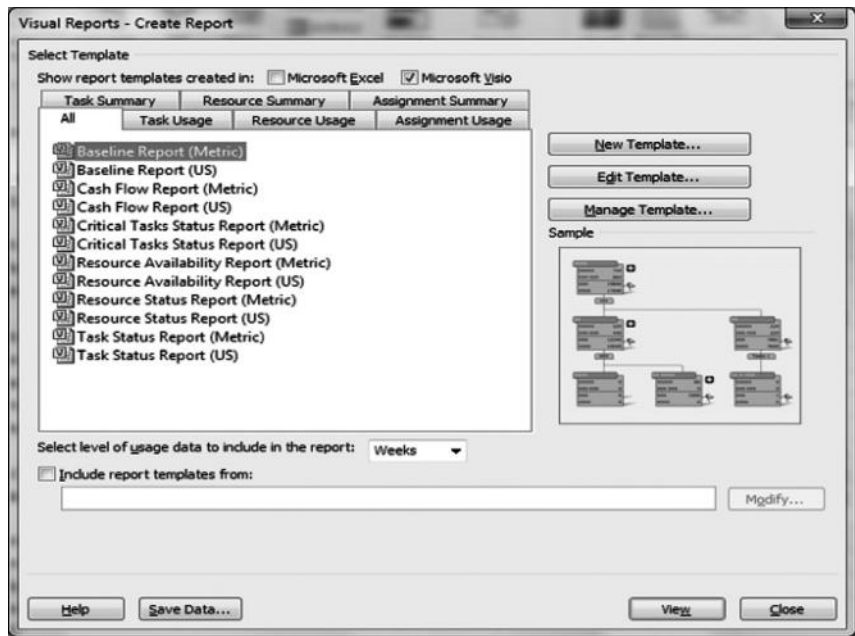


Figure 16.6 Visio visual reports.

and for that reason it is a mandatory tool for the PM. Figure 16.7 shows a “pivot” example of an Excel cash flow report. The first tab in Excel is really the pivot chart—a graph that displays the data and the second worksheet is the pivot table, which shows the graph’s data that was used from the saved cub file (note the .cub file extension). This pivot chart shows four quarters with the cash flow of \$750 spent for work in the third quarter (Q2

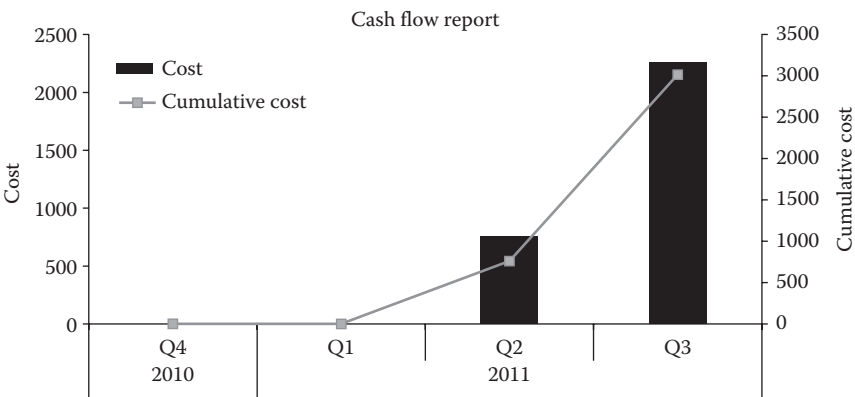


Figure 16.7 Excel visual reports for cash flow.

2011) and the remainder spent (\$2265) in the fourth quarter (Q3 2011). The total cumulative cost from the third and fourth quarters equals the \$3015 found in Table 16.2 (right under the cost column) and Figure 16.3 (the current cost field).

Summary

A quote from Dr. Robert Schuller is “When you fail to plan, you are planning to fail” (Smith 1981). Project status tracking is all about planning and staying in control of a project’s deliverables. The key reason for having project status tracking meetings is to identify potential issues, problems, and high risks before they can occur and then put recovery plans in place to avoid any harm to the overall project (Whitten 1995). These recovery plans must be routinely tracked by the PM and the ongoing status must be communicated to the stakeholders and the project team until resolved.

As part of the project’s communications plan, it is highly recommended to have periodic project status tracking meetings (i.e., daily, weekly, monthly, or as needed) at a set time and day and these meetings should run with a set agenda. This allows the participants to plan other activities and be able to prepare for the meetings. Meeting less frequently can allow problems to fester unchecked and could thereby do great harm to the overall project (Whitten 1995). The majority of status meetings occur weekly and it is best to have these meetings in the middle of the week, so Thursdays and/or Fridays can be used for follow-up work and/or escalation meetings if needed.

This chapter has covered many different kinds of project status report scenarios that can be utilized by PMs to help in tracking the project progress and communicate this information to the stakeholders and the project team. The more popular items in this tool bag used are the issue log, project plan, and pivot table-oriented visual reports for periodic project status tracking and reporting.

QUESTIONS

Review questions

1. Why are action logs so important?
2. Why baseline a project?
3. What is the most important topic to cover at weekly project status meetings?

In-class questions

1. What is a pivot table and why are they so useful?
2. Excel and Visio have common pivot visual reports. Name them.

EXERCISE

1. Develop a 6-month project plan for implementing a newly purchased accounting package with costs. Baseline the plan and assume that you are about halfway through the schedule. Run/output the six different Visio visual reports (USA).

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chapter seventeen

Techniques to influence the project outcome

Introduction

Historical surveys indicate that about 70–75% of all projects have been delivered late or have been cancelled (Whitten 1995). This has led to a “tainted” reputation for the projects and project management in general. Poor performance can occur for many reasons—poor management, no process or immature execution methodology, inadequate buy-in from stakeholders, ineffective sponsor and/or user involvement, unrealistic deadlines, and not learning from past lessons learned.

Projects that are completed often end up having fewer features and functions than originally planned to save development time and/or costs. Therefore, PMs need to be equipped with numerous techniques in their toolbox to help them *influence* the outcome of their projects in a positive manner. The techniques summarized here accomplish this. This suite of topics is based on the assumption that MSP 2010 is the primary tool. Each of the examples represents a technique to accomplish some planning or control aspect for the project and these are broken down into three major groups—scope, project, and scheduling management.

Scope management

Scope management focuses on defining project boundaries such as what is included and what is not included, and handling the process of orderly scope change. Scope or requirement creep refers to changes or an enlargement of a project’s original scope. The client has to decide whether the additional cost and/or lengthening the schedule are worth the cost or should be added as a follow-up project (Biafore 2010). Once a project is approved and gets rolling, invariably there will be requests to increase the scope and this must be handled very carefully because it will adversely affect the project’s budget and timelines. The following combination of scoping techniques is designed to have a positive influence on the outcome of a project.

Scoping it out

Given that scope generally equates to cost and time, it is desirable to keep it as small as possible. Not only is a large scope a negative factor in success, but scope change can also have a similar impact. The purpose of scope management is to ensure that all the required work is covered and only that work is completed—in short, setting up boundary lines for what work is included and possibly what work is not included. The project's closeout report should include a summary of the scope status by listing the deliverables and any items that were not completed and why. Also, if there were significant changes in the original scope (e.g., new technology or redesign), then these need to be listed out and described in detail.

Breaking it out

To improve control and bring benefits faster, project cycles are best kept as short as possible. After 12 months, requirements tend to shift and the overall control becomes more difficult. Also, it is more difficult to keep the team properly focused on the correct work. In other cases, success is decreased because of advances in the technical environment and other projects may take on higher priorities and extract project resources. If a project is longer than a year, it is best to consider how it could be broken down into defined phased subsets (i.e., phases or state gates) so that the individual pieces can be implemented quicker to help increase the chances of overall success.

What-if it out

MSP 2010 has a very useful analysis "What-if" capability. This can be used to compare variations (tasks and resources only) between the current version of a project plan and an earlier version of the same plan. A comparison of this type is especially handy when analyzing scope changes in a project. This allows for a quick comparative view to assess the effects of making a particular change. In performing what-if analysis, it is always smart to work with a backup copy in case it is decided to return to the original starting place.

To run the project's what-if utility, open the original file first and then the updated file. Then, choose Project, Reports, and Compare Projects. From the "Task Table" and "Resource Table" pull-down menus, select the desired data field to compare, and then click OK. This generates a comparison report (see Figure 17.1) on the top half of the screen with similar comparison columns in sets of three (e.g., Cost Current, Cost Previous, and Cost Difference), and a Legend on the left-hand side. In the first column of the comparison report, an image will appear consisting of either

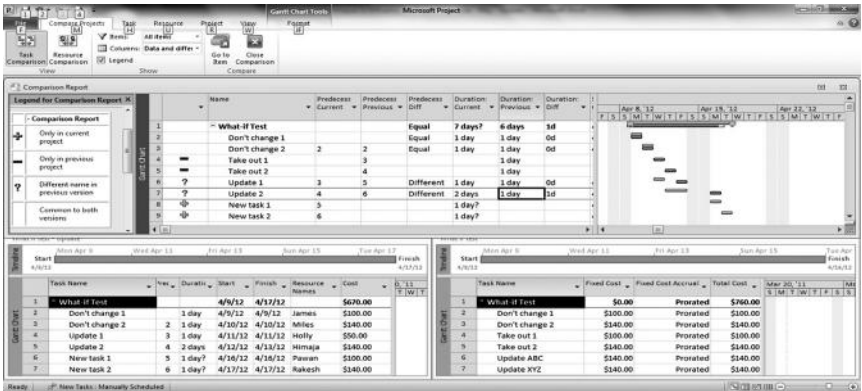


Figure 17.1 What-if utility.

a plus sign (only in the current project), minus sign (only in the previous project), question mark (a different name in the previous version), or a blank (common to both versions). The comparison report contains only the differences between the bottom two-pane file versions (updated file and the original file) and is not a consolidation of the two projects. This report can be saved if desired.

Changing it out

In most projects, there is significant pressure to change the various aspects of the approved scope. This essentially adds more work than originally planned and is a major source of time and cost variation if not properly planned for. Accommodations must be made to handle changes (e.g., integrated change control process) and this should be a formal orderly review and approval process managed by the project board. Once a change request has been approved, the new work needs to be integrated into the project plan with the new tasks, dates, costs, and so on. For historical purposes, it is best to keep the original baseline data and save a new or second one (e.g., baseline1) to show as the current approved plan. Procedures for moving the new scope into the project plan can be quite tricky and must be handled carefully.

In some cases when the sponsor sees the additional costs and extended timeline, he or she may back off from approving the proposed changes, or decide to have the requested change as a follow-up phase.

Closing it out

In some situations, closing or delaying an active project is required and can be a necessary management action because the project is now redundant, or

a new project request holds more value and promise (e.g., new technology) than the current project. For this reason, it is important to track not only the resource consumption status of the project, but also evaluate the business value. The management goal must be to strive to pursue an optimum portfolio of projects. Delaying a nonfunctional project can free resources and can allow opening up to a more productive nonfunctional project. A delayed project can be restarted when the opportune time comes. When restarting a project under this circumstance, the original scope should be revisited to make sure the requirements have not changed.

Project management

According to PMI, project management is defined as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Accomplishment of this goal is a real balancing act to meet the project's objectives against the constraints of time, budget, and quality (Biafore 2010). Time management deals with the current progress and what is left to do, cost management performs a similar role for the budget, and quality management deals with conformance of the deliverables compared to the approved plan. Given this high-level management goal, the following combination of project management techniques is designed to have a positive influence on the outcome of a project.

Gluing it out

Discipline is the glue that holds the project team together. Without good leadership and effective two-way communications, the complex interworking of a project will not mesh (Whitten 1995). Project plans need to be taken seriously by team members—Plan your work, work your plan, and strive to keep on track. The importance of the PM role in dealing with the team and stakeholders cannot be overstated. Also, it is important for the PM and team members to admit any wrongdoing which can change the mood from interactive uncooperation to cooperation. In short, actions speak louder than words.

Partnering it out

Make sure the client or customer is part of the planning and development life cycle so that there is a feeling of ownership or buy-in to the project objectives. This will help increase the chances of viewing the final program or product as a quality job well done (Whitten 1995). This includes partnering with future users in the requirements development process, working with third-party vendors in procurement activities, and obtaining buy-in from the various performing organizations. Also, remember

that the sponsor's involvement and continued support will increase the odds of having a successful project by them providing active support and backing when the PM most needs it.

Risking it out

In recent years, the recognized value of project risk management has risen. Gartner group estimates that proper risk identification will result in the cancellation of about 20% of all projects before the execution phase as a result of uncovering negative factors that erode the project value. Beyond the assessment of risk levels, there is a related process to help deal with the elements that remain. This includes the options to accept, mitigate, avoid, transfer, or share the identified risk items. This is now recognized as yet another important aspect of project management that has significant impact on the overall success. See Chapters 11 and 22 for more in-depth information on project risk management and its related mechanics.

Costing it out

The PM should always be aware of the different types of cost-related metrics (i.e., planned cost, actual cost, and earned value) to assess the project status. These status parameters are a critical aspect of effective management because of the need to show how the project is doing, what the related variances are, and what corrective action needs to be taken to move the project back on track. Chapters 10 and 15 offer more in-depth information on the cost aspects of project management.

Issuing it out

It is important to have an issue and action process to help manage over the daily minor items that occur during the life cycle. If an issue is not resolved in a timely manner, it can have a harmful effect on the outcome of a project. For example, an issue could affect the project's schedule, cost, resources, quality, or customer satisfaction. Also, whenever possible, tasks for testing should be included for any task in the plan for which feasibility is questionable.

Reviewing it out

Most organizations have a function called quality assurance or QA. The role of such a group is to evaluate the adequacy of the project processes to produce the required deliverables. This type of function provides an independent review of the project processes. There are three types of QA reviews—health, compliance, and deliverable—that are typically

contained in this process. Besides performing an “outside check-and-balance,” QA will ensure that the project and related documentation are being developed according to an acceptable process. Even though not part of the defined direct project task definition, failure to recognize this aspect can have a significant negative impact of project success.

One of the worthwhile internal quality-oriented tools is the MS Project 2010 Task Inspector. Use of this tool will aid in finding ways for improving the schedule and identifying resource overallocation or task link problems (Biafore 2010). To activate this utility, select the Task tab and then select Tasks—Inspect the pull-down menu to select Inspect Task, Show Warnings, Show Suggestions, or Show Ignored Problems. This will aid in showing different factors that could affect the chosen task and be shown as repair options (e.g., reschedule the task to the resources’ next available time) that can be helpful in fixing scheduling problems.

Pinching it out

Pinching is a management process that seeks ways to use cheaper resources such as contractors and/or materials to reduce the project costs. Keep in mind, once a contractor leaves the project, the knowledge held by the contractor is no longer available to the project team. For this reason, it is important to maintain good documentation or capture the knowledge in some sustainable manner so that it is not lost. Often, a project will have future issues that cannot be resolved by the core team because a contractor was the original developer of that knowledge. If there is a need for external expert resources, get them as soon as needed, but try to avoid leaving a knowledge gap when the expert exits the scene.

Coaching it out

Active PM mentoring and coaching through the life of the project should be proactive in all aspects of the management process. PM mentoring includes the areas of improving writing and communication skills of the project team members. Why? Development of team member skills through this process will improve not only the current project outcome, but will also improve that team member’s ability in future projects. One of the modern goals for a PM is to develop his team’s abilities for future efforts. The practical experience available in the project environment is the best teaching laboratory for this activity (Crawford 2011). In addition to a mentoring program, a formal training program helps to improve the overall team literacy and typically reduces employee turnover, increases employee satisfaction, and improves organizational loyalty. In summary, employees like to feel that their organization provides them with a more professional working environment compared to their competitors. This is

one of the best ways to build the professional reputation of the organization and the PM.

Schedule management

Schedule management involves keeping the project in time control. This is a key activity in that time dictates other aspects of the project outcome, most notably cost and resource usage. This activity defines the roadmap of activities to be performed by the team and can make the difference between profit and loss (Whitten 1995). A great deal of discipline is required in managing schedules and changes that come about during execution. The following combinations of scheduling techniques are often used to help influence the outcome of a project.

Buffering it out

Use of sufficient time and cost buffers is an important strategy to cushion the project plan from variances. In addition, the use of contingency and management reserves is an important part of dealing with those variation sources. As an organization gains more experience with project buffering percentages that can be adjusted accordingly. There are many root causes for generating the need for time and cost buffers. A sample of these could include vacations, unplanned time off, and the productivity of team members.

Baselining it out

Baselining is a method for analyzing a project's execution performance. This method compares the current performance with an approved value metric or "baseline." The project allows the current time and cost values to be compared to the defined baseline values once the project is underway. Once the project plan is approved by the management, the baseline is set by choosing Project—Schedule/Set Baseline/Set Baseline (Biafore 2010). To see a high-level quantitative table view of the project's status, choose Project/Project Information/Statistics.

Evaluating it out

The critical path represents the set of activities that dictate and constrain the project schedule. For this, a group of tasks must be monitored carefully. The critical path is the sequence of tasks that collectively controls the finish date for the project plan (Biafore 2010). The project assists in this identification by color coding that task set and this group should be given high priority in the management process. Resource management for this

group must be carefully controlled since failure to manage the staff levels for critical path tasks will likely lengthen the project schedule.

To show critical tasks in Project, choose View/Data—and from the Filter, pull-down menu select Critical. When a resource is working on both critical and noncritical tasks at the same time, make sure that the critical task takes first priority in any time conflicts. Finally, there are other ways within Project to view the critical tasks—insert a new column and select Critical, or within the Project tab, select Reports—Reports—Overview and then Critical Tasks.

Compressing it out

The requirement to compress a project schedule is a common occurrence. Chapter 11 reviews the various techniques for compressing a project schedule. Realize that there are various methods to accomplish this goal and collectively they constitute a mandatory skill for the PM. No one method will work best in all situations. The following are the two very traditional techniques for compressing time in a project plan:

- Crashing is the process of adding more resources to a task to shorten its duration. This has the impact of adding budget costs to the task, so that aspect should be evaluated before pursuing this option. This is a way of paying more for faster delivery. Also, keep in mind that adding too many resources can actually slow the task down (i.e., time to learn the requirement, more supervision, more communication channels, lower overall productivity, and more materials required).
- Fast tracking involves overlapping/related tasks on the critical path to shorten the overall schedule. Even though this appears to be a cost-free option, one must be careful with this option as it can bring with it the increased risk in having to redo the work. One good analogy for this is driving a car, talking on the phone, and putting on lip balm at the same time often creates accidents. It may shorten the duration of these activities if all goes well, but one must understand the potential consequences otherwise.

Linking it out

To produce a viable plan, the task sequencing must be technically accurate, agreed on by the stakeholders, and managed by the PM. It is up to the project team to verify that the plan's task sequencing is correct. In some cases, these relationships can be slightly modified to improve the overall schedule performance and it is up to the management process to ensure that this activity is performed.

In Project, double click a task that has a predecessor, select the Predecessor tab, and click the type of file field, which will open a pull-down

menu for FS (or FS which is probably the default), SS, FF, or SF. Changing the file Type for the task's predecessor can shorten the overall schedule. Also, to the right of the Type field, there is a field called Lag. The Lag field can be used to delay time or add time by minutes and/or days or a percentage of delay or lead time can be defined. Remember, any task could have no dependencies, a single dependency, or multiple dependencies. Another approach is coding the Predecessor's field. For example, "41SS + 2 days" means that this task starts 2 days (or Lag time) after task 41 starts.

Tracking/slipping it out

The most important reason for having project tracking or status meetings is to identify the potential problems before they happen or become severe (Whitten 1995). Related to this activity, the recovery plans should be defined to help mitigate the potential problems and to keep on the schedule. Failure to maintain timely communication allows this class of problems to fester unchecked (Whitten 1995).

Slipping tasks are defined as the ones whose finish dates are late and exceed their saved baselined finished dates. By frequently reviewing these tasks, it is often possible to stop the slippage or prevent it from getting worse (Biafore 2010). Task times slip for a wide variety of reasons, and none of which is desirable unless planned. For this reason, it is important to monitor these variations as a regular part of the overall management process. A good PM will use actions of this type to anticipate problems and use their bag of tricks to move the project back in the desired direction.

To view the Slipping Tasks report, choose Project/Reports/Reports/Current/Slipping Tasks. It is also possible to use a filter by choosing View/Data/Filter pull-down menu/More Filters. For the Tasks (at the top of the More Filters box), select the Slipped/Late Progress report or the Slipping Tasks report and select Apply or for the Resource (at the top of the More Filters box), the Slipped/Late Progress report can be selected or the Slipping Assignments report and select Apply.

Filtering/sorting it out

The volume of data in a project plan can be overwhelming. Project can help filter through this maze by using its filter option to sort the activities into groups that can be managed better. Some sample groupings of this are critical path, overdue tasks, and resource overallocations (Muir 2010).

Working it out

Reworking individual team member's schedules (i.e., standard, 24 hours, and night shifts) can shorten the project's work-elapsed time and help balance workloads, but realize that this can be a time-consuming activity.

Project can aid in this by changing the schedule calendar with the option Project/Properties/Change Working Time. Also, the Change Working Time function can be used for the entire team, an individual, or a single task.

Summary

This chapter has summarized the various management techniques that can positively affect the outcome of projects. All PMs should understand each of these and be proficient in their application to the project plan. A PM should never work in a vacuum and should always be on the lookout for other people's ideas (giving credit where due) that could have a positive outcome on the project. When used together, knowledge management and project management produce added and synergistic value (Crawford 2011). Remember that the established tools and techniques will never replace a good human project management!

QUESTIONS

Review questions

1. Why is risk identification an important aspect of the management process?
2. Why are baselines important management items?
3. Why is it important for the PM to have timely status meetings?

In-class question

1. What are the major sources used in defining the project scope?

EXERCISE

1. Utilize the what-if utility within MSP 2010 to show the comparison report screen. Use the sample car project plan titled *11 Car Project Case Discussion* from the Taylor & Francis website. Start with this plan and "save as" into an updated file. In the updated file, delete some of the original tasks, add some new tasks, and rename some tasks, then save the file. Now, run the what-if utility for your output.

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chapter eighteen

Integrated change control

Introduction

The focus of this chapter is on managing the project scope while changes throughout the project occur. The role of a steering committee is to select, control, and allocate resources (Redesigning project management 2002). Decision gates and project management boards are set-up to help manage and guide the scope change process. Project control tends to be connected to the type of leadership style that is outcome-oriented (Barber and Warn 2005). This means that the style tends to be affiliated with a proactive leadership who understands the big picture, anticipates events, and is focused on preventing problems. Such leaders are a natural fit with successful monitoring and control of changes to the project. PMs are responsible for successful delivery of completed projects which is achieved through both hard and soft skills and demonstration of flexibility and competency (Bourne and Waker 2004). Box and Platts (2005) suggest that technical skills alone are not enough to be a PM since good leadership, political skill, and change management capability is also necessary for success. Guidroz et al. (2010) further suggest that a project is successful through different strategies for implementing change within organizations or in this case, projects. There are many keys to success. Having clear expectations is one key which in projects requires having a clear process for integrating change. Another key is to have a well thought-out communication plan which applies in this chapter to communicating the change process and changes implemented to stakeholders. Closely monitoring the task status throughout the life cycle is another key to success.

Projects typically do not run exactly according to plan for a myriad of reasons (PMI 2008). When changes are being considered, they must be managed through a process called *integrated change control* (ICC). It is this process that adds the technical and managerial review of these proposed actions. This chapter discusses the purpose of project change requests (CRs) and project change boards. It also addresses the role of the configuration management (CM) system, the ICC process mechanics, and the overall importance of tracking and documentation of such action throughout the project lifecycle. There are often disconnects between planning, design, delivery, operation, maintenance, and the overall management of a project but there is becoming an increasing focus on life cycle costs and performance of built assets and deliverables (Kumaraswamy 2011). The

ICC process like other project management processes represents a model method of providing governance over the project evolving scope with regard to how changes impact costs and project deliverables which is in turn critical to success (Tynan et al. 2010).

CRs and change boards

CR is the name given to the standard form used to formally submit a proposed CR to the project scope. The purpose of having such formalization is to limit and control changes to the baseline plan. The related process is designed to keep changes in the hands of a defined management group (e.g., the Change Board). Changes that are submitted are triggered by both preventive and corrective actions. Preventive action CRs are submitted to be proactive to reduce the likelihood of a negative outcome associated with the current plan. Therefore, nothing negative has occurred but there is anticipation that if a change is not made that something undesirable may occur. For example, a certain type of technology is specified in the current plan, but based on further reviews there is an identified negative aspect in that item. This recognition could then stimulate a CR proposing that another known technology be utilized instead. Another example of a preventive action CR is the proposal to increase the number of quality inspections possibly due to the recognized number of inexperienced workers on a project team. CRs submitted as a result of a corrective action are stimulated by something negative that has occurred. Perhaps a product deliverable had defects and now the defects need to be repaired. Another example is the recognition that a requirement was missed in the original specifications and now needs to be added to the project plan.

The CR evaluation and approval process is formally defined and placed under the management purview of an ICC board. Each organization may have different names for this board such as a steering committee, configuration control board (CCB), change advisory board (CAB), and so on. However, the purpose of such groups will be similar across these organizations. That common role will be to deliver management support to the change management process by approving changes and assisting in the assessment and prioritization of changes for the project. The project charter and the resulting approved baseline plan can be viewed as defining a control envelope within which the project objectives must be contained. The ICC Board should be delegated authority to manage the project outcomes so long as they remain inside this control barrier. In other words, so long as the schedule and budget are maintained and the other project baseline metrics are within the defined tolerance. However, if a CR falls outside this control envelope, the board will be required to escalate the approval decision to the project sponsor (PMI 2008).

Table 18.1 CR Submission Form

Individual submitting the change: Natalie Jones	Submission date: Month/day/year
Individual contact information (phone, email, department):	Requested implementation date: Month/day/year
Area of project impacted by the change (hardware, software, facility, process, schedule, budget, etc.): Process	Change description: Insert an extra customer review on Month/day/year to provide the design team with additional customer feedback before the final review
Reason for CR: To provide the customer with a better design early in the design process which will also result in less time needed for redesign	Risks the change impact positively or negatively: Positively
Estimate of cost to implement (breakdown costs for items that will need to be purchased): No additional cost	Estimate of resources needed to implement (breakdown of resource types needed and estimation of the number of hours per resource type needed): No additional resources needed
For internal use only	
Change approved or denied: Approved	
Reason: Improved customer service	
Date: Month/day/year	
List any documentation changes if impacted: None	
List budget changes: None	
List schedule changes: None	
Follow-up procedure if change accepted: Schedule additional review with customer for month/day/year	
Follow-up completed on: Month/day/year by Craig Richards	

Table 18.1 displays an example of a CR form requesting a change to the product design which is approved by the board. Table 18.2 displays an example CR Tracking Document that provides internal analysis regarding the attributes of the change. This information and other input from the PM will be used by the board to display if a CR was approved, denied, returned to be reworked, or resubmitted with additional information to impact the board decision or even emergency CRs that have to be approved before the next meeting. Other scenarios for a CR could be an “automatic

Table 18.2 Sample CR Tracking Document

Name of person submitting the CR	Date the submission was received	Reason for submitted change	Submission status and reason	Date the submission was approved or not approved
Project team member Lindsay Carre	Month/ day/year	Initial customer feedback on the website was negative as additional navigation and content need to be added to it	Accepted as this change will enhance customer web experience	Month/day/ year
Project team member Ryan Campbell	Month/ day/year	Request for two additional weeks to develop the training course material	Rejected because PM identified an extra resource to provide 80 h of support to help with the training course preparation	Month/day/ year

Table 18.3 CR Process Template

New CR?						
No			Yes			
Assessment						
Not approved			Approved			
Rejected with reasons	Returned for more information	Delayed with reasons	Emergency	Cost	No-cost	Added Revisions
				Prioritize	CRs	
				Schedule	CRs	
				Monitor	Progress	

Template to assist the board in processing of CRs.

CR” as it may be something more of an update or a “no-cost CR” that does not change the scope or schedule. It will also include in the document the reason for the board’s decision. In some cases, the board may delegate to the PM authority to handle minor CR-related issues that do not affect time or cost. In this situation, the CR may come to the board after the fact and only for review. In all of the scenarios outlined above, the goal is to maintain change control on the approved project work. Finally, Table 18.3 provides a template that can assist the board with processing of CRs.

CM in ICC

What exactly is CM? First, think of this as a document control process whereby the flow of product and project documents is controlled. There are other attributes for this process, but this is the essence of its role within the ICC model. Now envision a CR flowing through its evaluation, decision-making, communications, and final tracking steps. As that occurs, the CM system will contain all of the known status for that process. In this view, it is a secure filing cabinet that all can go in order to find the latest status. Some have called this system “The one source for the truth.” So, regardless of what is contained in the CM system, it is kept under both defined and secure control. The ICC process utilizes CM as its various documentation moves through its decision process. In summary, a CM system provides a standardized and efficient means to manage project changes (PMI 2008). This is accomplished by continuously providing an opportunity and method for changes to be identified and requested and the status of these changes assessed. Part of CM is also to provide the data store to support communication to stakeholders of all documentation and/or requirements changes. This keeps everyone’s expectations in synchronization.

The specific aspect of CM that is affiliated with ICC is configuration identification, configuration status accounting, and configuration verification and auditing (PMI 2008). Configuration identification involves everything that pertains to products are configured (i.e., version numbering). This includes defining and verifying products, labeling of products and documents, managing changes, and maintaining accountability. Configuration status accounting involves being able to collect all pertinent information relating to a product so that its configuration information is constantly up to date and accurate. Configuration verification and auditing involves tracking the product’s evolving performance and current functional requirements as changes have occurred.

ICC process

The ICC process is a formal control process whereby changes are considered to be made regarding the project management plan, project scope

statement, deliverables, and so on. ICC utilizes data-oriented systems that store project information as well as expert judgment from stakeholders that serve on a board to approve or decline CRs. This process involves identifying approved changes that need to occur or negative events that have occurred (PMI 2008). It also involves influencing factors that impact the ICC process so that only approved changes to the project are implemented. This unfortunately is not to say that changes do sometimes and somehow occur that have not been approved. Therefore, a scope change that has been made in violation with the board may have occurred because a CR was either not submitted to the board for approval or a CR submitted was not approved yet somehow still was implemented. In either case, the board will need to document what happened and show that the change was made despite not going through the correct process (PMI 2008). Follow-up needs to occur in order to track status of an implemented change which is equally as important as the original decision. If the change is not acceptable, then corrective action is required to resolve the situation. Formal documentation is the key to tracking what has occurred as ideally only changes that have been approved have occurred.

The role of a formal CCB, regardless of the local name used, is a fundamental management entity needed to control project scope (PMI 2008). Also, it is vital that all changes submitted and installed need to be documented and tracked through the project life cycle. One of the important reasons for this is to minimize looking at the same type CR multiple times. When this occurs, the CM system can help resolve these redundant actions without excessive analysis work. Also, even if a CR was approved, the status needs to be documented as it is very possible that the PM at some point will be challenged as to why a CR was approved or rejected. Having formal ICC procedures and policies in place that are communicated to the team and stakeholders greatly contribute to reducing the likelihood of the procedures and policies being ignored. Stakeholder management and alignment must occur where effective communication is employed not only on just the procedures and policies, but also in the project changes that have been approved and implemented (Goubergen 2009).

Maintaining an approved baseline in terms of documentation and requirements as approved changes are implemented is also part of the change board's responsibilities (PMI 2008). This includes documentation related to the project management plan and scope statement as well as details related to scope, cost, budget, schedule, risk, and quality. Tracking the baseline status along with the changes to the underlying documentation must be formally included in the ICC role. When requirements in one area on the project change, there is a reasonable likelihood that associated impacts will be felt elsewhere. Current documentation of

all approved requirements is a fundamental management activity and drives the subsequent work plans for the project team. Without an accurate description of these requirements, the ultimate outcomes are likely flawed.

Managing and validating defect repair is another aspect of ICC as it is fundamental to achieving product quality (PMI 2008). During quality inspections, a defect may be found and therefore require repair or resolution. When this occurs, a CR may be created to guide the repair process. Once the needed repair is made, the item will need to be reviewed and either accepted or rejected. If rejected, it will require additional attention. Defect repair must be tracked until the item is approved signifying that it is good to move forward through the process. To control product quality, repairs may periodically be required. The tracking of quality measurements and repairs needed will be documented and tracked through the ICC process and reviewed through the lessons learned activity.

ICC costs

As indicated earlier, the charter and approved baseline plan represents the management envelope of the project in terms of identifying its specific time, cost, and other baseline requirements. Previous discussions have focused on managing the CR process. The issue now is to review how the added costs affiliated with a CR are handled? CRs often result in a cost increase to the project above the planned level. If the project budget does not have access to incremental resources to handle these changes, the project will have a budget overrun by definition. However, there are different approaches to supply funds to support the change process. If the project is under contract with a buyer and if the buyer approves of the scope changes, the added budget will then come from the buyer in the form of a contract change. If this is a multi-contract project, the complexity grows regarding who will approve the change(s) and supply the additional resources. For example, is the added amount split between all buyers, or will one or more buyers be willing to pay for the change. Alternatively, if the change occurs from an internal project, then the funds will need to be provided somewhere from within that project or organization. In some cases, it is possible that the project budget will have identified funds set aside for this purpose. If so, the project will be able to support a scope change that has costs affiliated with it. However, this is often not the case and if so the source of funding becomes more complicated. It is clear that some source of reserve funds will be needed to fund this class of activity. This is the preferred approach for handling variations with both task variation and change stimulated time and cost increases.

Summary

This chapter discussed the role of CRs and change boards, explained the CM system and its relationship to the ICC process, outlined the ICC process, and highlighted the importance of tracking and documentation of all CRs and their associated activity throughout the project lifecycle. When changes to the project management plan, project scope statement, deliverables, and other baseline items are being considered to be made, they must be managed through a controlled process called ICC where the proposed changes are either approved and implemented or rejected.

The purposes for submitting a CR are either to prevent something negative from occurring, fix something negative that has occurred, or make a modification based on newly defined requirements. With regard to project performance, it is often easy to remember to fix something negative and visible that has occurred but less obvious to deal formally with a positive event that has happened such as the addition of a new feature to a system that will decrease the turnaround time for a task by 50%. This chapter has emphasized that all changes to the approved baseline must be formally documented and processed by the ICC board. This board has authority to make project changes that fall within the approved baseline envelope. However, if a change falls outside the envelope, the board is required to seek external approval from the project sponsor (PMI 2008).

CM is defined here as the formal system that assures changes made to the project are properly stored and controlled through the ICC process. The companion ICC process as discussed is a formal management process where changes are considered to be made to the baseline project management plan, project scope statement, deliverables, and so on. If the project budget does not have resources for the approved scope changes, there are different approaches to seek the necessary budget, with the role of internal project reserves being required for internal projects and contract changes the rule for external-type projects.

Now that the change management process has been described, it is time to move on to review the process of matching required resources to the approved plan. Technically, this process is called *resource leveling* or *capacity management*.

QUESTIONS

Student review questions

1. What is ICC?
2. Describe the role of the CCB and the authority that it has.
3. What is the relationship of CM to the ICC process?
4. Who funds the costs affiliated with an approved CR?

In-class questions

1. Describe why an online CR process has advantages over a paper driven equivalent approach.
2. Using the Internet, find a Revision Tracking Document for tracking CRs.
3. Identify a company's ICC or specific CCB process.

EXERCISE

1. Create a CCB procedure for the car case project using the model approach outlined in this chapter.

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Resource leveling

PROJECTNMOTION BACKGROUND LESSONS

Refer to the video on Resource Allocation

Introduction to resource leveling

The fundamental wish list of PMs is that they have unlimited labor and monetary resources to perform the project work. However, the reality is that many PMs have this wish list in mind but management does not understand the operational significance of this. The unfortunate consequence of this is that there is a mismatch between the plan and actual resource availability. Therefore, management never actually commits the needed resources to successfully perform the planned work. There are two common problems faced by projects and that is setting a realistic date for deliverables and creating a schedule for resources to perform tasks that result in meeting the deliverables (Dumond 2005). In today's competitive environment, resource leveling is a key to cost reduction, faster service, and increased flexibility (Ashayeri and Selen 2005). Each project is unique in terms of time and resources needed to transform a project to its final state (Vidal and Marle 2008).

The purpose of this chapter is to demonstrate some of the mechanics related to resource leveling through the MSP view. In some cases, overtime is used to bridge the gap between the plan and actual resource availability. This is actually a way of stretching resources, but there are negatives related to what looks like a universal solution. This is a temporary solution, not a long-term solution. An on-going need for overtime signifies the need for a better solution whether it requires the approval by management to hire additional resources, change tasks within the schedule to a different time period that does not conflict with tasks on the critical path, change tasks to other team resources, or implement any other solution deemed necessary.

The area of resource leveling represents a common gap in the planning process and one which can crater the value if not recognized. Poor capacity planning and lack of capacity are core causes of problems (Ashayeri and Selen 2005). Companies can seek more control through the more exact scheduling of project resources (Porter et al. 1996). For instance, the person

managing this area needs to have immense experience in understanding that an analyst who is on the team and not working on an active task cannot necessarily take on the extra work that a mechanic is capable of performing. Everything within an organization is dependent on resources (Kalyani and Sahoo 2011). Throughout a project, there are changes in priorities causing tasks needed to be completed earlier, resources may be unhappy or unmotivated, or alternate tasks needing to be assigned (Shetach 2010).

Even a clever scheduling tool in the wrong hands will not be able to adequately perform resource leveling as the person managing these resources needs to have knowledge and experience (Porter et al. 1996). A simple example is in construction where there could easily be bad weather making it impossible for some tasks to be worked. The person who has planned for this will already have in mind the tasks that can be performed under cover even if those tasks are not scheduled to be worked until later. This way, the schedule is freed two weeks later so that the task being delayed due to weather can be performed. It is a balancing act but this chapter discussion should equip each reader with a toolset to make better decisions regarding resource leveling. Let us first discuss the term over allocation. Over-allocation can be simply defined as a resource that has been tasked to do more work than is considered a normal workload. For instance, a resource that has been assigned more than 40 hours of work within a week has been over-allocated.

Managing resource leveling

This section of the chapter will describe different tools within MSP where the PM can be alerted to resources being over-allocated. In Figure 19.1, the resource tab has been selected followed by clicking on the “Team Planner” menu to display different tools available to assist in the resource leveling process.

Team planner Gantt chart

The Gantt chart view within the Team Planner menu is displayed in Figure 19.2. In MSP, the person figure next to each task will be in red. In Figure 19.2, tasks 1.2.1.1, 1.2.1.2, 1.2.2.1, 1.2.2.2, 1.2.3.1, 1.2.3.2, 1.2.3.3, 1.2.4.1, 1.2.4.2, 1.2.5.1, 1.2.5.2, and 1.2.5.4 have the red person icon next to it, indicating that these specific tasks have resources in it that are over-allocated. When the cursor is placed over a red person, the message box appears as shown in Figure 19.2 to explain to the user that resources affiliated with the task have been overallocated. This alerts the PM that there is an overallocation issue with that particular task. In this specific view, the PM is alerted to the problem but is still unaware of exactly

Built-In	Items	Insert	Properties	Level		
☒ Calendar	Task Name		Predecessor	Duration	Cost	Finish
☒ Gantt Chart	Car Problem First Cut			506 days	\$1,252,920	Fri 7/11/14
Network Diagram	Planning & Project Initiation			75 days	\$166,400	Thu 11/15/12
Resource Sheet	Charter			10 days	\$17,200	Thu 8/16/12
Resource Usage	Stakeholders Identification	3		5 days	\$18,200	Thu 8/23/12
Resource Form	Scope Definition	3		15 days	\$45,600	Thu 9/13/12
Resource Graph	Schedule Development	5		15 days	\$50,400	Thu 10/4/12
Task Usage	Risk Assessment	6		5 days	\$8,600	Thu 10/11/12
Task Form	Budget Definition	7		15 days	\$11,400	Thu 11/1/12
Task Sheet	Management Charter Approval	8		5 days	\$3,800	Thu 11/8/12
Team Planner	Set baseline	9		5 days	\$11,200	Thu 11/15/12
Timeline	Engineering			291 days	\$737,460	Fri 12/20/13
Tracking Gantt	Body / Engine Draft Design			50 days	\$149,400	Thu 1/17/13
Reset to Default	Initial Draft	9		35 days	\$121,800	Thu 12/27/12
Save View...	Integration analysis	13		15 days	\$27,600	Thu 1/17/13
More Views...	Mechanical Engineering			110 days	\$238,800	Thu 6/13/13
	Engine Design	10		80 days	\$182,400	Thu 5/2/13
	Mechanics Design	10FS+10 day		30 days	\$56,400	Thu 6/13/13

Figure 19.1 Resource tab team planner menu.

when this task experiences an overallocation issue. For instance, the tasks with an overallocation issue may be tasks that are conducted for any period of time such as a year. Therefore, the overallocation could be just an issue on one particular day or it could be an issue consistently throughout the task duration. It is acceptable for a short period of time where there are overallocated resources, but if the overallocation is a more serious problem where overallocation is frequently occurring, then a more complicated approach to resolving the overallocation will need to occur. Examples of how to fix the overallocation issues will be discussed later in the chapter.

Team planner resource sheet

In Figure 19.3, a resource sheet is displayed. In MSP, the overallocated resources will display in red. In this figure, the tester, mechanical engineer, and mechanic resources are shown as being overallocated. When the cursor

1	WBS	Task Name	Duration	Total Slack	Predecessor	Cost	Finish
	1.2	Engineering	112 days	0 days		\$737,460	Mon 4/8/13
	1.2.1	Body / Engine Draft Design	45 days	0 days		\$149,400	Thu 1/3/13
	1.2.1.1	Initial Draft	35 days	0 days	9	\$121,800	Thu 12/20/12
	1.2.1.2	Integration analysis	10 days	0 days	13	\$27,600	Thu 1/3/13
	1.2.2	Mechanical Engineering	80 days	148 days		\$238,800	Thu 2/28/13
	1.2.2.1	Engine Design	80 days	165 days	10	\$182,400	Thu 2/28/13
	1.2.2.2	Mechanics Design	30 days	138 days	10FS+10 days	\$56,400	Thu 1/3/13
	1.2.3	Electrical Engineering	57 days	138 days		\$148,080	Mon 3/25/13
	1.2.3.1	Electrical design	30 days	138 days	17	\$81,600	Thu 2/14/13
	1.2.3.2	Wiring	15 days	160 days	19	\$27,600	Thu 3/7/13
	1.2.3.3	Others Elect	27 days	138 days	19	\$38,880	Mon 3/25/13
	1.2.4	Structural Engineering	67 days	0 days		\$120,480	Mon 4/8/13
	1.2.4.1	Body	30 days	0 days	12	\$66,080	Thu 2/14/13
	1.2.4.2	Other Body Parts	30 days	165 days	12	\$43,200	Thu 2/14/13
	1.2.4.3	Design integration review	10 days	138 days	14,17,21,24	\$11,200	Mon 4/8/13
	1.2.5	Body / Engine Structure	30 days	0 days		\$69,500	Thu 3/28/13
	1.2.5.1	Chassis	20 days	155 days	23	\$24,450	Thu 3/14/13
	1.2.5.2	Other Structures	10 days	0 days	23	\$9,950	Thu 2/28/13
	1.2.5.3	Mechanics Parts	20 days	145 days	28	\$16,250	Thu 3/28/13
	1.2.5.4	Electric - Electronic Parts	10 days	0 days	28	\$18,850	Thu 3/14/13
	1.3	Final review	10 days	0 days	30	\$11,200	Thu 3/28/13
	1.3.1	Part Ordered	15 days	0 days	31	\$33,000	Thu 4/18/13
	1.3.2	Part Delivered	10 days	0 days	33FS+20 days	\$6,800	Thu 5/30/13
	1.4	Manufacturing Assembly	18 days	0 days		\$41,120	Tue 6/25/13

Figure 19.2 Team planner Gantt chart.

1	Resource Name	Type	Material	Initials	Group	Max.	Std. Rate	Ovt. Rate	Cost/Use	Accrue At
1	Designer	Work		DES	DES	400%	\$75/hr	\$75/hr	\$0	Prorated
2	Tester	Work		TEST	TEST	200%	\$45/hr	\$45/hr	\$0	Prorated
3	Business Analyst	Work		BA	BA	500%	\$50/hr	\$50/hr	\$0	Prorated
4	Mechanical Engineer	Work		ME	ME	400%	\$40/hr	\$40/hr	\$0	Prorated
5	Electrical Engineer	Work		EE	EE	200%	\$35/hr	\$35/hr	\$0	Prorated
6	Procurement	Work		PROC	PROC	500%	\$25/hr	\$25/hr	\$0	Prorated
7	Mechanic	Work		MECH	MECH	200%	\$40/hr	\$40/hr	\$0	Prorated
8	The resource is overallocated and should be leveled.	Work		DRIVE	INV	100%	\$100/hr	\$0/hr	\$0	Prorated
9	Fiberglass	Material		GLASS	INV		\$225		\$0	Prorated
10	Tires	Material		TIRE	INV		\$50		\$0	Prorated
11	Wires	Material		WIRE	INV		\$300		\$0	Prorated
12	Metal	Material		METALS	INV		\$0		\$0	Prorated

Figure 19.3 Team planner resource sheet.

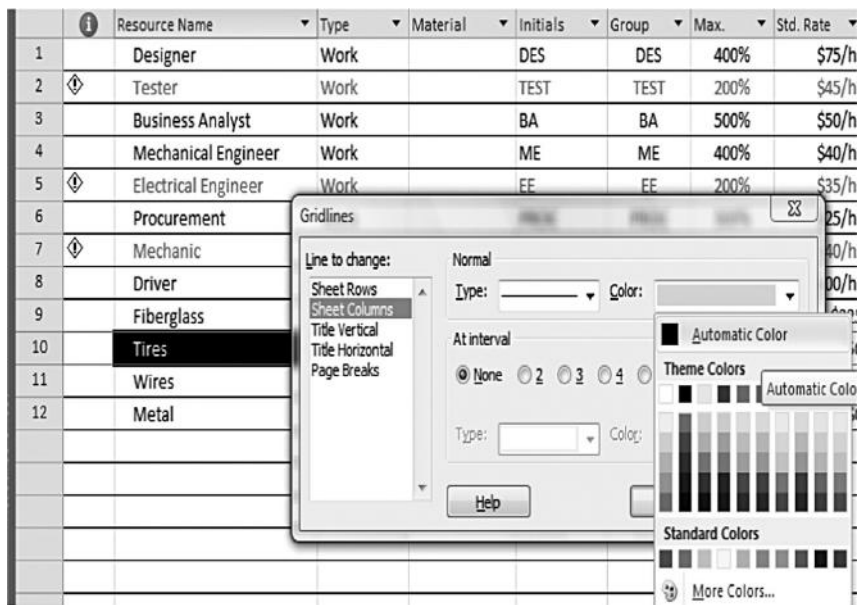


Figure 19.4 Team planner resource sheet format menu.

is placed over the yellow diamond shape figure with an exclamation point in it, a pop-up message is displayed as seen in the figure that states that the resource has been overallocated and needs to be leveled. The term leveled simply means that there is an imbalance between planned and actual available resources. PMI (2008) describes the term resource leveling as schedule decisions driven by resource constraints. Sometimes a schedule start or finish date could be impacted due to a resource constraint such as limited resources. Figure 19.4 displays how easy it is to format the resource sheet with gridlines and color options. For example, under the “Resource Sheet Tools” tab, a user can click on “format” followed by “gridlines” to change the appearance of the resource sheet.

Team planner resource usage

The resource usage chart under the team planner menu provides another view of resources and specifically provides information to the PM regarding where the overallocation is occurring. Figure 19.5 displays the resource usage tool. Within MSP, the “Tester” would appear in red and would also have the same yellow diamond with an exclamation point in it to indicate the overallocated resource. There is an “Overallocated” column, where the words “yes” or “no” appear indicating specifically where the overallocation occurs. For instance, with the

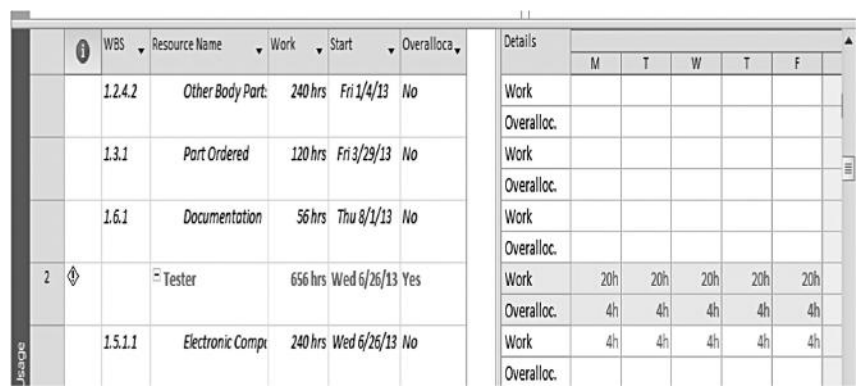


Figure 19.5 Team planner resource usage.

tester, it shows a “yes” for overallocation but a person has to then view all of the tasks located below that specific resource, tester in this example, to see which task involving a tester has been overallocated. Also, the user can scroll right or left on this page for each of the displays. The first display is of the resources and the tasks affiliated with each resource category. Whereas the second display, located on the right side of the screen, displays a calendar where a user can scroll throughout the duration of the project to view the overallocated tasks in red. This shows the exact time period and exact task along with the number of hours where there is an overallocation issue. If it is again a temporary infrequent issue of a few hours, then perhaps the easy solution is over-time but more often, a more complex resolution is needed.

Team planner resource graph

An example of a resource graph is displayed in Figure 19.6. A resource graph will be available for every category of resource identified within an MSP file. There are two different views or panes just as in the resource usage view. A user can scroll right or left within each pane to view different resource categories on the left-hand side of the screen and can scroll the schedule on the right-hand side of the screen until red is displayed to indicate the overallocated resource and at which specific time period the overallocation occurs. In the previous resource usage chart, the overallocation is displayed in terms of the number of hours that have been allocated and overallocated for a particular resource. The resource graph displays the information similar to the resource usage other than it does not show specific hours but is a graphical depiction of the allocation in terms of 100% indicating one person. Figure 19.6 shows a period in which the tester requirement is five resources (500%); however, the

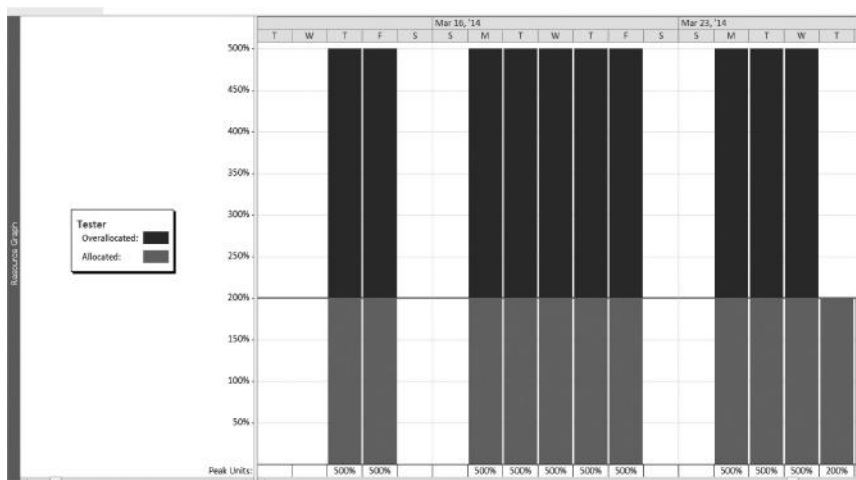


Figure 19.6 Team planner resource graph.

available level is only two (200%). In MSP, the bars will appear in red from 200% to 500% since three (300%) additional resources are needed on each of these days if the work is to be performed within the current time period. The bar color will appear in blue for 0–200%. Note that there may be other areas in the schedule where additional testers need to be assigned as resources to a specific task since this figure just displays a snapshot in time.

Team planner team planner

The team planner menu also has a team planner display which is shown in Figure 19.7. This graph is a visual way of seeing the overallocated resources as it displays which tasks are involved in the overallocation. In MSP, the overallocated resources would once again be displayed in red and in this instance apply to the tester, electrical engineer, and mechanic. The specific task where the overallocation is occurring will also have red around the task box. In this example, the red would be seen around “Station Electric” and “Finishing” tasks for the mechanic. Keep in mind that other resources are overallocated and other tasks for the mechanic may also be overallocated as this figure only shows a snapshot of the schedule. Scrolling to the right and left will display other overallocated tasks for these overallocated resources. Tasks can be moved with the cursor to other resources or other places in the schedule. Also, unassigned tasks can be assigned to a resource while in this view. This chart provides a high-level view, so moving tasks around is difficult but this view will let

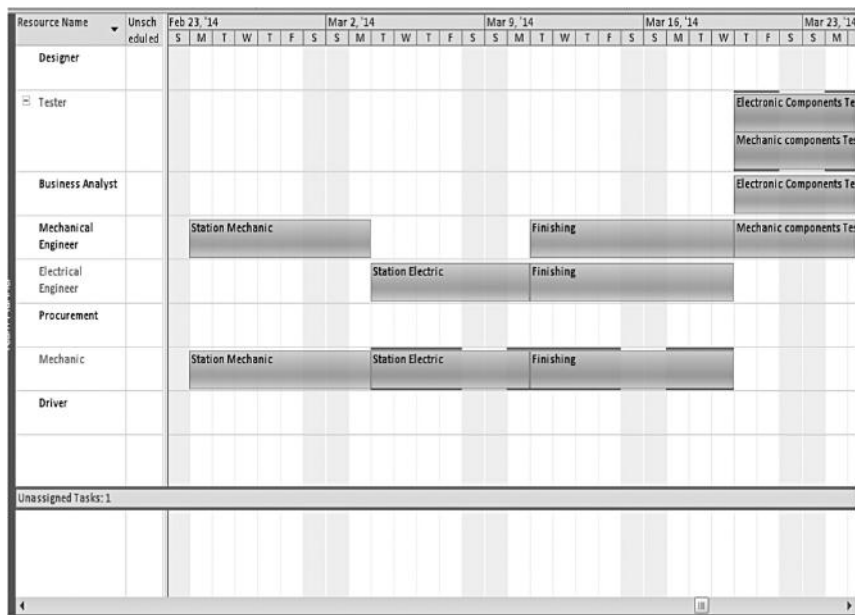


Figure 19.7 Team planner team planner graph.

the user grab a boxed task with a cursor and move it to a different place within the schedule or even move it up or down to a different resource to perform.

Wizard

There is a resource leveling wizard within MSP. The wizard is found by clicking on the “Resource Leveling” option of the “Resource Sheet” tab. The “Resource Leveling” menu is displayed in Figure 19.8. To run the wizard, click on the “automatic” box for leveling calculations and “Level entire project.” Different options can be selected for the “Leveling Order” section of the menu. The wizard must be used with caution. It may greatly add to the duration of the task and in some cases, the wizard is unable to resolve resource constraints.

Figure 19.9 demonstrates a sample of the many pop-up messages that function to notify the user that the wizard was unable to resolve the resource constraint. Therefore, just because the wizard was utilized does not mean that all or even any of the resource constraint issues for the project have been resolved. If the problems are not resolved, it will cause issues for the PM in getting the project work done. Always keep a backup file copy if the wizard is used so that comparison of the solution

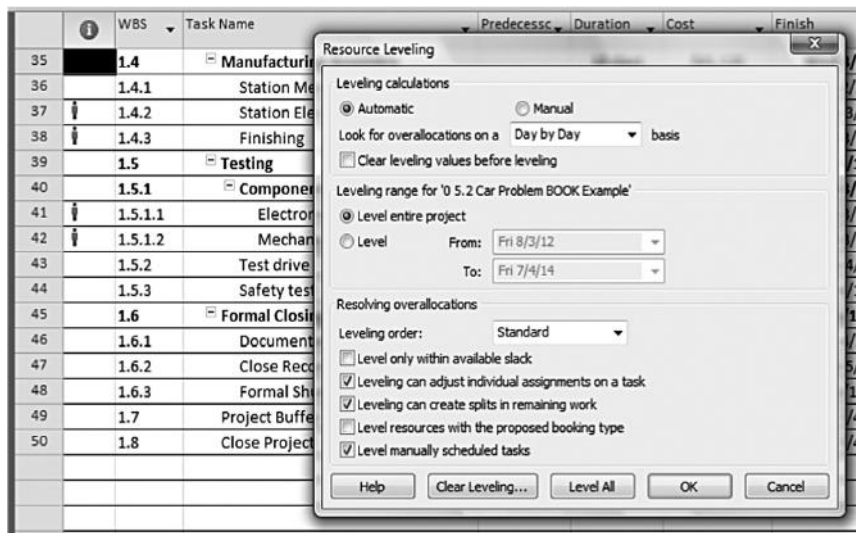


Figure 19.8 Leveling option wizard menu.

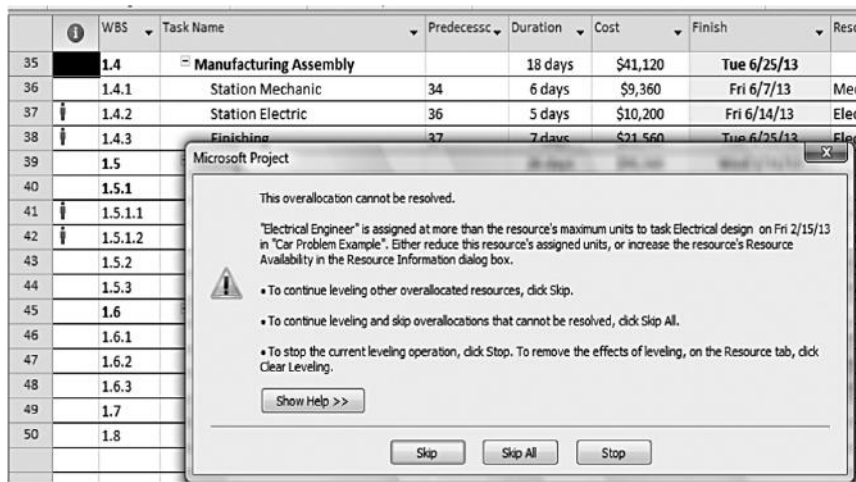


Figure 19.9 Wizard pop-up menu.

the wizard provided can be seen against the original file to make certain that the solution is viable. Again, it is important to note that when using the wizard, it may greatly impact the duration of the project. Figure 19.10 displays the resource sheet with unresolved overallocation issues. In MSP, the tester, electrical engineer, and mechanic would be displayed in red, indicating the overallocation of these resources. The

	Resource Name	Type	Material	Initials	Group	Max.	Std. Rate	Ovt. Rate	Cost
1	Designer	Work		DES	DES	400%	\$75/hr	\$75/hr	
2	Tester	Work		TEST	TEST	200%	\$45/hr	\$45/hr	
3	Business Analyst	Work		BA	BA	500%	\$50/hr	\$50/hr	
4	Mechanical Engineer	Work		ME	ME	400%	\$40/hr	\$40/hr	
5	Electrical Engineer	Work		EE	EE	200%	\$35/hr	\$35/hr	
6	Procurement	Work		PROC	PROC	500%	\$25/hr	\$25/hr	
7	Mechanic	Work		MECH	MECH	200%	\$40/hr	\$40/hr	
8	Driver	Work		DRIVE	INV	100%	\$100/hr	\$0/hr	
9	Fiberglass	Material		GLASS	INV		\$225		
10	Tires	Material		TIRE	INV		\$50		
11	Wires	Material		WIRE	INV		\$300		
12	Metal	Material		METALS	INV		\$0		

Figure 19.10 Wizard resource sheet result.

wizard in this particular case was unable to resolve the overallocation issues, yet somehow the project finish date was shown as being earlier than the original project end date. This is an interesting situation but the point to be made is that it is important to keep the baseline file for comparison purposes. Comparing both files would indicate to the PM that the project finish date was reduced, yet the resource overallocation issues were not resolved indicating to the PM that something is not correct. The reality of the situation is that unresolved overallocation resources would not actually result in a decreased project end date and instead result in a delayed schedule for the project. The next example section of the chapter discusses ways to use the different MSP tools to help resolve overallocation issues.

Resource leveling reallocation examples

The previous section discussed different MSP resource analysis tools available. This section presents four different examples of how to use these tools to detect the resource overallocation issue and how to resolve the overallocation. The first example resolves the overallocation issue through adding resources. The second example resolves the overallocation issue through reducing resources and extending the task duration. The third example resolves the overallocation issue through manually moving a task to a period where surplus resources exist. The fourth example resolves the overallocation issue through reducing resource workload as well as permitting overtime. Use of these methods or combination of these methods will illustrate techniques for the PM to resolve overallocated resource issues.

Example 1: Adding resources

In this example, the PM is faced with overallocated designers as displayed in the resource usage chart in Figure 19.11. Scrolling from right to left, we quickly learn that the designer category currently has four designers but needs two additional designers. The additional designers are needed since there is a continuous overallocation issue throughout the project. In this situation, the PM gets authorization from management to hire two additional designers, increasing the designer resource category from four to six. Therefore, resources can be added to MSP by clicking in the resource sheet box for designer and changing the resource from 400%, four designer resources, to 600%, six designer resources. Doing this results in the resource sheet within MSP turning from red to black for the “Designer” category since this category no longer has overallocated resources as displayed in Figure 19.12.

An alternative way of changing the designer from 400% to 600% is shown in Figures 19.13 through 19.15. Figure 19.13 displays that to add resources, clicking on a row in the MSP Gantt Chart view with a left mouse key brings up a menu with an add resources option. Click on “Assign Resources” and then another menu appears which is displayed in Figure 19.14. Click in this case on the designer resource. This will need to be confirmed as after you click on the designer resource, you then must click on “Replace” which brings you to another screen where you must click on the exact same category, a designer in this example, before the software

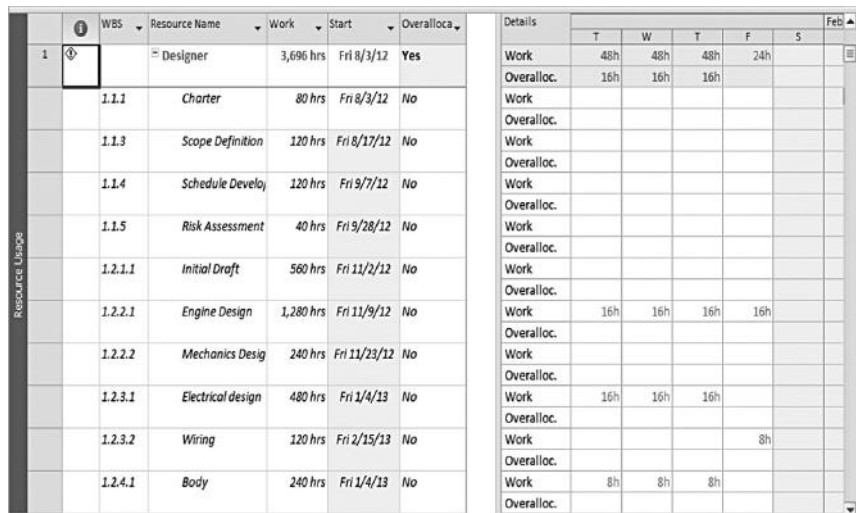


Figure 19.11 Resource usage chart of overallocated designer.

	Resource Name	Type	Material	Initials	Group	Max.	Std. Rate	Ovt. Rate	Cost/Use	Accrue At
1	Designer	Work		DES	DES	600%	\$75/hr	\$75/hr	\$0	Prorated
2	Tester	Work		TEST	TEST	200%	\$45/hr	\$45/hr	\$0	Prorated
3	Business Analyst	Work		BA	BA	500%	\$50/hr	\$50/hr	\$0	Prorated
4	Mechanical Engineer	Work		ME	ME	400%	\$40/hr	\$40/hr	\$0	Prorated
5	Electrical Engineer	Work		EE	EE	200%	\$35/hr	\$35/hr	\$0	Prorated
6	Procurement	Work		PROC	PROC	500%	\$25/hr	\$25/hr	\$0	Prorated
7	Mechanic	Work		MECH	MECH	200%	\$40/hr	\$40/hr	\$0	Prorated
8	Driver	Work		DRIVE	INV	100%	\$100/hr	\$0/hr	\$0	Prorated
9	Fiberglass	Material		GLASS	INV		\$225		\$0	Prorated
10	Tires	Material		TIRE	INV		\$50		\$0	Prorated
11	Wires	Material		WIRE	INV		\$300		\$0	Prorated
12	Metal	Material		METALS	INV		\$0		\$0	Prorated

Figure 19.12 Designer 600% resource sheet view.

Team Planner	Fix in Task Inspector...	Information	Notes	Details	Level Selection	Level Resource	Level All	Clear Leveling	Next Overallocation
View	Reduce Work	Properties							
	Increase Duration								
	Ignore Problems for This Task								
1	Cut Cell	First Cut	501 days	\$1,252,920	Fri 7/4/14				
2	Copy Cell	Project Initiation	75 days	\$166,400	Thu 11/15/12				
3	Paste		10 days	\$17,200	Thu 8/16/12	Business Analyst, Designer			
4	Paste Special...	ers Identification	3	5 days	Thu 8/23/12	Business Analyst			
5	Scroll to Task	Initiation	3	15 days	Thu 9/13/12	Business Analyst, Designer, El			
6	Insert Task	Development	5	15 days	Thu 10/4/12	Designer, Electrical Engineer, A			
7	Delete Task	ment	6	5 days	Thu 10/11/12	Business Analyst, Designer			
8	Inactivate Task	Initiation	7	15 days	Thu 11/1/12	Business Analyst			
9	Manually Schedule	ent Charter Approval	8	5 days	Thu 11/8/12	Business Analyst			
10	Auto Schedule	ie	9	5 days	Thu 11/15/12	Business Analyst			
11	Assign Resources...			286 days	\$737,460	Fri 12/13/13			
12	Fill Down	ine Draft Design		45 days	\$149,400	Thu 1/10/13			
13	Clear Contents	raft	9	35 days	\$121,800	Thu 12/27/12	Designer[200%], Electrical Engi		
14		ion analysis	13	10 days	\$27,600	Thu 1/10/13	Electrical Engineer[200%], Mec		
15	Information...	il Engineering		110 days	\$238,800	Thu 6/13/13			
16	Notes...	Design	10	80 days	\$182,400	Thu 5/2/13	Designer[200%], Mechanical E		
17	Add to Timeline	ics Design	10FS+10 day	30 days	\$56,400	Thu 6/13/13	Designer, Mechanical Enginee		
18	Hyperlink...	ngineering		72 days	\$148,080	Mon 9/23/13			
19		al design	17	30 days	\$81,600	Thu 7/25/13	Designer[200%], Electrical Engi		

Figure 19.13 Assign resources step 1.

will properly edit the selected task. This is displayed in Figure 19.15. *Note that it is very easy to accidentally click a different category of resource on the menu, so be sure to click the exact same resource on both menus so that the system correctly assigns the correct resource category. Once again, we see that adding additional resources will resolve the overallocation.*

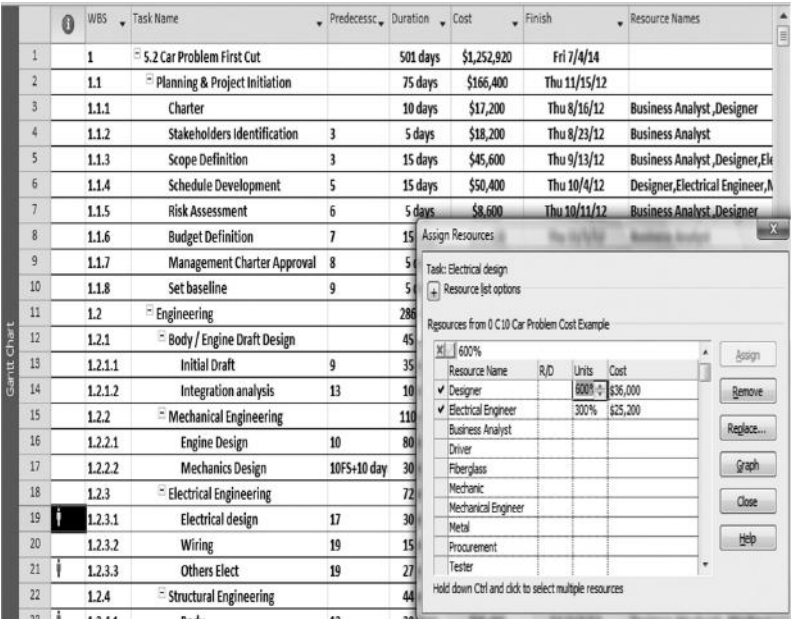


Figure 19.14 Assign resources step 2.

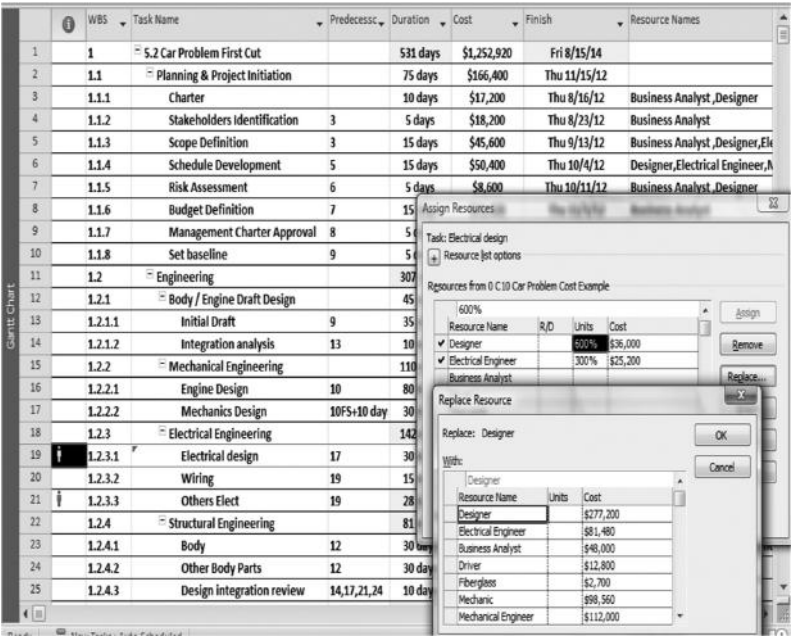


Figure 19.15 Assign resources step 3.

Example 2: Reducing resources and extending task time

In Example 2, the PM is faced with an overallocated electrical engineer. In this situation, there is only an issue with one task, task 1.2.3.1 which is named “electrical design.” The PM will resolve this issue through decreasing the number of electrical engineers from three to two since the project is only assigned two electrical engineer resources. However, this task will still require three resources if it is to be completed within the same time duration. Therefore, the PM will extend the task to make the task duration longer since the PM noticed that there are 209 days of slack affiliated with this task. So, there is no negative consequence with extending the task duration.

We begin by decreasing the resources to just two since we only have two available electrical engineer resources. To do this, refer back to Figure 19.13 to recall how to assign resources. Then, view Figures 19.16 and 19.17 which displays a similar view as shown in Figure 19.14, except this time we are reducing the electrical engineer resource category from three, 300%, as shown in Figure 19.16 to two, 200%, as shown in Figure 19.17. Clicking on replace brings you to Figure 19.17 which is a confirmation of which resource to modify, so select the electrical engineer box and then press “OK.” Note that in Figures 19.16 and 19.17, task 1.2.3.1 has a slack column value of 209 days and a task duration column of 30 days. Figure 19.18 displays how the slack and duration columns were automatically adjusted in task 1.2.3.1 due to the resources for the task being changed from three electrical engineers down to two electrical engineers. This figure shows how the slack column value decreased from 209 to 139 days and the duration column value increased from 30 to 45 days.

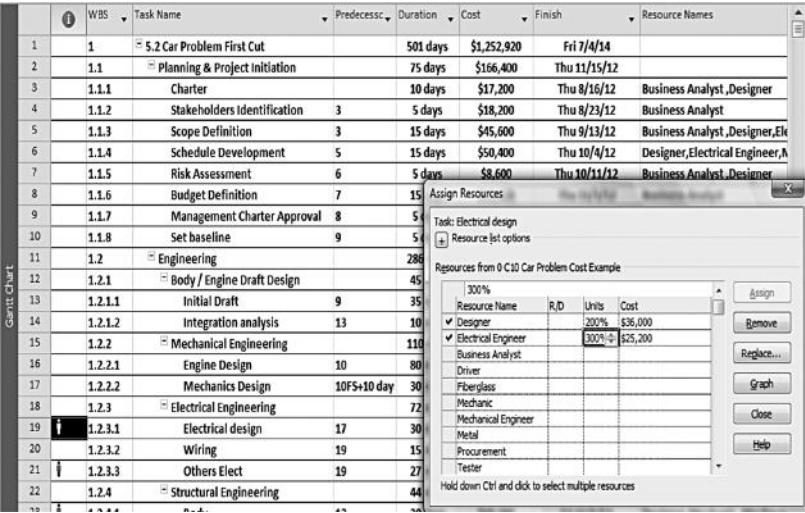


Figure 19.16 Reducing electrical engineer resource step 1.

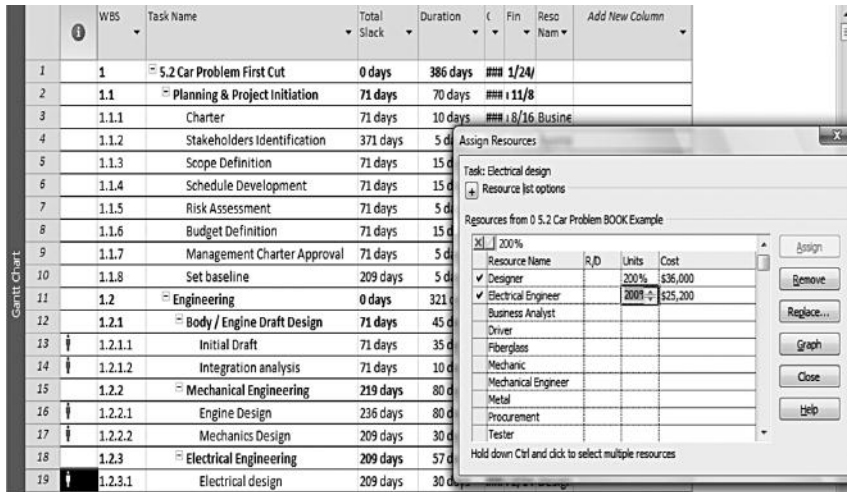


Figure 19.17 Reducing electrical engineer resource step 2.

	WBS	Task Name	Total Slack	Duration	Cost	Finish	T	F
1	1	5.2 Car Problem First Cut	0 days	531 days	\$1,252,920	Fri 8/15/14		
2	1.1	Planning & Project Initiation	0 days	75 days	\$166,400	Thu 11/15/12		
3	1.1.1	Charter	0 days	10 days	\$17,200	Thu 8/16/12		
4	1.1.2	Stakeholders Identification	516 days	5 days	\$18,200	Thu 8/23/12		
5	1.1.3	Scope Definition	0 days	15 days	\$45,600	Thu 9/13/12		
6	1.1.4	Schedule Development	0 days	15 days	\$50,400	Thu 10/4/12		
7	1.1.5	Risk Assessment	0 days	5 days	\$8,600	Thu 10/11/12		
8	1.1.6	Budget Definition	0 days	15 days	\$11,400	Thu 11/1/12		
9	1.1.7	Management Charter Approval	0 days	5 days	\$3,800	Thu 11/8/12		
10	1.1.8	Set baseline	139 days	5 days	\$11,200	Thu 11/15/12		
11	1.2	Engineering	0 days	322 days	\$737,460	Mon 2/3/14		
12	1.2.1	Body / Engine Draft Design	0 days	45 days	\$149,400	Thu 1/10/13		
13	1.2.1.1	Initial Draft	0 days	35 days	\$121,800	Thu 12/27/12		
14	1.2.1.2	Integration analysis	0 days	10 days	\$27,600	Thu 1/10/13		
15	1.2.2	Mechanical Engineering	219 days	110 days	\$238,800	Thu 6/13/13		
16	1.2.2.1	Engine Design	336 days	80 days	\$182,400	Thu 5/2/13		
17	1.2.2.2	Mechanics Design	139 days	30 days	\$56,400	Thu 6/13/13		
18	1.2.3	Electrical Engineering	139 days	157 days	\$148,080	Mon 1/20/14		
19	1.2.3.1	Electrical design	139 days	45 days	\$81,600	Thu 8/15/13		
20	1.2.3.2	Wiring	246 days	15 days	\$27,600	Thu 9/5/13		
21	1.2.3.3	Others Elect	139 days	43 days	\$38,880	Mon 1/20/14		
22	1.2.4	Structural Engineering	0 days	96 days	\$120,480	Mon 2/3/14		

Figure 19.18 Reduce task duration.

	WBS	Task Name	Total Slack	Duration	Cost	Start	Finish	
26	1.2.5	Body / Engine Structure	20 days	50 days	\$69,500	Mon 11/4/13	Fri 1/10/14	
27	1.2.5.1	Chassis	185 days	20 days	\$24,450	Mon 11/4/13	Fri 11/29/13	
28	1.2.5.2	Other Structures	0 days	10 days	\$9,950	Mon 12/2/13	Fri 12/13/13	
29	1.2.5.3	Mechanics Parts	155 days	20 days	\$16,250	Mon 12/16/13	Fri 1/10/14	
30	1.2.5.4	Electric - Electronic	0 days	10 days	\$18,850	Mon 12/16/13	Fri 12/27/13	

Figure 19.19 Overalllocation task 1.2.5.1.

WBS	Task Name	Total Slack	Duration	Cost	Start	Finish	October	November	December	January
							Oct	Nov	Dec	Jan
1.2.4.3	Design integration review	139 days	10 days	\$11,200	Tue 2/11/14	Mon 2/24/14				
1.2.5	Body / Engine Structure	20 days	50 days	\$69,500	Mon 11/25/13	Fri 1/31/14				
1.2.5.1	Chassis	185 days	20 days	\$24,450	Mon 11/25/13	Fri 12/20/13		11/25		12/20
1.2.5.2	Other	0 days	10 days	\$9,950	Mon 12/2/13	Fri 1/3/14			12/23	1/3

Figure 19.20 Movement of Gantt chart bar.

Example 3: Manually moving tasks

In this example, the PM is faced with an overallocated mechanic for task 1.2.5.1, chassis. The total slack is 185 days and the duration for the task is 20 days as displayed in Figure 19.19. Therefore, the best way to handle this overallocation is to simply move the task to a different 20-day time period that does not violate the range of the slack time period. This is accomplished by manually moving the Gantt bar with the mouse to an open time period. The start date was 11/4/2013 and finish date 11/29/2013 for the task. The task in the Gantt chart view was moved with the mouse to later in the schedule making the new start date to 11/25/2013 and new finish date to 12/20/2013. This was an easy way to resolve the overallocation (Figure 19.20).

Example 4: Reducing resource workload and permitting overtime

In this example, the PM is faced with an overallocated tester resource category for task 1.5.1.1, electronic components testing as displayed in Figure 19.21. Since there is slack time of 138 days and the task duration is 15 days, the PM has decided to handle this overallocation by reducing

	WBS	Resource Name	Work	Start	Overalloca	Details
	1.6.1	Documentation	56 hrs	Thu 8/1/13	No	
2		Tester	656 hrs	Wed 6/26/13	Yes	
	1.5.1.1	Electronic Comp	240 hrs	Wed 6/26/13	Yes	
	1.5.1.2	Mechanic comp	160 hrs	Wed 6/26/13	No	

	T	W	T	F	S
Work					
Overalloc.					
Work		40h	40h	40h	
Overalloc.		24h	24h	24h	
Work		24h	24h	24h	
Overalloc.		8h	8h	8h	
Work		16h	16h	15h	

Figure 19.21 Overallocated tester task 1.5.1.1.

the resources which will extend the task duration and handle the small remaining resource gap through overtime. Figure 19.13 earlier in this section displayed how to initiate the add resources menu. Figures 19.22 and 19.23 display the two steps taken once the user is at the add resources menu. In this example, the resources for the tester were reduced from two testers, 200%, to half of a tester, 50%, so that the tester would be able to complete other tasks during this period. This stretched the task to a longer duration but as discussed in earlier examples, there is slack available, so extending the task does not cause a negative outcome for the project. This still leaves the PM with 16 hours of work needed over an 8-day period. The PM in this case will authorize overtime since it results in the two testers needing to each work 2 hours of overtime a day for a short period of time. Figure 19.24 displays a portion of the 8-day period where two testers will work 2 hours of overtime each. This resolves the overallocation.

	WBS	Task Name	Total Slack	Duration	Fin	Reso Nam	Add New Column
41	1.5.1.1	Electronic Components Testing	138 days	15 days	### Tue	Busine	
42	1.5.1.2	Mechanic components Testing	71 days	10 d		/16/1 Analys	
43	1.5.2	Test drive	71 days	8 d			
44	1.5.3	Safety test	71 days	8 d			
45	1.6	Formal Closing	71 days	21 d			
46	1.6.1	Documentation	71 days	7 d			
47	1.6.2	Close Records	71 days	7 d			
48	1.6.3	Formal Shutdown	71 days	7 d			
49	1.7	Project Buffer	71 days	35 d			
50	1.8	Close Project	71 days	0 d			

Assign Resources

Task: Electronic Components Testing

Resource list options

Resources from 0 5.2 Car Problem BOOK Example

Resource Name	R/D	Units	Cost
Business Analyst		100%	\$4,000
Tester		200%	\$10,800
Designer			
Driver			
Electrical Engineer			
Fiberglass			
Mechanic			
Mechanical Engineer			
Metal			
Procurement			

Hold down Ctrl and click to select multiple resources

Assign Remove Replace Graph Close Help

Figure 19.22 Reducing tester resource step 1.

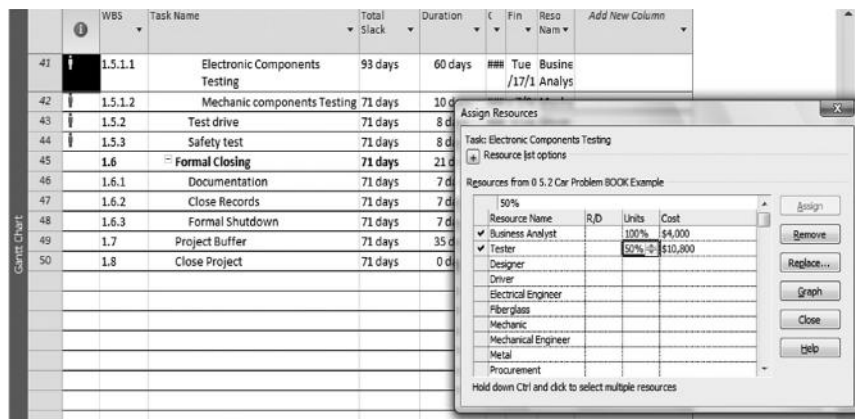


Figure 19.23 Reducing tester resource step 2.



Figure 19.24 Tester overtime hours.

There is an alternative way in MSP of resolving resource conflicts. Clicking within the MSP Gantt Chart view and specifically on the over-allocated person (in the software it will appear in red on the Resource Sheet view), will bring you back to Figure 19.13. Previously, the “Assign Resources” option within this figure was discussed. However, there is an option at the top of the menu called “Fix in Task Inspector” which can be clicked on to bring you to the view in Figures 19.25 and 19.26. Figure 19.25 provides the user with button options to increase duration, reduce work, and assign additional resources. Figure 19.26 can be seen by scrolling down on the “Task Inspector” window as it alerts the PM to the specific factors affecting the task with resource overallocations which includes repair options. This is just another example to show how to resolve a resource constraint. However, it is important to note that this still may not fully resolve the issues. It is easy for the PM to use these tools but caution must be taken as full resolution of all issues may not occur without additional manual manipulation.

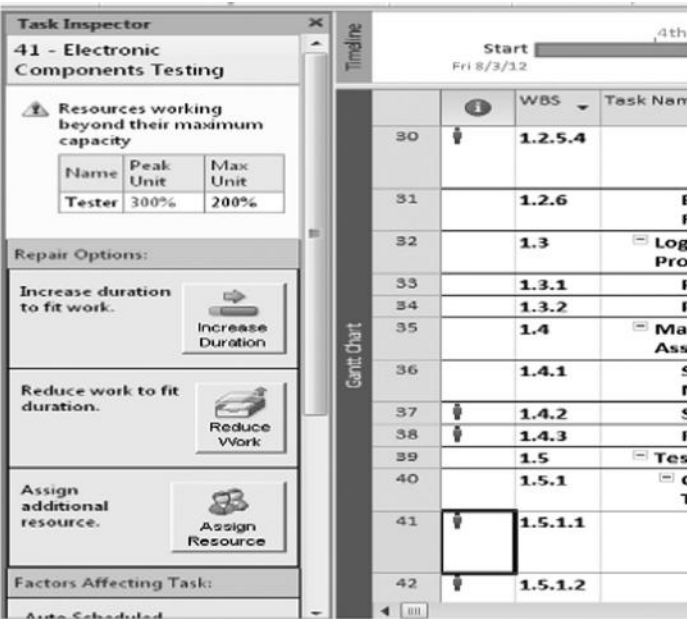


Figure 19.25 Task inspector display 1.

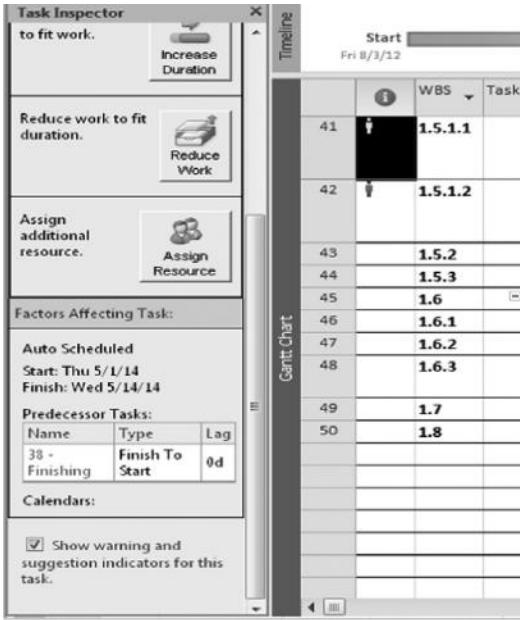


Figure 19.26 Task inspector display 2.

Summary

Users need to be well versed in understanding resource leveling options and the internals of the project itself. An analyst cannot take over the job of a mechanic, as obviously not every resource can perform the jobs of other resources. In fact, most resources cannot perform the job of other skill resources. The dynamic management of resources is one of the most difficult tasks faced by the PM. If you do not do anything at all to resolve resource mismatches, the project will likely slip. One of the jobs of the PM is to do the best job possible in keeping the project moving. Just as the construction project example, resources can be assigned to work on a different task early under cover since an outdoor construction task cannot occur during severe weather. Different methods and combination of methods were discussed here in handling overallocated resources. Use of these methods or combination of these methods provides a sample of how the PM can resolve overallocated resource issues.

QUESTIONS

Review questions

1. What is resource leveling?
2. What are the primary methods for resolving resource constraints?

In-class question

1. Use the Internet to identify and describe the functionality of two different software tools available for resource leveling.

EXERCISES

1. The publisher's website contains a file labeled *C19 Student File*. Use these data and your knowledge of resource leveling to resolve one of the many resource constraint issues. Demonstrate which method or combination of methods was used in resolving one of the resource constraints.
2. The publisher's website contains a file labeled *C19 E2 Student File*. Use these data and your knowledge of resource leveling to resolve the simple resource constraint using the wizard.

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section six

Advanced tools and techniques

This section of the textbook contains a collection of materials that would be categorized as both contemporary and advanced. Each of these topics represents an important aspect of the project life cycle that, if utilized, can improve the overall chances of success. In each case, the method described in these chapters focuses on a different aspect of project decision-making from early on in the selection process to team management during execution. The learning objectives for this section are

1. Understand the PERT model as it relates to variable time scheduling.
2. Describe how simulation modeling can be used to model future project performance.
3. Outline the basic mechanics of the risk model to illustrate how simulation tools can help with the evaluation of the project performance.
4. Identify tools and techniques for a PM to utilize in the management of the human element of the project.
5. Understand tools and techniques that can be utilized by a PMO to be successful.
6. Understand project, program, and portfolio management as it applies to an enterprise PMO.

A brief goal statement for each topic is included below.

Variable time analysis

Recognizing that time and cost estimates are not a deterministic value, is an important aspect of management maturity. Chapter 20 approaches this topic through the classical PERT model developed in the mid-1950s. This background represents a fundamental level of understanding related to variable time scheduling. That classical view is translated into an MS Project format through the use of custom macros. Also, Excel functions

are brought into the picture to illustrate how they can produce various time predictions based on the model.

Simulation modeling

A modern extension of variable time analysis is illustrated through computer simulation techniques in Chapter 21. In project management, the area of simulation modeling is increasingly becoming more popular as a tool to identify similar information as identified with the PERT tool but without relying on extensive statistics theory. The authors suggest that use of simulation can help forecast future project performance so that less overruns and late completion times occur. Overall, simulation modeling tends to be more easily understood and more content-rich making it worthy of inclusion as a valuable management tool. For that reason, the goal of this section is to describe how this technique can be used to model future project performance. The Full Monte add-in will be used to provide examples of this class of tool.

Risk mechanics

One of the least mature processes in project management involves the concept of risk. Over the past 10 years, the development of a risk model is beginning to be embraced as a required management activity. Chapter 22 outlines the basic mechanics of this standard model and illustrates how simulation tools can help with the evaluation of this aspect of the life cycle.

Team tools

As project management theory has evolved over the past 60 years or so, there has been a growing recognition that success ultimately rests with the humans associated with the effort. Chapter 23 discusses many aspects regarding the team management activity to include tools that are important to this process. Probably the most significant human management artifact is planning and tracking of the human element. Previous mechanics have indicated that a perfect plan will fail if it is not properly staffed with the required quality and quantity of resources. Also, it is important to formally define the roles for the project team.

Enterprise PMO

The enterprise PMO or strategic PMO strives to make sure the right projects are done at the right time with the right tools and templates and contributes to the organization's strategic plans. Chapter 24 covers the main reasons why the majority of today's PMOs have mediocre success and

what can be done to improve the situation. The chapter also covers projects, programs, and portfolio management and how to move wisely to an enterprise PMO.

Summary

Collectively, these chapters complete our overview of major tools and techniques. We recognize that whole texts exist for each of these topics, so these introductions are meant more to sensitize the reader to their existence than to cover the complete topic.

chapter twenty

Variable time project planning

Introduction

Up to this point task durations have been shown as a single time estimate and from that a project schedule and completion date were calculated. Sufficient background has now been developed to relax this simplifying assumption. It should now be obvious that project dynamics and the related complexity will make any work unit estimate somewhat uncertain. For this reason, it is time to explore how to handle this recognition. Think about the implications of this new view. If the plan says that a project is going to be completed on June 1, we now know that is highly unlikely to be the case. The question to ponder from this is, “what would be a more honest approach?” Would it not be more accurate to say that the most likely completion estimate is June 1, but there is a 50% chance that it could exceed August 1, or that there is a 90% chance of the completion being in the range of April 1 through August 1. It may well be true that stakeholders are more used to getting a single answer to this question, but from a maturity viewpoint, we need to infuse a more insightful (and accurate) approach to both scheduling and cost estimates. One way to accomplish this is by estimating task times using an assumed probability distribution with multiple estimated task duration values. The goal of this chapter is to describe a classic approach for dealing with this class of project schedule estimation.

PERT history and theory

The original variable time project planning model emerged from the high-technology project world of DoD in the mid-1950s. This classic network-based model was named PERT and it uses three time estimates for task durations. In this manner, the PERT model established a method for looking at project completion range times through the manipulation of a scheduling network and empirical probability functions.

The original PERT model was developed by the U.S. Navy, the Lockheed Corporation, and the consulting firm of Booz, Allen, and Hamilton for use on the highly complex Polaris missile project (Sapolsky 1972). The goal of this project was to develop a missile that could be launched from a submerged submarine, jump out of the water, ignite, fly 5000 miles to a target, and land very close to that target. At the time, this goal was felt by many to be unattainable, but the project was in fact successful and PERT was given

much of the credit. A historical review of the project suggests that it was in fact given too much credit, but the underlying time management concept is still recognized as a valuable contribution to project management theory. This tool focused on developing a schedule for a technically complex project and it illustrated how the multiple time estimate approach could be used to generate a probabilistic range completion schedule (Gale 2006). The initial step was to define the required tasks and work sequence using an AOA network diagram similar to that previously discussed in Chapter 9. Step 2 defined each task as having a range of values based on an assumed probability distribution. The underlying logic of this design was based on the understanding that high-technology projects were prone to significant estimating errors, so the first order of business was to identify a method for defining a variable time estimate (Brown 2002). In the high-technology project world, it was found that a symmetrical distribution was not appropriate since a task might optimistically take as little as 3 days to complete, most likely take 8 days, but in the pessimistic worst case could take as long as 30 days. After some consideration, it was decided to model this situation using a beta probability distribution, which has the characteristic of being able to represent skewed values in either a positive or negative direction. Figure 20.1 illustrates both examples.

Note the sample values shown on each sample beta distribution. In each of these cases, the curve shape is defined by three shaping time estimates: optimistic (a), most likely (m), and pessimistic (b). The underlying statistics for this are beyond the scope of this textbook, but well documented in the industry literature. To simplify commercialization of this model, the designers defined two empirical formulas to represent the median time and standard deviation parameters. These formulas and the associated definition of variance are as follows:

$$T(E) = (a + 4 * m + b)/6 \quad [\text{median time}]$$

$$\sigma = (b - a)/6 \quad [\text{standard deviation}]$$

$$\text{Variance} = \sigma^2$$

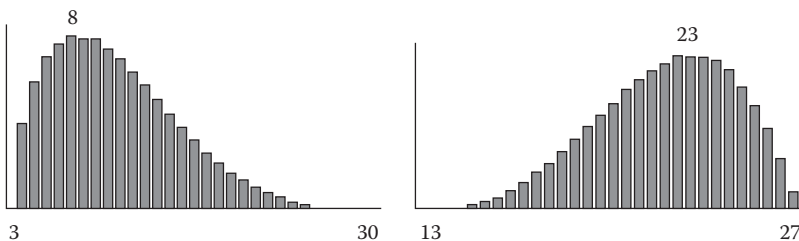


Figure 20.1 Sample beta distributions.

By using the three work unit time estimates, it is possible to produce an estimated duration time $T(E)$, which is intended to be the median (50th percentile) task estimate. Also, the standard deviation formula provided a range-estimating-type measure. $T(E)$ values would then be used to produce an expected project schedule time just like the normal scheduling process; however, the addition of task standard deviation and variance values for each task adds another dimension to the problem. With this latter information, it is possible to estimate how much variability exists in the plan and from that data a measure of completion variability can be computed. The project schedule range assumption is based on the notion that the critical path defines the project duration, so the challenge is to define the variation of the critical path. $T(E)$ values on the critical path then define the most likely schedule for the project, while the sum of the critical path task variances provides a statistical measure to define its range. Given the lack of project management maturity during this early period, PERT offered a more complex solution than most organizations could handle. As a result, even today, this model is not used in the majority of project plans. Notably, MS Project 2010 dropped its built-in calculator for this technique supposedly because of low usage. Nevertheless, as a project management concept, PERT still has analytical merit and the tools in existence today make its usage reasonable. Certainly, the schedule analysis aspects of the model make it a tool that should be understood and used more frequently. We will see in Chapter 21 that other more modern tools now exist for this purpose, but the textbook would be remiss for not describing the classic role of PERT in project management evolution.

A major goal of this chapter is to show how viewing project time estimates as variables rather than single-valued estimates can bring improved insights into project schedule and cost planning. The first step in this culture change is to understand the logic of multiple time estimates. Once these are translated into a median schedule, the next question becomes how to define the overall variability of the project. To accomplish this, we rely on a statistical concept called the central limit theorem (CLT). This technique says that if we have a sufficiently large enough number of tasks on the critical path (say 30 or more), the resulting project schedule variability would be a normal distribution. Furthermore, the standard deviation of this distribution could be calculated by the square root of the sum of the task variances on the critical path. Our goal here is certainly not to dwell on proving the CLT, but rather to recognize what it means in the context of a project plan with variable time task estimates. Interested readers can find more on this through several other sources (see <http://www.netmba.com/operations/project/pert/>). The main goal of this discussion is to describe how variable time task estimates can be used to model a project schedule and then predict the probabilistic range values for that schedule. Mature organizations need to become familiar with this class of analysis since it actually is a more

accurate representation of the future than a single deterministic value that is almost certain to be wrong. One might consider the philosophy expressed by this view of project schedule status as *being approximately right is better than being absolutely wrong*. A subtle but indeed a valid point!

One must understand that not recognizing the ranges indicated by uncertain time estimates can leave a project vulnerable to a significant schedule overrun that could have been reasonably forecast using this technique. This resultant overrun creates the image that the PM does not understand what is happening.

The following section will show how the use of variable time estimates offers a different perspective for completion forecasting.

PERT mechanics

Note: Before starting this example, be aware that it is too small to technically obey the statistical CLT law of large numbers, but it is shown here to illustrate the calculation process. A larger network sample would be more arithmetically accurate, but the same process mechanics apply.

For this example, we define a project consisting of only four tasks, each assumed to be beta-distributed and each task with the same value ranges (see Figure 20.2).

Each task will be estimated with variable time range parameters of

- Optimistic (*a*) = 5 days
- Most likely (*m*) = 10 days
- Pessimistic (*b*) = 20 days

The expected time, $T(E)$, and variance for each task would yield a $T(E)$ of $(5 + 4 * 10 + 20)/6$, or 10.8 and a variance of $((20 - 5)/6)^2$ or 6.25. The four sequential tasks shown here obviously constitute the critical path and the estimated project duration is 43.2 days.

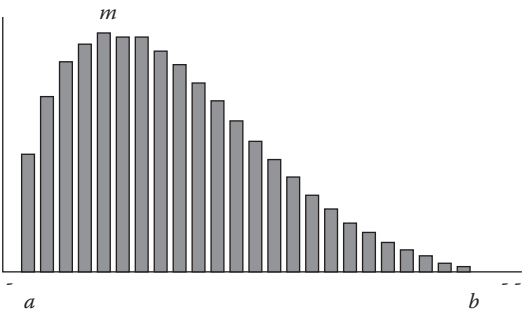


Figure 20.2 Beta distribution shape parameters.

	Task Name	Duration	Predecessors	a	m	b	Std Dev	Var	Start	Finish
1	Fig 20.3	43.2days		0	0	0	0	0	1/2	3/4
2	A	10.8days		5	10	20	2.5	6.25	1/2	1/16
3	B	10.8days	2	5	10	20	2.5	6.25	1/16	1/31
4	C	10.8days	3	5	10	20	2.5	6.25	1/31	2/17
5	D	10.8days	4	5	10	20	2.5	6.25	2/17	3/4

Figure 20.3 Sample program output.

PERT network calculation steps

The basic mechanics for analyzing a project schedule will be described using the multiple time estimate data in Figure 20.3. The checklist below summarizes the computational steps required to perform variable time analysis using the PERT model:

1. Collect a , m , and b parameters for each task (optimistic, most likely, and pessimistic).
2. Calculate $T(E)$ and σ^2 values for all tasks (see formulas previously shown).
3. Compute the project schedule using calculated $T(E)$ values as task durations.
4. Select the activities on the critical path for variability analysis. The calculated critical path duration value is defined to be μ , which is the central tendency of the project duration range.
5. Sum the computed variances for the critical path activities.
6. Compute the square root of the summarized variances from the step above. This value will yield the σ distribution shape parameter that is used to define the project statistical probabilistic range.
7. Perform the desired analysis regarding completion probability using the calculated μ and σ shape parameters. Excel built-in functions can be used to compute various range probability evaluations (shown below).

Schedule analysis

From the example data, the resulting expected project critical path duration would be 43.2, or four times 10.8 (see Figure 20.3). Values for standard deviation and variance can either be calculated using a spreadsheet or internally created with an MSP custom formula. As described above, project variability is dictated by the variance parameters on the critical path. In this example, the variance would be four times 6.25 or 25; therefore, the project standard deviation would be the square root of 25, or 5 days. Project does not automatically handle the aggregation of critical path variance or standard deviation, so this is a manual calculation. In a larger

network, these values will either have to be manually extracted from the critical path or sorted by total slack value to group the critical path tasks into a single manageable group. In this latter form, the critical path group could then be exported to Excel for further manipulation. Once the project $T(E)$ and critical path standard deviation (σ) have been identified, the required “shape parameters” are defined to evaluate expected project duration and a measure of dispersion (range).

The CLT assumption supports the notion that the resulting project probability distribution is represented by a normal distribution even though in the example plan there are technically an insufficient number of observations to satisfy the size requirement. In this example, this assumption is used to demonstrate the mechanics of the calculation process.

Figure 20.4 defines the basic shape parameters for the normal distribution. Note that its shape is determined by the two parameters μ and σ , where μ is the central tendency (median) or expected value and σ is a statistical measure of variability (dispersion around the median). For our sample program, the calculated expected time is 43.2 (or stated as 43, which is more realistic in this case) and the standard deviation is 5 as described above.

Using these two project characteristics, it is possible to define an expected duration range of the project schedule. Note the 2σ point on the distribution shows that there is 2.1% remaining area to the right under the curve. So, a 2σ point defines that there is a 2.1% probability that the project will exceed that point. Given a σ value of 5 and a μ value of 43, the 2σ point on the distribution would be 53 (i.e., $43 + 5 + 5$). In this type of estimating, decimal point-level accuracy should be dropped since this data does not have that accuracy level in the estimates. Also, recognize that other probabilistic statements regarding project duration by

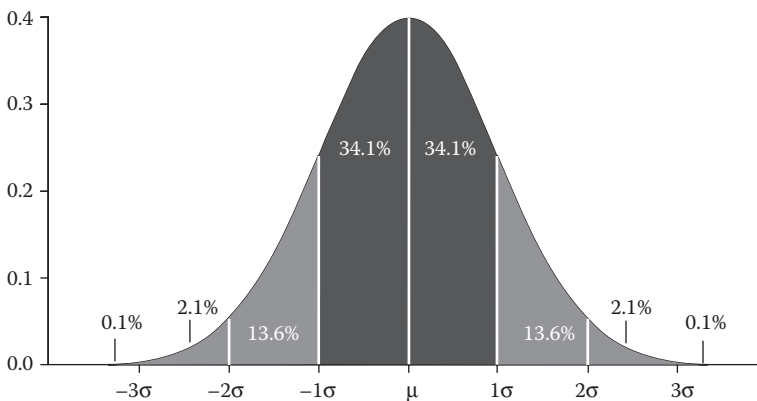


Figure 20.4 Normal probability distribution.

a defined point may be more appropriate to describe. In other words, at what point X is there an 80% probability of completion? Here is a sample statement that a PM could make from this type of calculation: "Our estimated project time is 43 days, but given variable time projections for each task, we estimate a project range to be in the 33–53-day range with a 95% confidence level (i.e., two sigma standard deviations in each direction from the median). Likewise, there is a 68% confidence level that the project range will be 43 ± 5 days" (see the normal distribution curve parameters to illustrate how these values were derived). Does that type of statement not sound like you have a good handle on this project's characteristics compared to just showing a 43-day schedule and then having that not come to pass? The calculation of confidence levels is an important consideration in the planning process and by itself makes going through this process a worthwhile exercise. Obviously, schedule analysis in this format can portray a much more meaningful view of the project schedule than a single value.

Project schedule range quantification

The previous examples of schedule probability have been limited to integer values of σ based on the standard deviation integer curve values shown above. However, there are occasions when this does not handle the desired question. Let us look a little deeper into a technique to add more options to the range analysis. It is possible to have a more granular interpretation of project duration by using the Excel built-in functions NORMINV and NORMDIST. These two functions are mirror images of each other in that they can alternatively define any duration point or probability value in the distribution given the two shape parameters. For instance, if we wish to estimate a 90% confidence duration completion point for the example program, this could be derived by the following Excel function:

=NORMINV(prob,μ,σ) or
=NORMINV(0.90,43,5)

This yields a value of 49.4, so the interpretation of that would be that we have a 90% probability of finishing prior to 49 work days. If we execute the same function for a 0.98 probability, the result would be the same as described earlier for a two sigma range calculation. Alternatively, the NORMDIST function yields a mirror image of the same data by computing the probability of finishing by some specified date. The syntax for this function is

=NORMDIST(X,μ,σ,CUMULATIVE DIST)

So, if we wish to know the probability that the project would finish prior to a target time X of 50 days, the syntax would be

`=NORMDIST(50,43,5,TRUE)`

This returns a value of 0.92, which translates to “there is a 92% probability that this project will finish prior to duration 50.”

It is unfortunate that this data is not more readily available through the standard MS Project variable set, but the important idea for now is to understand the basic logic of variable time scheduling. Chapter 21 will open this door a little further using simulation modeling for a similar result.

Triangular distributions

One of the complicating factors that have inhibited broader adoption of the PERT model variable time analysis is the level of statistics literacy in organizations. Use of beta distributions and the CLT simply offer too many mathematical concepts and Greek symbols for many to digest. One simplifying view to counter this has been to use a geometric triangular distribution with the same three time estimates. Figure 20.5 illustrates this distribution's shape in this role. It should be obvious that this shape is easier to explain to someone who does not have a good understanding of statistical probability distributions. Also, the related question that often arises in the use of PERT parameters is “how optimistic or pessimistic are we talking about?” This question will still remain regardless of the assumed distribution, but the triangular pictorial view seems more logical to most nonmathematical types.

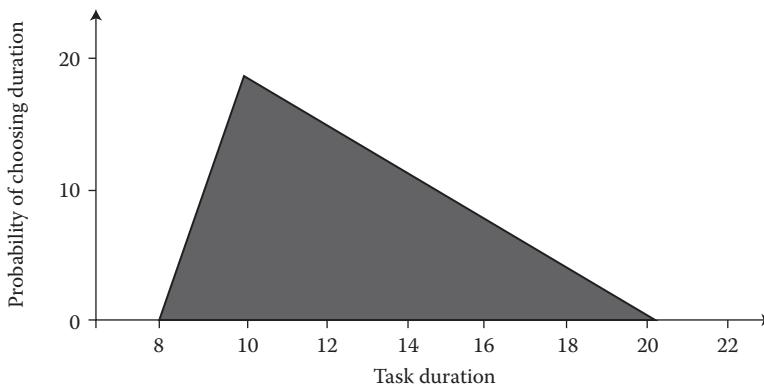


Figure 20.5 Triangular distribution.

The three shape parameters (a , m , and b) introduced for the beta distribution can also be used to describe this distribution; however, the $T(E)$ calculation formula is changed somewhat. Comparative $T(E)$ and variance formulas for the PERT and the triangular distributions are as follows:

$$T(E) = (a + 4m + b)/6 \quad \text{PERT Beta Model}$$

$$\sigma(\text{PERT}) = (b - a)/6$$

$$T(E)_{\Delta} = (a + 4m + b)/3 \quad \text{Triangular Model}$$

$$\sigma_{\Delta} = (a^2 + m^2 + b^2 - a * m - a * b - m * b)/18$$

The University of Virginia published a more accurate modification of the triangular distribution formula as follows (University of Virginia 2008):

$$\sigma_{\Delta} = [(b - a)^2 - (m - a)(b - a) + (m - a)^2]/18$$

Normally, formulas as complex as these should be avoided because of their complexity; however, desktop spreadsheets and stored macros make using them somewhat more reasonably. The triangle distribution option shown here is to simply illustrate that it is up to the project team to decide which set of mechanics best fit their environment. Regardless of the choice, many will still use the PERT empirical beta distribution formula regardless of the assumed distribution because it is most visible in the literature. Others will favor the triangular view and formula because it seems more understandable. In any case, regardless of the mathematics utilized, recognition of task variability is something that should not be ignored in project schedule analysis. The thing that is important to point out is that this class of method is more of a sizing calculation than a true mathematical one. Experience in using the approach will be necessary to answer the question of best results. There is no attempt made here to support one method over the other, although a brief example will be offered to illustrate the arithmetic differences generated with similar data.

Serious mathematicians will likely be more critical of using a triangular distribution over the more formal beta; however, realize that the empirical formulas for beta also contain arithmetic inaccuracies. Possibly the best way to leave this model topic is to suggest that we are looking for degrees of variation with more than two-digit accuracy. Realize that the three (a , m , and b) task-estimating parameters are subject to errors in their own right. Think of this process as a management analysis concept more than an engineering design calculation.

Table 20.1 is shown here to provide a comparison of arithmetic formula difference between these two methods. The standard PERT empirical formulas are compared to equivalent triangular parameters. The University of Virginia (UVA) standard deviation formula is used for the triangular standard deviation (σ_{Δ}).

Table 20.1 Comparison of PERT Beta and UVA Triangular Formulas

Activity	<i>a</i>	<i>m</i>	<i>b</i>	PERT <i>T(E)</i>	Triangular <i>T(E)</i>	<i>T(E)</i> Diff	PERT σ	Triangular σ_{Δ}	σ_{Δ} Diff (%)
A	1	2	4	2.2	2.3	0.2	0.50	0.62	25
B	1	2	3	2.0	2.0	0.0	0.33	0.41	22
C	2	3	6	3.3	3.7	0.3	0.67	0.85	27
D	2	3	3	2.8	2.7	−0.2	0.17	0.24	41
E	2	3	4	3.0	3.0	0.0	0.33	0.41	22
F	3	4	7	4.3	4.7	0.3	0.67	0.85	27
G	3	4	6	4.2	4.3	0.2	0.50	0.62	25
H	4	5	8	5.3	5.7	0.3	0.67	0.85	27
I	4	5	7	5.2	5.3	0.2	0.50	0.62	25
J	4	5	9	5.5	6.0	0.5	0.83	1.08	30
K	5	6	8	6.2	6.3	0.2	0.50	0.62	25
L	5	6	7	6.0	6.0	0.0	0.33	0.41	22
M	6	7	9	7.2	7.3	0.2	0.50	0.62	25
N	7	8	11	8.3	8.7	0.3	0.67	0.85	27
O	8	9	12	9.3	9.7	0.3	0.67	0.85	27
P	9	10	20	11.5	13.0	1.5	1.83	2.48	35
				AVG Diff		0.3			27

Note: Note that the PERT *T(E)* formula generates results for the sample data that are essentially the same as the triangular formula values, while the average standard deviation for the PERT formula is about 27% lower in comparison to the more complex UVA formula.

This difference is significant and it would be worthwhile to explore the underlying assumptions in both distributions to decide the preferred option. If we assume that this calculation difference is significant in the overall analysis, the project team will have to decide whether this error level warrants having to explain the more complex beta model, which is more frequently documented in the literature. In either case, the resulting values for *T(E)* and standard deviation are utilized the same in the schedule calculations. From this statistical base view, we have derived a reasonable measure of project variability quantification. Chapter 21 focuses on a similar view of this type analysis using simulation modeling, which represents the more modern and sophisticated method for dealing with variable task analysis.

Using macros for calculation

A macro can be loosely defined as a set of stored keystrokes or logic instructions much in the same operational form as a computer program. A more rigorous definition is that it is a rule set or pattern that specifies how an input set is to be mapped to an output. This technique is often used to simplify the execution of a complex sequence of logic operations

and this is the essential idea behind the use of macros in the variable time calculation role. A comparable result can be obtained using Excel spreadsheets to manipulate the data and then import the results directly into the MS Project plan data sheet.

To introduce one example to show why the stored macro approach might be more preferred, it is only necessary to look at the University of Virginia triangular standard deviation formula and imagine the difficulty of accurately translating that formula in any format without making an error. A debugged and stored macro would help eliminate such laborious input and calculation errors. Also, if the organization has a goal to use a standard method of project scheduling, a macro would be a reasonable mechanism to support that. In this case, the standard form would define the data items to enter and from that the standard calculations would be produced by the macro logic.

It was indicated earlier that MS Project 2010 dropped the PERT built-in calculation function. This omission says a great deal about current trends in industry. Regardless, our hope is that you as the reader now see the potential value of using variable time estimates to improve project plan forecasting. The macro approach described here makes this process a reasonable adjunct to the basic planning process.

Technical details related to the macro demonstrated in this section are shown in Appendix E with details on how to obtain more documentation on this topic. Also, an electronic copy can be retrieved from the technical documentation section of the ProjectNMotion website (refer Appendix F).

Figure 20.6 illustrates the MS Project plan data layout required to set up the expected time duration macro. A brief description of the required setup data columns shown is summarized below:

- Task name—standard MS Project definition
- Duration—standard MS Project definition; however, the value is left at zero for the macro to calculate
- Optimistic (a)—earliest time loaded into Dur1
- Most likely (m)—most likely time loaded into Dur2
- Pessimistic (b)—pessimistic time loaded into Dur3

	Task Name	Duration	Optimistic	Most Likely	Pessimistic	Optimis Weight	Most Likely Weight	Pessimi Weight	Sigma	Variance	Text 30/PERT MACRO
1	Fig 20.6	0 days	0 days	0 days	0 days	1	4	1	0	0	
2	A	0 days	1 day	4 days	7 days	0	0	0	0	0	
3	B	0 days	2 days	2 days	2 days	0	0	0	0	0	
4	C	0 days	2 days	5 days	8 days	0	0	0	0	0	
5	D		0 days	0 days	0 days	0	0	0	0	0	
6	E	0 days	3 days	4 days	5 days	0	0	0	0	0	
7	F	0 days	4 days	6 days	8 days	0	0	0	0	0	
8	G	0 days	5 days	6 days	9 days	0	0	0	0	0	

Figure 20.6 PERT macro setup.

- Optimum weight—defined as Num1; value is 1 for PERT and 2 for a triangular distribution
- Most likely weight—defined as Num2; value is 4 for PERT and 2 for a triangular distribution
- Pessimistic weight—defined as Num3; value is 1 for PERT and 2 for a triangular distribution
- Sigma (σ)—defined as Dur4; this is calculated by an internal MS Project formula
- Variance (σ^2)—defined as Dur5; this is calculated by an internal MS Project formula
- Text 30—this field is used to report macro completion status; no calculation role

Note that this macro treats all tasks as fitting one distribution type. There are obviously other modifications that could be made to increase the macro logic sophistication, but our point here is to show the role of this class of tool more than its complexity. The macro logic requires each of the fields defined above to be loaded prior to its execution. As in the previous examples, the variable task time raw data would be entered along with the weightings, shape, and error columns. Review Figure 20.6 to verify that you understand the role of each column shown. From this base point, all that is required to produce the plan is to create custom formulas for sigma and variance, then load, and execute the macro.

Macros can be stored permanently in the Project library, or loaded with each use. The basic steps for local execution are summarized below:

1. Set up the plan data as shown in Figure 20.6 using the dummy field names described above.
2. Go to [View/Macros/VB Macros].
3. Insert the macro code into the VB code panel.
4. Execute the macro (Run).
5. The duration values should now be generated according to the $T(E)$ formula.
6. Verify the duration, sigma, and variance calculations. Check the Text 30 status field to ensure that the macro executed successfully and then proceed with the process (see Figure 20.7).

The same mechanics are used for a triangular distribution, except the variable time estimate weights need to be changed from 1, 4, and 1 to 2, 2, and 2 as illustrated in Figure 20.8. From this point, the calculation process proceeds in the same fashion as previously discussed.

The PERT formula is used to calculate sigma for this example; however, it would be a minor effort to change the macro code to one of the other formulas.

	Task Name	Duration	Optimistic	Most Likely	Pessimistic	Optimis Weight	Most Likely Weight	Pessimi Weight	Sigma	Var	Text 30/PERT MACRO
1	Fig 20.8	6.67 days	0 days	0 days	0 days	2	2	2	0 days	0 days	
2	A	4 days	1 day	4 days	7 days	0	0	0	1 day	1 day	Duration Calc'd: 5/4/2012 4:03:01 PM
3	B	2 days	2 days	2 days	2 days	0	0	0	0 days	0 days	Duration Calc'd: 5/4/2012 4:03:01 PM
4	C	5 days	2 days	5 days	8 days	0	0	0	1 day	1 day	Duration Calc'd: 5/4/2012 4:03:01 PM
5	D	6.67 days	0 days	0 days	0 days	0	0	0	0 days	0 days	
6	E	4 days	3 days	4 days	5 days	0	0	0	0.33 days	0.11 days	Duration Calc'd: 5/4/2012 4:03:01 PM
7	F	6 days	4 days	6 days	8 days	0	0	0	0.67 days	0.44 days	Duration Calc'd: 5/4/2012 4:03:01 PM
8	G	6.67 days	5 days	6 days	9 days	0	0	0	0.67 days	0.44 days	Duration Calc'd: 5/4/2012 4:03:01 PM

Figure 20.7 PERT macro executed.

	Task Name	Duration	Optimistic	Most Likely	Pessimistic	Optimis Weight	Most Likely Weight	Pessimi Weight	Sigma	Var	Text 30/PERT MACRO
1	Fig 20.7	6.33 days	0 days	0 days	0 days	1	4	1	0 days	0 days	
2	A	4 days	1 day	4 days	7 days	0	0	0	1 day	1 day	Duration Calc'd: 12/23/2011 9:06:40 AM
3	B	2 days	2 days	2 days	2 days	0	0	0	0 days	0 days	Duration Calc'd: 12/23/2011 9:06:40 AM
4	C	5 days	2 days	5 days	8 days	0	0	0	1 day	1 day	Duration Calc'd: 12/23/2011 9:06:40 AM
5	D	6.33 days	0 days	0 days	0 days	0	0	0	0 days	0 days	
6	E	4 days	3 days	4 days	5 days	0	0	0	0.33 days	0.11 days	Duration Calc'd: 12/23/2011 9:06:40 AM
7	F	6 days	4 days	6 days	8 days	0	0	0	0.67 days	0.44 days	Duration Calc'd: 12/23/2011 9:06:40 AM
8	G	6.33 days	5 days	6 days	9 days	0	0	0	0.67 days	0.44 days	Duration Calc'd: 12/23/2011 9:06:40 AM

Figure 20.8 Triangular distribution output.

CASE STUDY

This example problem exercise is designed to demonstrate the impact of using discrete time estimates versus variable time equivalents. Four supporting files need to be retrieved from the publisher website to help follow this analysis in detail (see Appendix F for retrieval details). The work files are:

- a. 20 Car Problem First cut discrete Time 320.mpp
- b. 20 Car Problem Var Time 253 W MACRO.mpp
- c. 20 Car Problem Variance Sorted.mpp
- d. 20 Car Problem Var Time WBS.png

File “a” represents a car problem project plan based on discrete single-value padded time estimates. Note that the calculated project duration for this plan is 320 days. File “b” contains the same basic plan using three essentially equivalent activity time estimates based on the PERT model. File “c” is included to provide the critical path variance calculations. File “d” is a schematic WBS to help envision the overall plan structure. The project is scheduled to start on 8/3/2012.

A sample duration example for the two approaches can be seen in files “a” and “b” at WBS 1.2.2.1, Engine Design. File “a” uses 80 days in the padded version for that task and this same task is translated to 60, 65, and 80 or a 66.67 median estimated duration for the variable time estimate in Figure 20.7 (file “b”). One can quibble with the translated variable values

used here, but the process is meant to show the general impact of padded discrete versus variable time estimates more than the accuracy of the three time estimates. Also, recognize that both plans contain a 35-day project buffer (WBS 1.8); however, one could argue that the buffer in the padded plan was already included in each task and should not be duplicated at the end.

Comparative outcomes

With the project starting on 8/2/2012 and based on the two plans estimated times, the results of the outcome can be summarized by the two MSP plans as follows:

1. Padded version—320 days duration; plan finish on 10/23
2. Three time estimates—253 days duration; finish on 7/23

The three time estimate version needs to be further analyzed to create a probability range calculation. File “c” helps with that process in that it shows all critical path activities sorted into a group and the variance on the critical path summarized. Remember that the project critical path dictates time variability of the plan. The sum of the critical path variances is 13.86 and the standard deviation of the critical path is the square root of that number, or 3.7. Thus, the value 3.7 represents the distribution σ variability shape factor for the range analysis. The other shape factor, μ , is represented by the 253-day planned median duration shown in file “b.” The Excel NORMINV function can be used to calculate the values for 10% and 90% probability of completion as follows:

10% probability duration $\text{NORMINV}(0.1, 253, 3.7) = 248$

90% probability duration $\text{NORMINV}(0.9, 253, 3.7) = 257$

Based on the working calendar, this translates to July 16, 2013, to July 29, 2013, as the 10/90 forecast range for completion.

Compare this analysis with the original padded discrete plan, which simply says that the project will be finished in 315 days. If we were to take the 35-day buffer out of both estimates, the durations would each be shortened by that amount. A comparative analysis of the two plans is shown below:

	Duration	Finish	Finish WO buffers
Discrete plan	283	9/3	7/16
Variable time plan	253	7/23	6/4

These variations in defined completion make an interesting analysis of planning strategies. Goldratt (1984) and others have described the psychology

of project execution in the padded environment versus a more constrained variable time approach (Leach 2005). According to these researchers, padded duration times not only tend to increase the overall project duration but actually encourage longer times simply based on the team knowledge that time estimates contain extra time. The counter theory then says that omitting task padding would encourage more focus on completing tasks sooner. So, part of the value in the variable time model is in showing a shorter task schedule and using the project buffer to absorb any task overruns. Mature PMs should understand both the mechanical and psychological underpinnings of related critical chain model and variable time theories. References by Goldratt (1984), Leach (2005), and others can offer more on this topic.

Summary

This chapter has introduced the concept of using variable time task estimates for project planning. This is the recommended approach for all projects in order to obtain a better measure of potential outcome completion ranges. This approach may be used in the planning stage and then converted to a standard fixed duration view for ongoing status tracking. Also, project buffers would then be added to the plan in anticipation of future variability.

The ability to forecast and analyze project plan outcomes in this model format is now more feasible as availability of robust computing resources has evolved. The PERT model basically failed to be embraced by the project management community when it is introduced initially in mid-1950s because of its statistical complexity, but it is now time to dust off the concept and begin to utilize what it represents in order to improved status prediction (Archibald 1987). The mechanical concepts related to the classic PERT model illustrated here are certainly usable, but we must also recognize that new technology will continue to offer alternative methods to perform this type of analysis. The most likely successor for this role is simulation, which will be discussed in Chapter 21. This method involves more advanced software availability, but offers a wider range of analysis tools. Just as in the earlier case of the PERT model, simulation pushes the current analysis capability envelope and for that reason it may take some time to gain wider acceptance in the project management community. The reader will have to decide whether the classic PERT-type model or the newer simulation analysis tool approach that best fits their needs.

QUESTIONS

Review questions

1. When did the PERT model of project management emerge?
2. What is the basic difference in philosophy between the PERT and CPM models?

- 3. Why was the beta distribution chosen to model PERT task duration variable times?
- 4. What does $T(E)$ signify?
- 5. What role does the CLT play in producing a normal distribution of the project duration?
- 6. What role does a custom macro play in the PERT or triangular distribution scheduling process?
- 7. What are the Excel functions that help interpret project schedule variability?

In-class questions

- 1. Use the project parameter information shown in Table 20.2 and execute the process questions summarized below.
 - a. Calculate $T(E)$ values using either the PERT or triangular formulas.
 - b. Draw a manual AOA network based on the computed $T(E)$, and precedence parameters.
 - c. Calculate the duration and critical path of the project.
 - d. Using the Excel built-in functions, calculate the probability that this project will complete by duration 155.
 - e. At what duration can you say there is a 95% probability of being finished?
- 2. Assume that the calculated shape parameters for a variable time project are
 - $\mu = 50$
 - $\sigma = 4$

Using these shape parameters and the Excel built-in functions, calculate completion parameters for the following situations:

- a. What is the probability of completing the project by time period 56?

Table 20.2 Variable Time Problem Data

Task	Predecessor	<i>a</i>	<i>m</i>	<i>b</i>
A	— — —	10	15	20
B	— — —	14	28	50
C	B	40	60	80
D	A	40	45	50
E	D,C	30	35	42
F	A	5	10	12
G	B	3	16	25
H	E,F,G	10	15	18
I	B	7	12	18

Table 20.3 Variable Time Task Values

ID	Task Name	Duration	Predecessor	<i>a</i>	<i>m</i>	<i>b</i>
1	Upgrade system software					
2	Infrastructure					
3	Order hardware/receive hardware			20	30	50
4	Order software/receive Software		3	12	16	25
5	Install hardware and software		3,4	11	16	22
6	Test		5	3	4	10
7	Deployment to production		6	18	20	30

- b. What is the point in time for which we have a 75% confidence level in completion?
3. Answer the following concept questions:
 - a. How will management view a plan showing a probability range completion in lieu of a firm date?
 - b. How often should the variable time estimate be updated during the course of a project?
 - c. Would variable time estimates be useful in pinpointing why a project is not successful?
 - d. What types of projects would the PERT method be most useful for?
 - e. What is the best way to simplify a presentation of the outcomes or predictions for explanations to executive management?
4. You have been tasked with coordinating an upgrade to an enterprise-level software application. Based on previous similar projects you have determined the basic tasks along with their optimistic, most likely, and pessimistic durations are as given in Table 20.3.

Use your knowledge of PERT to model this simple project. Before finishing your analysis, you find that the test team has been scheduled for a high-priority project during the time period in which testing is scheduled for this project, which means that you will have to move out of that time period. Senior management has asked you to provide them an 80% confidence level for project completion. Make whatever reasonable assumptions are needed to present your answer.

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Simulation modeling

Introduction to simulation modeling

The previous chapter described the classic mechanics for using the PERT model as a statistical tool to measure and forecast project outcomes with variable task times. This afforded a view into how variable time estimates can be manipulated into a probability distribution showing estimated project completion times. Since many do not awake with a driving need or want to become a statistician, it is common to shy away from using statistics and specifically statistically oriented tools such as PERT. In project management circles, the use of simulation modeling is increasingly popular as a tool to identify similar information as identified with the PERT tool, but without requiring as much of a background in statistics.

Haga and Marold (2004) suggest that PERT ignores the stochastic nature of activity completion times, which serves only to identify a completion time without consideration for what the penalty is to the project for not completing a project on time. It also does not consider bottlenecks that could impact the project when one task is completed later than anticipated since the task may serve as input to another task. This situation can result in noncritical tasks moving to create another critical path. Because of this dynamic characteristic, the use of simulation modeling is recommended to evaluate potential project variance. In an operational model, simulation modeling tends to be more easily understood and more content-rich. As a result of this capability, it is the focus of this section. The goal here is to describe modeling and simulation as it pertains to the project model. Specific mechanics and benefits will be shown in the examples. The modeling methodology will be based on Monte Carlo-type random value generation used to simulate variable performance for specific tasks.

Modeling and simulation is an analytic discipline that allows us to develop a level of understanding regarding the interaction of the parts of a system, or tasks within a project, as well as the system or rather project as a whole. From this descriptive modeling, an improved level of understanding is developed beyond that rarely achievable from any other discipline. Model dynamics produced through this technology can then simulate project probabilistic outcomes by assigning variable time values to project activities.

A system can be simulated by defining the interaction of its parts driven through thousands of iterations, then capturing the resultant behavior after each pass. This output then reflects what would actually happen if the real-world system were to operate in the same way. It is important to recognize that a model is only as good as the details and parameters included within it. Too little detail runs the risk of missing relevant interactions and therefore not promoting sufficient understanding, and too many details can cause it to be too complicated and confusing. In a very broad sense, simulation is, in essence, imitation with another term for it is that the model has *verisimilitude* meaning that it accurately represents the real-life behavior of the target. There are not enough hours in the day or days in a lifetime to fully imitate how a project can be repeated 1000 times. However, a simulation model can be exercised like this as a result of the availability of cheap and powerful computing technology. In essence, this is the power of the tool and one that has not long been available to the practitioner. To apply this technology to the project environment, all that has to be introduced is the proper software to drive the simulation.

Monte Carlo

Uncertainty is simulated using a computational algorithm tool such as Monte Carlo, which allows real-world phenomena to behave in variable forms. In the simplest terms, the Monte Carlo technique uses random numbers to describe these variable events. For this, the underlying model simulates the likelihood and impact of risk events such as predicting ranges of project cost or schedule. Details outlining this process are discussed further in the following section, which is focused on project risk mechanics. The Monte Carlo name was coined from its similarity to the roulette wheel in gambling casinos and its related chance outcome (Farid et al. 2010). Full Monte is an MS Project add-in software utility that uses the Monte Carlo technique to produce time and cost analysis of a project model (Barbecana, Inc. 2012b). There are also multiple MS Excel add-in software options that use this approach. Other tools such as Excel, @Risk, or Crystal Ball can also be used for similar types of analysis (Olson and Wu 2011). Customized software such as this is extremely helpful in gaining a better understanding of uncertainty present within the project environment.

One of the outputs of simulation modeling is sensitivity analysis, which can be used in determining which risks have the most potential impact on the project (Richardson 2010). In this mode, the model takes each task and sees what that variable's effect is on project completion. This adds a new perspective to the more traditional approach, which uses a deterministic value (Barbecana, Inc. 2012b). One form of sensitivity

analysis comes in the form of a *tornado diagram*, which ranks the project activities in order of significance for, say, a critical path (Richardson 2010). Therefore, it often explains when or during what period a task is on the critical path. In the case of the Full Monte software, it displays the optimistic and pessimistic duration times for each task. The format of this is a vertical bar histogram chart with the data category being the time range for a task. A tornado diagram format is also created in this process and it will be described later in this chapter. These diagrams help us provide an expanded view of potential project outcomes and show where attention should be focused. The Full Monte report format provides an optimistic and pessimistic time range for when a task or total project is active.

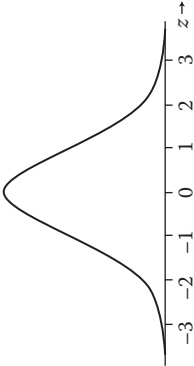
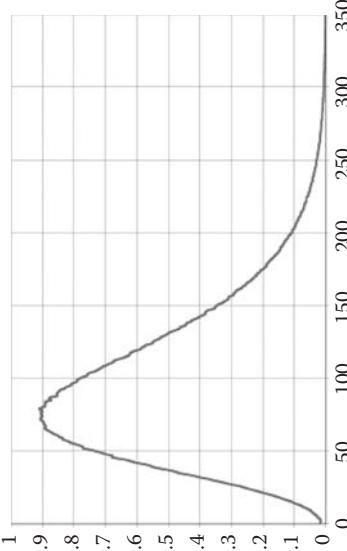
How does Monte Carlo work?

On the basis of defined probability distributions, the Monte Carlo technique provides an array of outcomes that could occur, resulting in better schedule and cost overview when compared with a deterministic approach (Palisades Corporation 2012). Monte Carlo defines uncertainty through a probability distribution specification for each project task. From this, it can evaluate plan status by sampling each task with randomly generated values over thousands of cycles, calculating values again and again using different random values from the probability functions. The iterative analysis process results in a histogram distribution of possible outcomes. Probability distributions for model components provide a realistic method for improved understanding of the real-world system behavior.

Different probability distribution options can be used as noted in Table 21.1. Full Monte offers a range of these distributions that can be selected for this purpose. From these options, it is possible to generate random time and cost events such that the frequency of occurrence of any particular value is proportional to its probability of occurrence. Full Monte uses this data to simulate the probabilistic behavior of each task. Then, it uses these values to compute the MS Project plan, except that it now also stores the results for each iteration as it repeats the entire process hundreds or even thousands of times. The end result of this is a repository of model results that reveals the probabilistic range of outcomes resulting from the iterations. One typical way of displaying these results is in the form of a project completion histogram for time and/or cost. A *project finish histogram* describes the probability of project finish at each time within the calculated range. The corresponding *project cost histogram* calculates similar histogram data for the total cost of the project. Data of this type can be used to evaluate variability of the project time or cost outcomes.

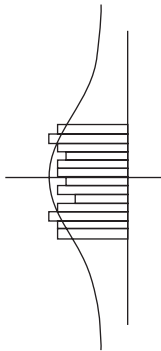
Depending upon which probability distribution shape is chosen, the required data entry is either a 2 or a 3 data value (Barbecana, Inc. 2012b). On the basis of these data values and the defined probability distribution,

Table 21.1 Probability Distribution Types

Type of probability distribution	Description	Visual
Normal	The symmetrical bell-shaped curve is concentrated in the center and decreases on either side with the values in the middle near the mean most likely to occur. It has less of a tendency to produce unusually extreme values, compared to some other distributions. It describes natural phenomena such as inflation or individual's weights	
Lognormal	This curve has values that are positively skewed. It is used to represent values that do not go below zero but have unlimited positive potential. Examples of variables described by lognormal distributions include real estate property values, stock prices, and oil reserves	

Uniform

All values have an equal chance of occurring such as tossing a coin with equal chances of getting heads or tails. The minimum and maximum values need to be identified



Triangular

It favors the most likely value and gets its name because the most likely value that is referred to as the mode creates the top point of the triangle. There is no requirement that the distribution is symmetrical about the mean and therefore depending on the estimates for minimum, maximum and most likely, the shape of the triangle may be skewed to the left (minimum) or right (maximum) values. Although the triangular distribution can model a variety of different circumstances, it can produce too great a value for the mean of the risk analysis where the maximum for the distribution is very large. An example of variables include past historical data such as sales

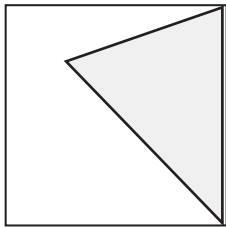


Table 21.1 (continued) Probability Distribution Types

Type of probability distribution	Description	Visual
PERT-Beta	This distribution is used for identifying risks to the project as well as cost models to predict the likelihood of the project in meeting specific goals. The PERT also known as PERT-Beta, which is a version of the formal beta distribution, yet requires the same three parameters as the triangle distribution consisting of the minimum, mode, and maximum. An example usage is to describe the duration of a project task	
Discrete	This distribution is used when there is a specific probabilistic value that occurs with each event. For example, flipping a coin 20 times will result in specifically 0–20 tails occurring as opposed to 2.3 times a tails occurring (as this is not possible because it is either heads or tails). An example might be the number of accidents on a college campus in a given month	

it is possible to define the variation characteristics of the task. Once this is accomplished, a simulation can be executed based on random samples from those distributions. Iteration is the term given for each time the model is sampled and outcome recorded. This generates a single value for the time and cost histogram. Repeating this process generates a comprehensive view of what may happen as well as how likely it is to happen (Palisades Corporation 2012).

Benefits of Monte Carlo

In general, simulation modeling provides an effective alternative to other forms of analyses as the cost to perform the simulation analysis is generally less costly (Zhan 2011). This is because it is less time-consuming to conduct a simulation, especially if a utility such as Full Monte fits the analysis requirement. Also, it can produce information that can be difficult or even not obtainable with other methods (Marquez and Benoit 2007; Zhan 2011). Monte Carlo simulation has many benefits over *deterministic* or “single-point estimate” analysis (Farid et al. 2010; Haga and Marold 2004; Palisades Corporation 2012). A sample of these benefits is listed as follows:

- Provides reasonable probabilistic estimates of the true project length.
- Provides a full probabilistic distribution showing the range of outcomes and how likely different potential outcomes are occurring.
- Permits use of various distributional assumptions for activity times.
- Does not require extensive historical data.
- Does not require assumption on linearity, distribution, correlation, or volatilities.
- Performs sensitivity analysis providing awareness regarding which inputs have the greatest effect on bottom-line results.
- Provides a greater problem understanding by having the data behind an outcome such as which input most affected a specific outcome.

Examples

With the theoretical background being complete, let us now show how to run a sample project plan simulation using Full Monte. The first step is to create a traditional project plan structure. Resources are allocated to the tasks in the normal way as previously described. To set up the simulation model, each task needs to be defined through a probability distribution and its associated parameters. For instance, if the task is assumed to be PERT-Beta, three task time estimates are required. After this is defined, Full Monte data entry is required for each task. Figure 21.1 shows the data entry format for the WP-level tasks. This step will be repeated for each

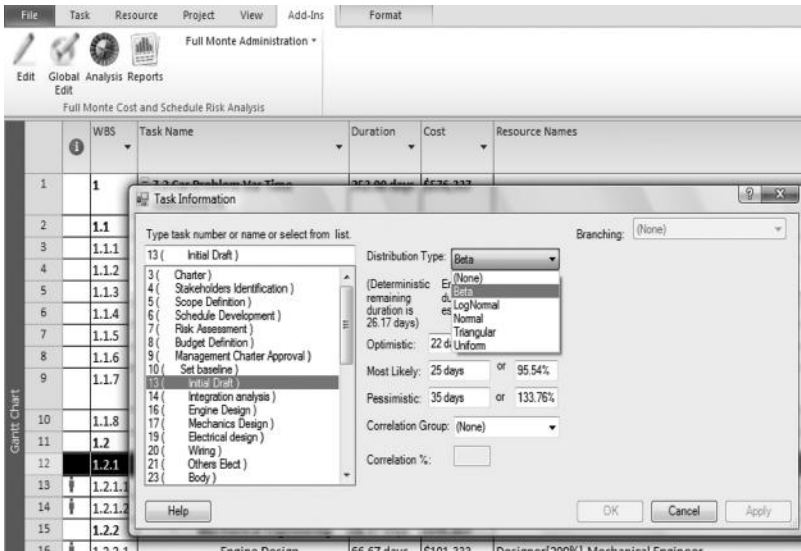


Figure 21.1 Probability distribution types.

task. Once the task-specific data entry is completed, the software will handle the rest of the simulation process.

Executing the model

To execute the model, select the “Analysis” button, which will bring up the screen displayed in Figure 21.2. The default options are prechecked, but other options can be checked if desired. Selecting “OK” will send the model into execution and generate the time histogram as shown in Figure 21.3. This displays the projected mean execution time in the upper left corner of the chart as the date, 7/21/2013 at 9 pm. However, the chart displays the mean, 50% mark, by rounding up or in this case moving the date to the next day, which is 7/22/2013. If a person samples from multiple bins of items that are each distributed in various ways (i.e., normal, beta, uniform, etc.), the resulting sample distribution will be normal as this is what the central limit theorem (CLT) states. In other words, if you sample from a population of events (tasks in this case) that are distributed in various ways, the result will be a normal distribution. Therefore, the critical path will be normally distributed regardless of probability formats. In the case of a project, each task (bin) is potentially distributed differently and therefore the resulting project distribution fits the model provided there are 30 such tasks, which then make the CLT valid. As a result of this relationship, it is now possible to state that the project schedule will range across three standard deviations, or 65% of the potential range will be within



Figure 21.2 Analysis Full Monte menu.

one standard deviation. The resulting distribution is normal as a result of the CLT. The standard deviation in this example is displayed as 5.67 days, suggesting the most likely range of the project to finish will be within 5.67 days before or after the mean date. It shows that there is essentially a 100% probability that the project will be completed by 8/10/2013 and a 0% probability of it being completed prior to 7/2/2013. The chart then provides the probability percentage of various dates displayed in terms of the likelihood for the project to be completed. Terminating this histogram will then present an equivalent cost histogram, which is shown in Figure 21.4. This chart displays the project cost mean in the upper left corner as being \$564,300, whereas the mean, 50% mark, on the chart is shown as \$563,675. The cost histogram rounds up for the mean value in the upper left-hand corner and displays the actual value of the cost mean at the 50% mark on the chart. Note that the opposite occurs for the project early finish histogram as the mean on the upper left corner shows the actual date value and the rounded-up version of the date value shows on the chart at the 50% mark instead. The standard deviation for the cost histogram is shown as \$9400, signifying the likelihood of the project cost to be \$564,300 ± 9400.

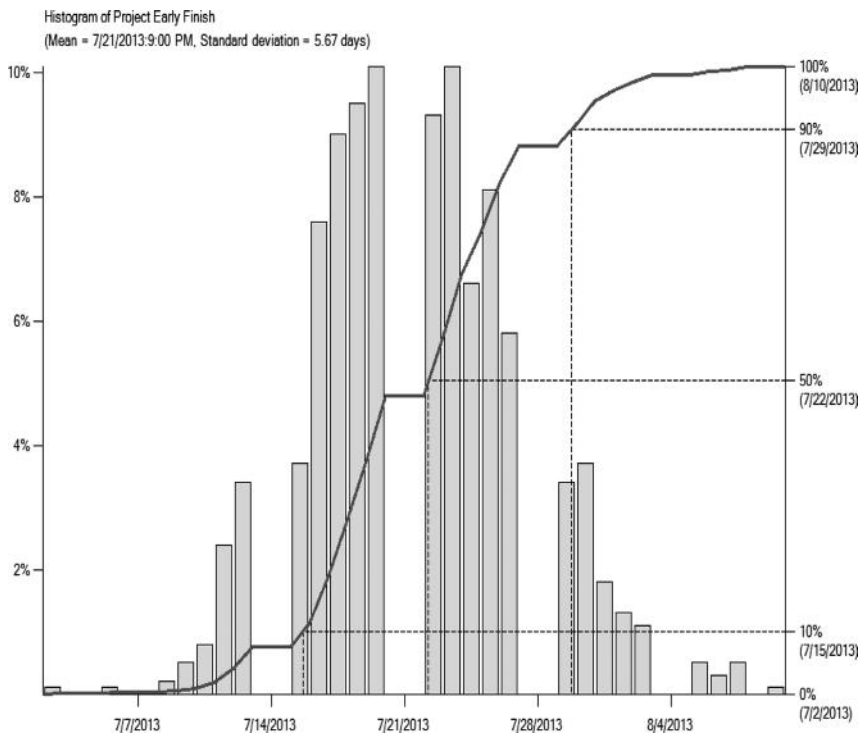


Figure 21.3 Histogram of project early finish.

The chart values further describe different values of probability of occurrences for the project cost. The ranges in this case show the project not costing over \$606,000 and not costing less than \$536,000.

A third major output artifact from the simulation is the tornado chart, which can also be displayed by selecting the "Report" button. Specifically, the tornado chart is displayed by selecting "File" within the report option followed by "Open Report Specification" and then choosing "Tornado." These two views are displayed in Figures 21.5 and 21.6. Figure 21.6 can be interpreted as showing the optimistic and pessimistic time range for when different tasks are active. Those tasks with a larger range are on the top with the smaller range tasks on the bottom, which is the reason the chart looks like a tornado. For instance, the task, Initial Draft, is showing that it will be completed between July 16, 2013, and August 2, 2013. The optimistic time is displayed in the column as being the July 16, 2013 date, whereas the pessimistic time also displayed in the column is being shown as August 2, 2013. This provides information to the PM on where to focus attention especially as the task is not completed and the pessimistic time period is quickly approaching. The sensitivity index is a rough indication

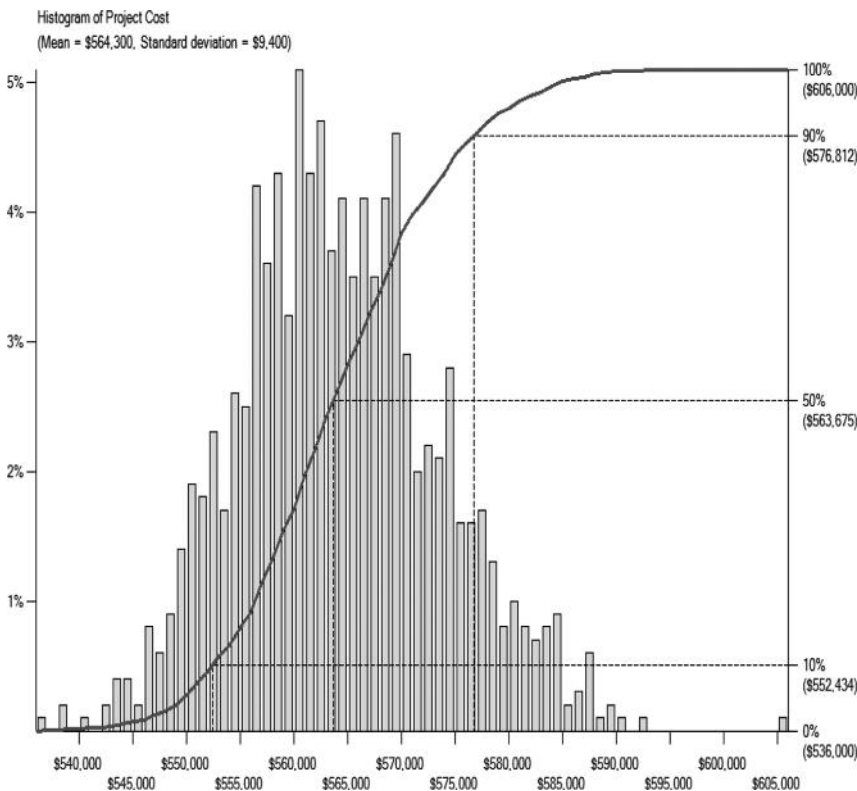


Figure 21.4 Histogram of project cost.

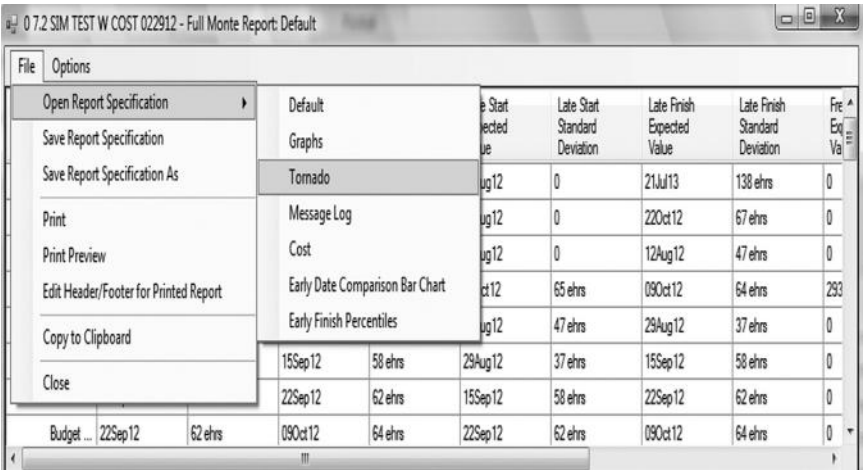


Figure 21.5 Report menu display.

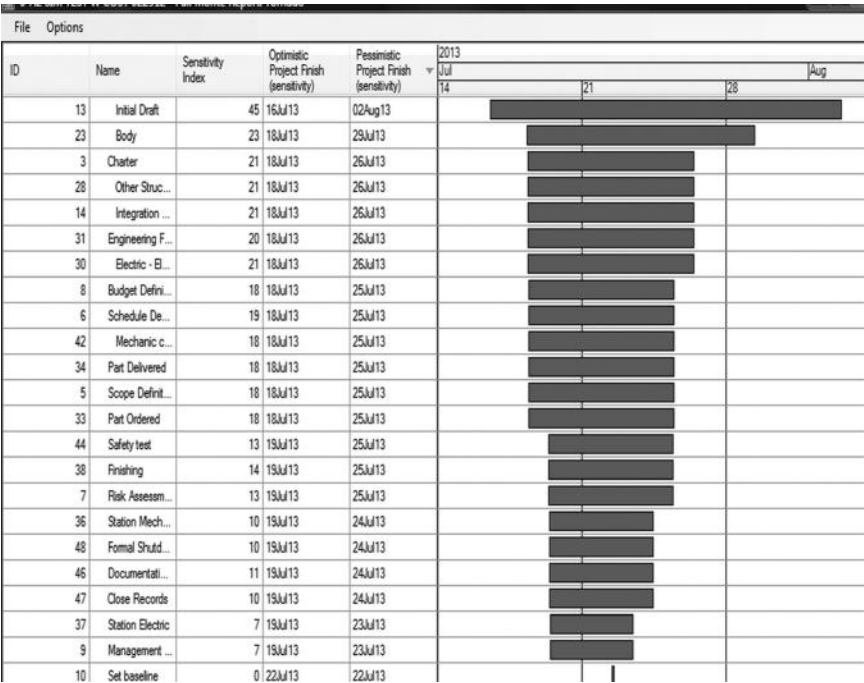


Figure 21.6 Tornado chart.

of which tasks’ duration uncertainties have the most potential impact on the project finish date (PMI 2008). It is not a perfect measure but is fast to calculate. According to Tony Welsh (2012), the developer of Full Monte (Barbecana, Inc. 2012a), this index provides an approximate rank-ordering of the tasks that have the most impact on project outcomes, so that those high on the list should be examined more thoroughly. Additional information on the output interpretation can be found using the Full Monte User Guide (Barbecana, Inc. 2012b).

Summary

In project management, the area of simulation modeling has become increasingly popular as a tool to evaluate variability of project outcomes based on probability estimates for the various tasks. This output is somewhat similar to the preceding PERT theory, but without needing as much user statistical background to understand the results. Modeling and simulation is a discipline that allows us to develop an increased level of understanding regarding the interaction of the parts of a system, tasks within a project, as well as the project as a whole. Overall, simulation modeling tends to be more easily understood and more content-rich. The examples

shown in this chapter have attempted to demonstrate the data requirements and core outputs of this process regardless of the brand utility used. For all of these reasons, this chapter's material represents a core plan analysis skill area for the PM. The next chapter will continue to broaden this general topic area by focusing on risk management mechanics.

QUESTIONS

Review questions

1. What is the basic purpose for choosing project plan simulation modeling?
2. Describe the Monte Carlo process.
3. What are the benefits of simulation modeling over the traditional PERT model?

In-class question

1. Use the Internet to identify and describe the functionality of two different project management software tools available for performing a Monte Carlo simulation.

EXERCISES

1. Figure 20.6 described variable time macromechanics. Refer to this figure and use the sample data to illustrate simulation. Specify a Beta distribution for each of the tasks and use Full Monte (Barbecana, Inc. 2012a) software or other simulation software of your choice for the execution process. From this process, produce a probabilistic schedule estimate for the project in the form of a histogram (similar to Figure 21.3).
2. The publisher's website contains a file labeled *C21 Student File*. Use this data and your knowledge of Monte Carlo simulation to model this project. Produce a histogram of the project early time finish, histogram of the project cost, and a tornado chart. Use Full Monte (Barbecana, Inc. 2012a) software or another software tool of your choice. Draft a short report suitable for the management to describe what this model indicates for the project.

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chapter twenty-two

Risk mechanics

Risk management

This chapter expands the introduction to risk provided in Chapter 11 through a discussion specific to the analysis of risks, risk response planning, and monitoring and controlling. *Risk management* is the systematic process of planning for identifying, analyzing, responding to, and monitoring project risks involving processes, tools, and techniques to help the PM maximize the probability of a predictable outcome. Risk management identifies tools and techniques to minimize uncertainty through understanding, assessing, and managing the uncertainty inherent in projects. This chapter addresses through tools and techniques how risks can be assessed. In the framework of a project and as referenced in the *PMBOK Guide* (PMI 2008, p. 273), the risk management process consists of six major processes. The first two processes were discussed in Chapter 11 and the remaining four processes are discussed in this chapter. Below are the six processes:

Plan risk management: Consists of how to approach, plan, and execute the risk management activities for a project with the main output of this process being the risk management plan.

Identify risk: Determines the risks that are likely to affect a project and documents the characteristics of each with the main output of this process being the risk register.

Perform qualitative risk analysis: Prioritizes risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact with the main output being to update the risk register.

Perform quantitative risk analysis: Estimates numerically the effects of risks on project objectives with the main output also involving updates to the risk register.

Plan risk responses: Develops options and actions to enhance opportunities and to reduce threats to project objectives. Using the outputs of the above processes, various risk response strategies are made, resulting in the main output of this process being also to update the risk register as well as the project management plan and risk-related contractual agreements.

Monitoring and controlling risks: Tracks identified risks, monitoring residual risks, identifying new risks, executing risk response plans, and evaluating their effectiveness throughout the project cycle. The main outputs of this process are recommended corrective and preventive actions, requested changes, updates to the risk register, and revised project management plan.

Risk analysis

Risk analysis in the form of qualitative and quantitative analyses takes place after all the risks affiliated with a project has been identified. The purpose of risk analysis is to continuously assess the risk situation throughout the project in the ever-changing business environment (Benta et al. 2011). A PM will begin with a qualitative analysis and then move on to a quantitative analysis.

Qualitative risk analysis

These analyses are simply a way to prioritize risks based on the consequences that could occur should the risk occur. Prioritization is generally based on criteria set by the team and often listed from most to least of concern. As the *PMBOK Guide* (PMI 2008) states, the purpose of these types of analyses is to analyze the likelihood of occurrence and impact to the project should the risk occur. Different templates can be used to assist with this analysis. Table 22.1 is a template to assess project risks. Also, Figure 22.1 is an example of a qualitative risk analysis scorecard tool. The qualitative risk analysis tool such as the risk scorecard provides a way to assess how likely it is for a risk to occur (probability of occurrence) and the impact the risk, if it occurs, will have on a project (consequence). In this example there are different categories for probability such as very small, small, moderate, great, and very great. For instance, a “5” is given for a probability assigned to a risk of “very great.” Although it appears as if these categories are subjective, there is a very detailed document that accompanies different risk scorecards so that each risk will be analyzed exactly the same. For consequences, there are also categories such as insignificant, low, moderate, serious, and very serious. These consequence categories also have a specified description and rating affiliated with each description so that all risks will be analyzed exactly the same. Almost every project will have risks that fall under each of these categories. Hopefully, the risks that fall under very serious such as a loss of life or billion dollar cost have a probability that is very small. Table 22.2 displays a platform risk calculator to be used to make decisions based on risks present, such as risks with the company’s infrastructure. For instance, a project that has a technology component can utilize such a template in identifying the risk

Table 22.1 Measuring Project Risks Template

Tool: Tracking your project risks	A project's risk (filled-in example)				Your project			
	Low (1)	Medium (3)	High (5)	Risk level	Low (1)	Medium (3)	High (5)	Risk level
How likely will this adversely affect your project?								
Application complexity			5	5				
Baselines	1			1				
Contract or statement of work	1			1				
Customer expectation			5	5				
Customer involvement		3		3				
Customer acceptance	1			1				
Design level of detail		3		3				
External dependencies like deliveries	1			1				
Hardware, that is, switching to new technology	1			1				
Software, that is, switching to new technology	1			1				
Interfaces with other systems		3		3				
IT experience with system applications		3		3				
Productivity rates of IT team members		3		3				
Project management		3		3				
Project planning/scheduling	1			1				
Project resources		3		3				
Requirements change		3		3				
Requirements definition	1			1				
Subcontractor involvement		3		3				
System performance requirements			5	5				
Telecommunications network		3		3				
Workload estimate of IT team members		3		3				
Current month	8	33	15	56				
Last month	8	30	30	68				
First month	8	24	50	80				

Source: Adapted from Smith, R. 2007. *Baseline Magazine*, July:67.

Instructions: If an item is not relevant to your project, delete it and add new ones as needed. Grade each item for risk from 1 for low, 3 for medium, and 5 for high.

For each item, enter your assessment grade and the same number in the risk level column.

When done, compute your monthly totals. Analyze what is happening over time; look for negative trends and take corrective action such as taking all of your high risks and creating a risk containment plan with your team.

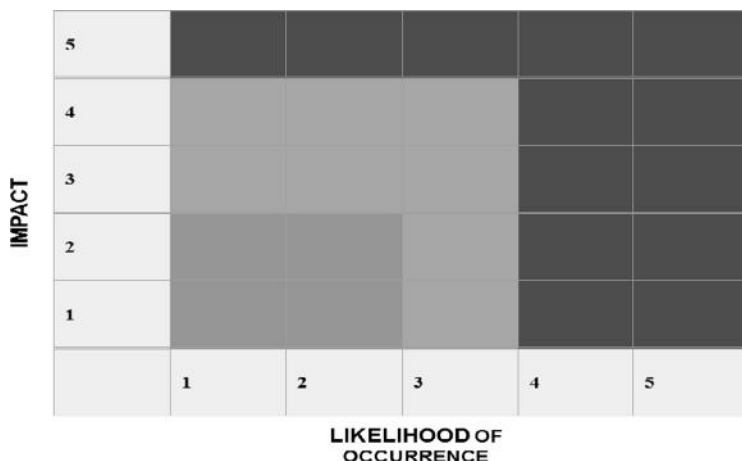


Figure 22.1 Qualitative risk analysis scorecard tool.

of the company's current software infrastructure impacting the project (Richey and Smith 2007).

Quantitative risk assessment

Common quantitative risk assessments often use decision tree analysis, sensitivity analysis, and simulation modeling. Decision tree analysis is a probabilistic evaluation of an event, which can be modeled using the decision tree diagramming technique (Richardson 2010). The technique traces different outcomes of their projected results, and from this, one can judge the appropriate course of action. For example, it encompasses the cost of each available choice, the probabilities of each possible scenario, and the rewards of each alternative logical path. Solving the decision tree provides the expected monetary value for each alternative when all the rewards and subsequent decisions are quantified, such as the example decision tree in Figure 22.2.

This decision tree example compares a strategy of pursuing a lawsuit or using arbitration to settle a dispute. Each of the branches outlines options that are considered and the corresponding probability of that individual outcome. At the end of each branch, the monetary result is displayed. By multiplying the probability of the event times the outcome and summing the branch, it is evident that the decision to pursue a lawsuit receives the greatest expected value. However, it also has the highest potential for loss at \$250,000. Sometimes, the avoidance of a major loss is more desirable than achieving maximum return.

Sensitivity analysis is used in determining which risks have the most potential impact on the project (Richardson 2010). It takes each task and

Table 22.2 Infrastructure Platform Risk Calculator

Category	Example Oracle Financials	Your platform
	Risk scale 1 = Low, 3 = Moderate, 5 = High	
1. Age of platform: How old is it? 1 = 1–24 months 3 = 25–47 months 5 = 48+ months	3	
2. Platform complexity: How many functions are supported? 1—Provides single function and application with single-user device 3—Provides multiple functions and applications for single business unit 5—Provides multiple functions and applications for multiple business units	5	
3. Platform supportability: Is vendor support available? 1—HW/SW currently available/supported or not available but still supported 3—Platform retirement announced and support is currently available 5—No longer supported by vendor and/or your company	3	
4. Historical risk of failure: What is the failure rate? 1—Lower than normal 3—Normal 5—Higher than normal	3	
5. Business value at risk: What is the impact of an outage? 1—Would disrupt noncritical business functions 3—Would disrupt customer-facing systems 5—Would disrupt (hard down) critical business functions	5	
Risk total and level =	19	
What your score means:		
17–25: Develop a plan to replace or update this component within the next year		
9–16: Consider replacing within the next year or two		
5–8: Periodically reevaluate because the score may change, but replacement is not a priority		

Source: Adapted from Richey, J. and R. Smith. 2007. *Baseline Magazine*, November:70.

Instructions: Go to the column labeled “Your Platform” and enter your selected platform name. Answer each category question by entering the appropriate value (1, 3, or 5) to help you assess the right risk scale. Add up your values to get your risk total and risk level.

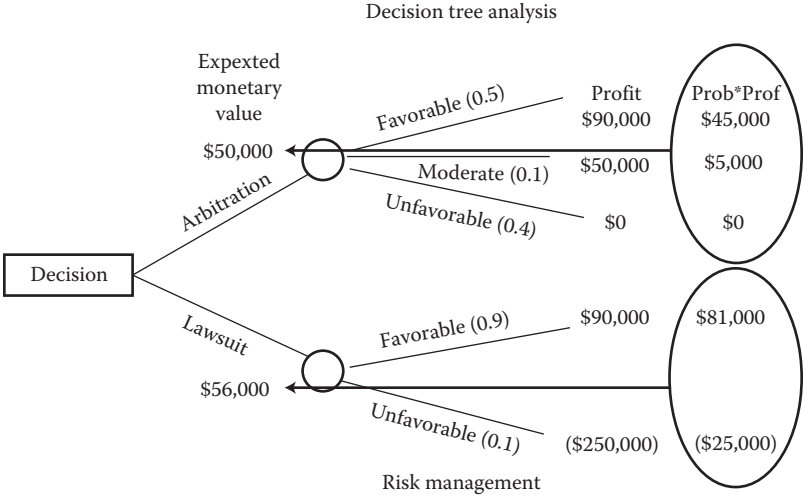


Figure 22.2 Sample decision tree analysis. (From Richardson, G.L. 2010. *Project Management Theory and Practice*. New York: CRC Press, Taylor & Francis Group.)

sees what the effect on project completion would be if it took its optimistic or pessimistic duration, while all other tasks took the deterministic value (Barbecana, Inc. 2011b). Sensitivity analysis can be in the form of a *tornado diagram* that ranks the project activities in order of significance for, say, critical path (Richardson 2010). The tornado diagram helps decide where to focus attention. An example of a tornado diagram is shown in Figure 22.3.

Modeling and simulation is another form of quantitative risk analysis (Richardson 2010). It is a typical method used to simulate project outcomes by assigning variable time and/or cost probabilities to project activities. Uncertainty is measured using computational algorithm tools such as Monte Carlo, which models phenomena with great uncertainty. This can also be helpful in simulating scenarios to identify the likelihood and impact

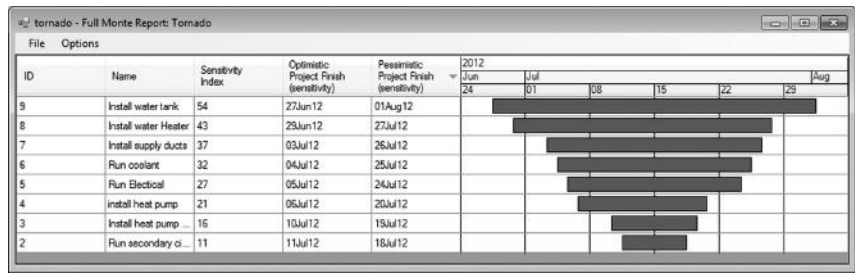


Figure 22.3 Tornado diagram. (From Barbecana, Inc. 2011b. Full Monte™ User Guide.)

of risk events such as predicting cost or schedule overruns. Full Monte™ is an example of software that uses the Monte Carlo simulation, which received its name after the casino since it incorporates chance (Barbecana, Inc. 2011b). Full Monte models the duration of each task by a probability distribution. From these probability distributions, it is possible to generate samples such that in the long term the frequency of occurrence of any particular value is proportional to its probability. Full Monte does this for each task. It then analyzes the project similar to Microsoft Project except that it stores the results and repeats the entire process such as performing a simulation of a thousand times. The end process is that Full Monte summarizes and stores a record of all the simulations as expected value and standard deviation. Excel is another tool that can be used for simulation along with add-on products such as @Risk or Crystal Ball (Olson and Wu 2011). There are also additional add-on tools such as RiskyProject by Intaver Institute, Pertmaster software by Pertmaster Limited and Risk+ by Deltek (Virine and Trumper 2007–2008). Software is extremely helpful in assessing risks in gaining a better understanding of uncertainty present within the project environment. Virine and Trumper (2007–2008) suggest that this analysis will assist in identifying the chance that the project will be completed on schedule and within budget, a task will be on the critical path, tasks that most affect the project duration and even the project success rate.

Full Monte will display a *project finish histogram* and/or *project cost histogram* (Barbecana, Inc. 2011b). The project finish histogram calculates histogram data for the early finish of the entire project. The display project cost histogram calculates histogram data for the total cost of the project. The net result of this is a histogram of defined results and from that data appropriate risk-related decisions can be made (Richardson 2010). Depending upon the probability distribution shape chosen, the controls will allow entry of either a two- or a three-point estimate of the duration (Barbecana, Inc. 2011b). To construct probability models such as the Monte Carlo simulation, a range of estimates are needed such as a minimum value, maximum value, and most likely value if it is available. Based on the estimates, a probability distribution is constructed. Once this is accomplished, a Monte Carlo simulation can be conducted based on samples from that distribution. Once the range of estimates is available, there are different ways to model the distribution so that values can be generated. Before we display sample histograms using different distribution shapes, let us discuss probability distributions. Full Monte uses the input, task durations, and the output, dates, slacks, and costs as probability distributions. Full Monte supports five families of probability distributions consisting of beta, uniform, normal, triangular, and lognormal distributions.

For the purposes of this chapter, the discussion will focus on beta, normal, and triangular. The beta distribution is specified by no less than four parameters, which provide a variety of shapes. However, in project

management, the term PERT-Beta is used because it does not actually have four parameters and therefore is not a true beta distribution. In a Monte Carlo simulation, the PERT-Beta distribution is used for identifying risks to the project as well as cost models to predict the likelihood of the project in meeting specific goals. The PERT-Beta distribution acquired its name since it is based on the same assumption about the mean as PERT networks used for project planning purposes. The PERT-Beta is a version of the beta distribution that requires the same three parameters as the triangle distribution consisting of the minimum, mode, and maximum.

The normal distribution is very useful for natural phenomena and follows a bell-shaped curve. The normal distribution has infinite tails, so the optimistic and pessimistic duration estimates cannot be interpreted. It is not, however, always best to use the normal distribution. The reason the PERT model used the BETA is to facilitate skewed estimates. In some projects, it is possible that the optimistic and most likely duration estimates might be close together. However, if the task does not go as planned, the estimate could be double the most likely estimate such as 3, 5, and 12. Full Monte addresses this by interpreting the duration estimates as three-sigma (or three standard deviations) away from the mean (Barbecana, Inc. 2011a, b). The triangular distribution has long been used for schedule risk analysis mostly due to its simplicity (Barbecana, Inc. 2011b). It has a triangle shape defined by the optimistic and pessimistic estimates. This distribution can be used if there is a "most likely" estimate in addition to having a minimum and maximum estimate. A triangular distribution uses this information to construct a probability distribution that favors the most likely value and gets its name because the most likely value that is referred to as the mode creates the top point of the triangle. There is no requirement for the distribution to be symmetrical about the mean and therefore, depending on the estimates for minimum, maximum, and most likely, the shape of the triangle may be skewed to the left, minimum, or right, maximum, values. Although the triangular distribution can model a variety of different circumstances, it can produce too great a value for the mean of the risk analysis where the maximum for the distribution is very large. Figures 22.4 through 22.6 display the probability distributions project finish histograms and Figures 22.7 through 22.9 display the probability distributions project cost histograms using car case study tasks.

Risk response planning

The next step is risk response planning to develop action plans on how the risk is reduced or risk effects mitigated. In staying with the potential risk of system downtime, the team through continuing to brainstorm may come to the conclusion that not only is a back-up system needed, but the back-up system should also be housed within a different state or region

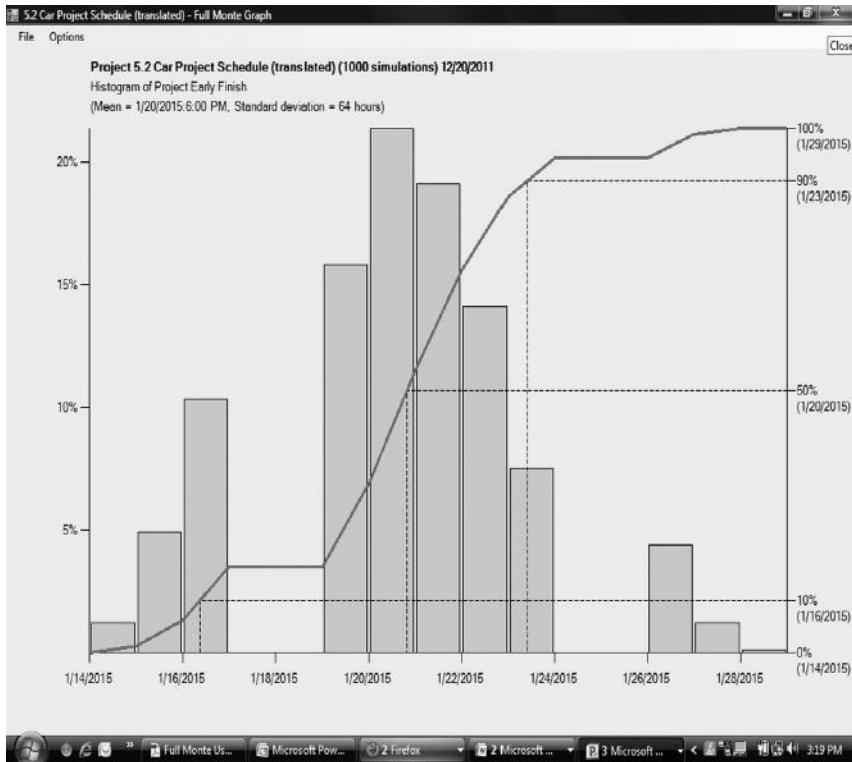


Figure 22.4 Beta project finish histogram using car case study tasks. (From Barbecana, Inc. 2011a. Full Monte™ Software, <http://barbecana.com/full-monte/>.)

within the country. This back-up system could be housed at a different site of the company or by a completely separate organization to reduce the likelihood of the organization completely losing system access. If the system back-up was only in another building and a disaster occurred, then the back-up may be damaged as well. Moving a back-up to a different state or region within the country and/or organization in this case would be the better plan of action for the team. With this example, the risk response planning results in the team identifying that the best way to reduce this risk and/or mitigate the effects of the risk is to seek and implement a back-up system in another state.

Defining risk responses is necessary so there is a plan in place to respond to a risk should it occur. This plan is helpful as it is a plan written in advance of the risk occurring so that the team can easily refer to the plan should the risk occur. Being proactive with risks is important as once a risk occurs, the team could be in a state of distress trying to identify a solution if there isn't a plan to fall back on regarding the best risk

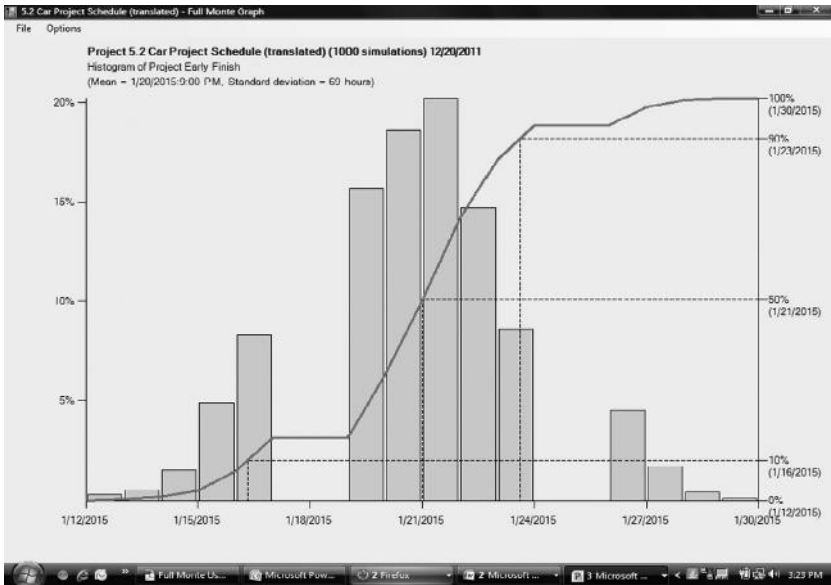


Figure 22.5 Normal project finish histogram using car case study tasks. (From Barbecana, Inc. 2011a. Full Monte™ Software, <http://barbecana.com/full-monte/>.)

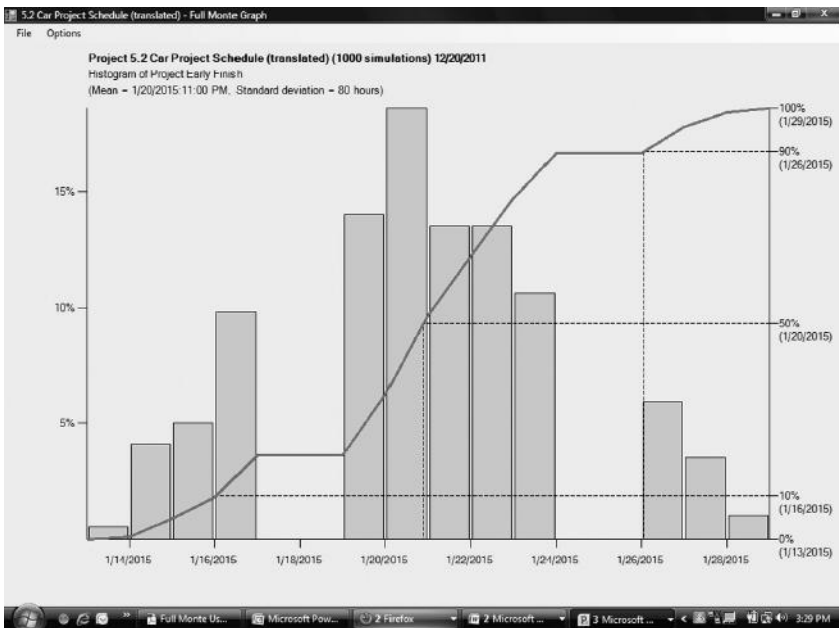


Figure 22.6 Triangular project finish histogram using car case study tasks. (From Barbecana, Inc. 2011a. Full Monte™ Software, <http://barbecana.com/full-monte/>.)

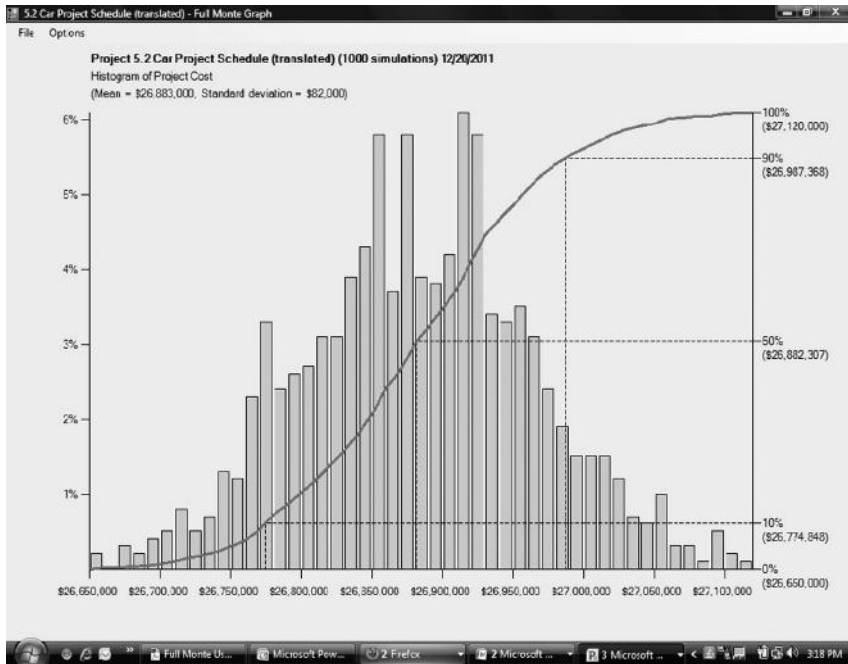


Figure 22.7 Beta project cost histogram using car case study tasks. (From Barbecana, Inc. 2011a. Full Monte™ Software, <http://barbecana.com/full-monte/>.)

response. Following a plan that was written in advance helps the team be proactive with the goal of enhancing opportunities and reducing threats to the project's objectives.

The four different risk strategies are accept risk, avoid risk, mitigate risk, and transfer risk. As discussed previously in Chapter 11, identifying the root cause of a risk or risks helps to understand the reason why the risk could occur, which brings insights into whether a risk will be accepted, avoided, mitigated, or transferred. Sheehan (2010) suggests that a risk be accepted if the likelihood of the risk occurring and the financial impact to the project are both low. If the likelihood of the risk occurring and the financial impact to the project are both high, Sheehan (2010) suggests that the risk be avoided. Furthermore, if the likelihood of the risk occurring is high and the financial impact to the project is low, Sheehan (2010) suggests the risk mitigation strategy may be the best decision. Finally, Sheehan (2010) suggests that if the likelihood of the risk occurring is low and the financial impact to the project is high, a risk-avoidance strategy may be best. However, each industry, company, and even project is unique, so what works for one project in one company within one industry may not also work in a different project within a different company or industry.

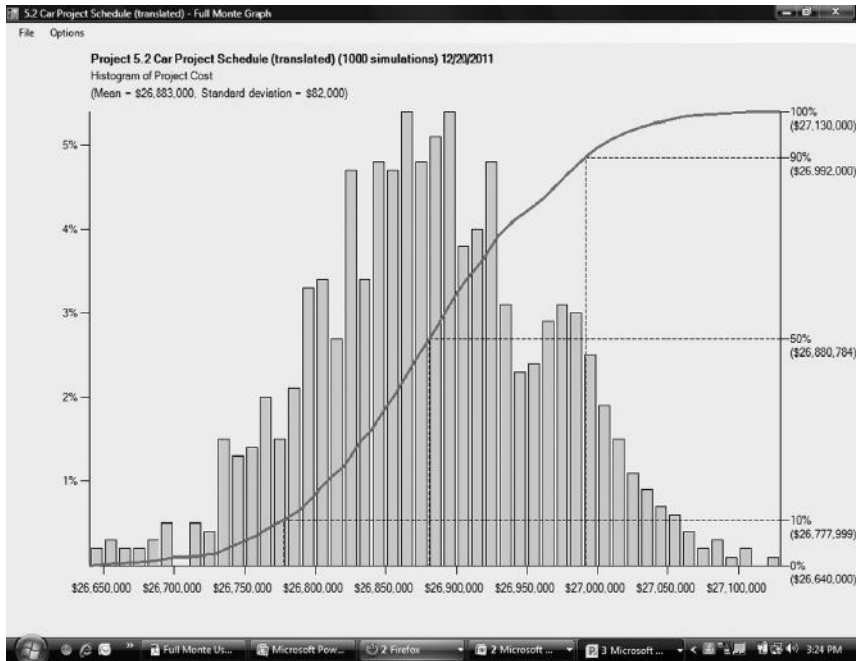


Figure 22.8 Normal project cost histogram using car case study tasks. (From Barbecana, Inc. 2011a. Full Monte™ Software, <http://barbecana.com/full-monte/>.)

Even one project within the same industry and company may have very strong views and differing views on how to handle risks. Each of these strategies will now be addressed. Risks can also be positive such as using a new software tool to speed up a task. Using the tool could complete the task much earlier than estimated, which is a positive risk. However, there may also be potential negative risks affiliated with the tool due to the amount of time it may take for the team to learn how to use the tool, which could potentially impact the project negatively if the learning time takes away from other project tasks.

Accept risk

Accepting a risk takes place when a project team is aware of a risk that could occur and decides not to reduce the likelihood of the risk occurring or the impact it would have if it does occur. An example of accepting project risk is using a new technology. For instance, new software may have potential bugs in it that could negatively impact the project in some way. Ultimately, the PM has decided that no course of action is going to be identified for dealing with this potential risk should it be realized.

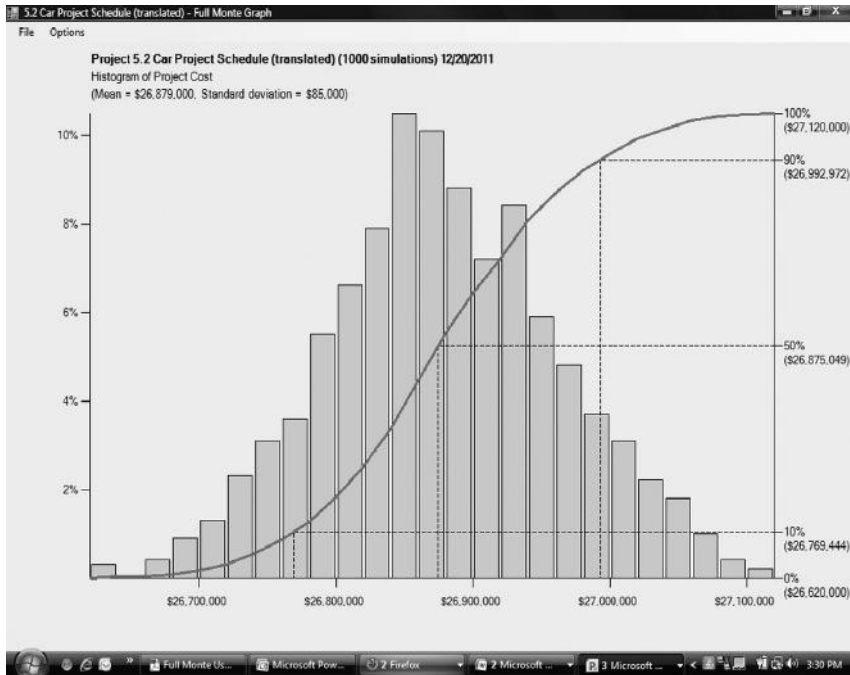


Figure 22.9 Triangular project cost histogram using car case study tasks. (From Barbecana, Inc. 2011a. Full Monte™ Software, <http://barbecana.com/full-monte/>.)

Another example could be an outside community fair that carries the risk of weather impacting the success of the fair. Since dates for the fair must be set, the project team will just accept the risk that the fair may not be successful due to weather. In some cases, a project risk has to be accepted due to circumstances such as this example where there may not be a building large enough in a community to house an indoor fair or the cost of such a building is beyond the funds available to host the fair. Accepting project risks is no different than the risk a person takes every day by assuming risks in traveling by car, for instance. Sometimes, it is impossible to do anything but to accept risks to move forward within a project.

Avoid risk

Avoiding a risk occurs when a project team is aware of a risk that could occur and decides to identify a plan of action to reduce the likelihood of the risk occurring. This way the risk can be avoided and thereby it is unable to impact the project. To avoid the risk, a plan of action could be identified. Furthermore, sometimes a risk is decided by the PM to be ignored for many reasons such as viewing new technology as an opportunity versus a

risk or for many political reasons as well. Now, an example of avoiding risk for a wedding planner is planning a wedding with a concern of an outdoor wedding being rained out to instead hold the wedding in an indoor location. This is a way to completely avoid the risk from impacting the project, in this case, a wedding. Another example is of a company adapting different technology and considering new technology. The risk is that there may be problems finding skilled new hires experienced with the new technology. A way to avoid the risk is for the company to instead adapt proven technology where there is an abundance of skilled workers to hire.

Mitigate risk

Mitigating a risk occurs when a project team is aware of risks and develops a plan of action to reduce the impact a risk will have on the project should the risk occur during the project. An informal way of describing the process of mitigating risk is to develop an action plan to basically control the exposure in terms of controlling the degree to which a risk occurring can negatively impact a project. Typically, a PM will prioritize the risks based on the probability of it occurring and of impacting project objectives. Risks, once identified, should be uniquely numbered and ranked (Benta et al. 2011). This is accomplished through identifying which risks could potentially impact the project most severely and which risks have the highest probability of occurring. Through ranking the risks, the top risks will surface to the top of the lists, which assists in monitoring and controlling project risks. Strategies for mitigating these risks can occur in numerous ways.

An example of mitigating risk might be to use new technology for the entire system instead of choosing to only have a portion of the project use the new technology. Or, the project could be turned into small phases where phase two does not begin until phase one is completed, thereby resulting in phase two only using the same technology if it is proved successful in phase one. This would then reduce the impact the risk has on the project if the new technology is not successful because only the first phase of the project would have used the new technology. Another example could be for a project that involves sending project team members away on training of a highly in-demand skill. The risk is that these team members, once trained, could leave the organization and work for a competitor instead. One way to mitigate this risk is to have these team members sign a contract that they must fulfill 1 year of employment for the company after being trained or must reimburse the company for the cost of the training. Yet another example could be that a project team in need of certain supplies for a project could order the supplies much earlier than needed to mitigate the risk of the supplies not arriving on time. Another example is to perform research to read reviews and industry reports to

see if a certain supplier, technology, product, and so on has a proven track record before it is adopted by the project team as this also mitigates risk.

It is important for a contingency fund or a risk reserve to be established, so there are funds in place to use if needed to implement mitigation plans immediately. Organizations should have reserve pools in place so that projects can tap into these buckets of funds if necessary. Simulations can be performed to help determine the amount of reserve funds an organization or specifically a project may need. Simulations will help a PM recognize the variability that can occur with time and cost in carrying out the project. Having knowledge of the variability information will help in planning accordingly for risks that could occur by making sure that an adequate risk reserve is in place. A hidden problem in organizations occurs when a PM doubles the work plan schedule and costs to accommodate any risks that impact the project. This is not an acceptable way to plan for risks because work will expand to the increased cost and schedule provided, making an organization operate in a costly manner to be inefficient. Instead of this bad management practice, PMs should be direct in their interactions with the management and instead insert cost and schedule buffers for the project as a whole versus adding a cost and schedule buffer to every task. The cost and schedule project buffer provides the PM with a better understanding of how to monitor the project to assess how it is doing in terms of the true schedule and cost.

Any action taken to mitigate the risk thereby reducing the likelihood of the risk occurring or the impact the risk will have if it occurs falls under the strategy of mitigating risk. Table 22.3 displays a mitigation plan template that could be filled out to develop an action plan prior to the start of the project or at the time the potential risk is identified to help the project team lessen the impact to the project. Also important in mitigating risks is to identify risk triggers, which are those events that could alert the PM or project team that a risk is close to occurring. A risk trigger is merely identifying something that the team can measure which can then serve as a way for the team to predict that a project risk is likely to occur (Liebig and Hastings 2009). The analogy used by Liebig and Hastings (2009) describes how a meteorologist can anticipate weather changes through a barometer. Therefore, project risks need to have a trigger identified that can be a predictor of a risk occurring. An identified item in the risk register is a risk event and when it triggers, it is the occurrence of the risk event (PMI 2008).

Transfer risk

The transfer of risk occurs when another party assumes the negative outcome should the risk occur. Every day, people take part in activities that have affiliated risks. For instance, driving a car has risks ranging from getting a speeding ticket to being involved in a car accident with negative

Table 22.3 Risk Mitigation Plan

Rank	__1__ out of __40__
Title	
Description	Full description of the risk and its impact on the project
Contingency plan	Describe the plan of action that will be implemented if the risk occurs
Status	Update the status from continuously monitoring the risk throughout the life cycle of the project and assign a category to the status such as execute contingency, watch, hold, or closed
Probability that the risk will occur	Use a consistent scale such as 1% to signify an extremely unlikely occurrence to 99% to signify an almost certain occurrence
Impact the risk will have on the project if it materializes	Use a consistent scale such as 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high
Earliest date the risk impact could materialize	Identify the month/day/year or use the term “BOP” to signify the beginning of a project
Latest date the risk impact could materialize	Identify the month/day/year or use the term “EOP” to signify the end of a project
Departments or program areas that would be impacted by the risk	Identify department or project areas affected by the risk

consequences from a financial perspective or a health perspective. For example, the purchasing of car insurance transfers the risk incurred to another party that would then assume the consequences should the risk event occur. Another example that was previously discussed in this chapter involved a system that could be permanently destroyed by a hurricane. A way to transfer the risk is to transfer the back-up system to another organization or a different location such as a different state. The responsibility of the back-up system resides with the other organization, thereby transferring the risk to another party. Sharing risks also is a form of transfer where a third party may be involved. Another form of sharing risks is to transfer the risks to another project.

Risk monitoring and control

Finally, risk monitoring and control needs to occur. This consists of merely tracking all the risks previously identified and implementing

response strategies as necessary, so the project is not impacted by the potential risks. The monitoring and controlling of risks is an ongoing effort throughout the life of the project. Those risks that have been previously identified along with an identified risk strategy need to be monitored to gauge how likely it is that the risk could occur. As a good rule of thumb, a PM should not leave the risk monitoring and controlling effort open-ended and instead set certain time intervals officially established for monitoring and controlling risks (Benta et al. 2011). Therefore, one should not monitor and control risks once in the life of the project as that is not enough. Perhaps, the project plan should state that risks must be monitored and controlled when each major milestone work begins and ends. If the monitoring of the risk results in unveiling that the risk is more likely to occur, the risk mitigation plan can be implemented, such as the template displayed previously in Figure 22.3. The risk can be better controlled by implementing the mitigation plan.

The team cannot decide to suddenly begin monitoring and controlling risks in the middle of a project. For project success, a process at the onset of the project must be established for the team to follow in monitoring and controlling risks. Therefore, it is important to develop the process for your team to carry out the task of monitoring and controlling risk so that risks can be reported, which is not limited to but should include the following tasks:

- Look at current risks in exploring how these risks could be reduced or eliminated and no longer need coverage.
- Track systematically the identified risks in a risk log displayed in Table 22.4.
- Identify new risks continuously throughout the life cycle of the project.
- Produce lessons learned for future risk assessment and allocation efforts.

After all risks have been identified and analyzed, the PM needs to set aside sufficient reserves to support these future events (Richardson 2010). The simple example shown in Table 22.5 illustrates the mechanics of this process. Mathematically, these calculations would indicate that a contingency fund of \$33,500 would be sufficient to cover this probabilistic set of items. However, note that risk D by itself would wipe out the fund, so what is wrong with this process? First, we have to recognize that the expected value calculation requires a sufficient number of observations to function properly. Second, this process is not a pure science and there will likely be events occurring that are not in the list, as well as probability and impact quantification errors. Under normal situations, the number of items identified will suffice for the mathematical size requirement,

Table 22.4 Tracking Risk Log

Risk ID number	Risk category	Description	Impact to project	Probability of risk occurring	Range of time risk could occur	Status (execute contingency, watch, hold, or closed)	Action currently taken	Assigned team member(s)
Assign each risk a unique number/name for tracking purposes	Vendor, software, hardware, resources, and so on	Describe the risk	Describe what will happen to the project if this risk materializes such as an extra cost, scheduled delay, and so on	Use a consistent scale such as 1% to signify an extremely unlikely occurrence to 99% to signify an almost certain occurrence	Identify the range in terms of month/day/year or use the term “BOP to EOP” to signify the beginning of the project to the end of a project	Update the status from continuously monitoring the risk throughout the life cycle of the project and assign a category to the status such as execute contingency, watch, hold, or closed	What is being done to monitor or control the risk such as extra meetings with the customer, hiring of additional resources, and so on	Team member assigned to the project

Table 22.5 Contingency Fund Calculation

Risk	P (risk probability)	I (cost impact)	Risk contingency
A	0.8	\$10,000	\$8000
B	0.3	\$30,000	\$9000
C	0.5	\$8000	\$4000
D	0.10	\$40,000	\$4000
E	0.3	\$20,000	\$6000
F	0.25	\$10,000	\$2500
Total		\$118,000	\$33,500

Source: Adapted from Mocal, T. 2008. Management Tip of the Week, www.Tenstep.com (accessed September 2011).

leaving behind the quantification and undefined event issues. Experience will help with the specification of a valid contingency reserve and on that basis will be somewhat stable to management. However, it will always be an issue to show reserves in a project for items that have not yet been physically defined or happened. Regardless of the amount set aside for this class of unknowns, it is important to recognize this time and cost aspect of the planning process. *The PM has the challenge of justifying to management why these additional funds are needed.*

Summary

Risks are analyzed with a quantitative or a qualitative assessment. Once the risk has been thoroughly assessed, a plan as to how to respond to the risk is identified. Therefore, a plan is put in place to respond to each risk event with the goal being to enhance opportunities and reduce threats to the project’s objectives. The last step is the monitoring and controlling of risks throughout the life of the project. This section has discussed many tools and techniques in risk management, which will require many resources for the PM and project team to be successful. Most importantly, although risks are identified at the beginning of the project, new risks may become identified throughout the life cycle of the project, so it is important to continuously assess potential risks throughout the project.

QUESTIONS

Student review questions

1. Describe and differentiate between quantitative and qualitative risk assessments.
2. Describe the risk response strategies.
3. Explain the importance of the risk monitoring and controlling process.

In-class questions

1. Give three examples of risk assessment tools used by companies.
2. Create a risk scorecard appropriate for use by your university or company in rolling out a new system.

EXERCISES

1. In using the car case study tasks, what is the time and cost variance using an assumption of $\pm 15\%$? Generate a histogram using a tool such as a trial version of the Barbecana Full Monte software that can be downloaded for free at <http://barbecana.com/>.
2. In using the car case study, your team is tasked to produce the following:
 - a. *Risk assessment—qualitative analysis:* Develop a risk matrix that can be used to assess risks affiliated with the car case study in terms of the likelihood of a risk event occurring and the probability of impact the risk event would have on the project. Sources for locating sample risk matrices are listed in Appendix C. Also, see: http://deanofstudents.utexas.edu/sald/downloads/Risk_Assess_Matrix.pdf
<http://www.corporater.com/en/products/showcase/risk-management/>
<http://www.mtpinnacle.com/pdfs/RiskMatrix.pdf>
 - b. *Risk assessment—qualitative analysis:* From the risk log, develop a risk mitigation plan for each of the five risks. The plan should include the components in the risk and mitigation plan which was previously discussed in Chapter 11, Figure 11.3.
 - c. *Risk assessment—quantitative risk assessment:* Download a trial version of the Full Monte software (Barbecana, Inc., 2011a) at <http://barbecana.com/full-monte/to> to produce a tornado chart and normal distribution histogram.
 - d. *Risk response:* Describe which of the following strategies your team will utilize for three risks that were identified for the car case study. Also, identify the amount of contingency funds needed for:
 - Risk avoidance
 - Risk acceptance
 - Risk transference
 - Risk mitigation
 - e. *Risk monitoring:* Develop a process for your team in monitoring risk. The process developed is not limited to but should include the following tasks:
 - Look at current risks in exploring how these risks could be reduced or eliminated and no longer need coverage.

- Systematically track the identified risks.
- Identify new risks.
- Capture lessons learned for future risk assessment and allocation efforts.

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chapter twenty-three

Team tools

RAM charts and staffing profile

Most PMs do not awake and decide to be an ineffective and/or unorganized PM or team member. Generally, team members and PMs intend to do well with respect to their professional positions (Shetach 2010). Different tools that help a PM and project team be organized will maximize the team performance in terms of efficiency. Chaordic systems thinking is defined as something that is both orderly and chaotic at the same time (van Eijnatten 2004, 431; Bourne and Walker 2005). Therefore, situations to include even those that are chaotic often have an underlying logic to them even if it takes reflection to see the logic. Many researchers have examined chaordic systems thinking, suggesting that to be a good leader, one must not rely on control and inflexible processes but take on a role more of path finding (Backström 2004; Bourne and Walker 2005; Jensen 2004; van Eijnatten 2004). Therefore, let our path finding begin so that we conquer our project effectively. With this mindset, we need to discuss different tools to help guide us through the chaos so that our journey through managing a project is successful.

Organizational definition

Project teams need to have a clear understanding of their role within the team and the overall organization. There are many situations where groups of input/output relationships model the way in which project tasks are completed. Figure 23.1 merely shows that every team member's "output"

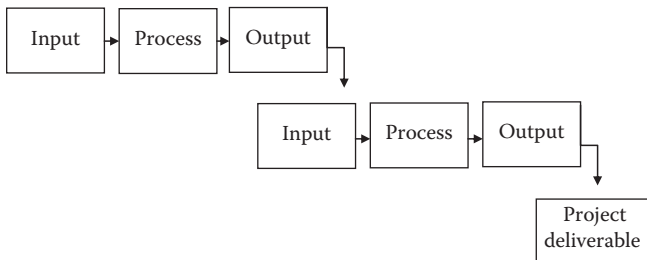


Figure 23.1 Team member's input and output.

is “input” for another team member’s assigned task. Understanding of this concept truly helps a team identify with not only how they fit into the scheme of the project, but also how important their role is in terms of keeping with deadlines as their output is greatly needed as input for another team member to perform their task. Eventually, all the output generated leads to the successful completion of project deliverables. Project software tools will allow for names to be displayed such as a business analyst (or even a person’s actual name) next to different work tasks, which essentially serve the purpose of the simple input and output figure. One example is shown in Figure 23.2. However, a brief discussion on the importance of each team member fulfilling their responsibility is vital to the success of the team working together, resulting in the project being a success.

A simple organizational chart must be developed for project teams so that the PM and the team members know who is responsible for various aspects of the overall work. Figure 23.3 displays a sample organizational chart. An organizational chart can list names under each box so that each team member has instant awareness of the chain of command relative to their position. This assists in communication flowing to the appropriate team member, resulting in the most efficient way to resolve problems that may occur throughout the project duration. Also, keep in mind that there are many different types of organizational charts, which were previously

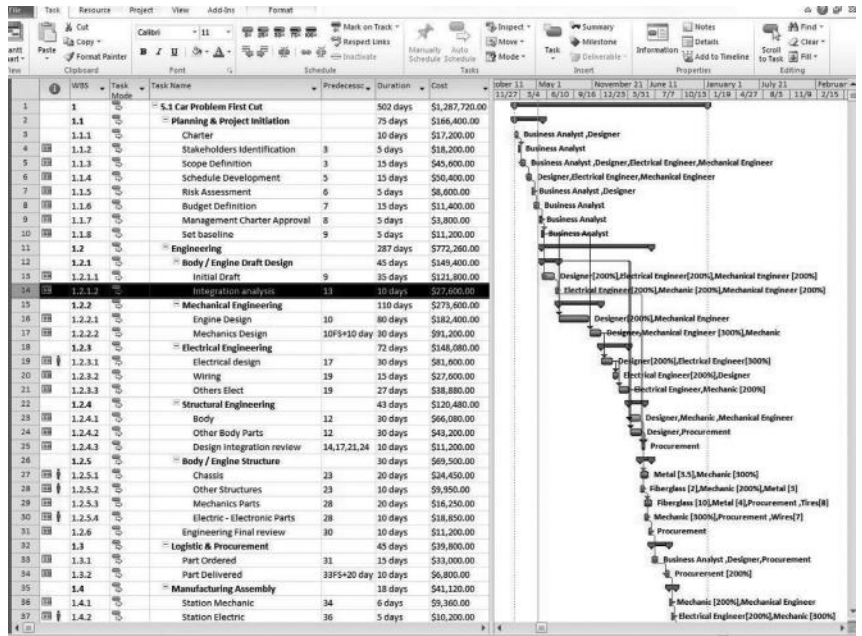


Figure 23.2 Microsoft project Gantt chart.

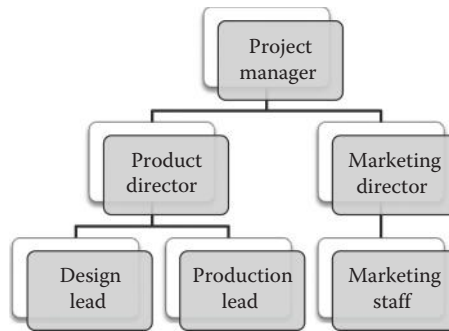


Figure 23.3 Organizational chart.

discussed in Chapter 3. To summarize, there are three main benefits of having a formal organizational chart. First, it provides all team members with an understanding of how each member fits into the overall project. Second, it provides internal team members with information regarding the different levels of authority. Third, it provides external individuals affiliated with the project such as project sponsors and customers with an understanding of the roles and authority that different individuals have. Almost every organization uses some form of organization definition to show how individuals are structured on the project team. However, PMs do not always think to provide one that is specific for the team.

Roles and responsibilities matrix

Instrumental to the success of the project team, each team member must have an in-depth understanding of where they fit in terms of the project tasks. The roles and responsibilities matrix (RAM) is one tool that can be established to document which tasks belong to which individuals (Table 23.1). Furthermore, a sheet for each team member with detailed information consisting of individual responsibilities can also be helpful. Let us start the discussion with the popular RAM, which serves multiple purposes as it is an easy way for the PM to have a general idea of which team members may be involved in too many tasks. Of course, the Gantt chart provides additional details such as the amount of time needed to conduct the task that this chart omits. However, a RAM chart can still help the PM at a glance to see who may have too many responsibilities.

There are many benefits to a project team having a RAM chart. To begin with, the RAM is helpful for each team member as it provides even more details than the organizational chart in clarifying different team member's roles and responsibilities. It also provides clarity to the internal team members so that they know instantly which other team members have responsibility for the same task. It is also helpful to external

Table 23.1 Example of the RAM Chart

Tasks	Richie	Craig	Natalie	Mark	Ryan	Lindsay
Develop the database	X	X		X		X
Perform the statistical analysis			X		X	
Develop the website				X		X
Create the training manual	X	X			X	
Create the training survey		X				X
Conduct the training			X			

individuals outside the organization so that they too have an understanding of which employees are responsible for different tasks. However, depending on the type of project, a RAM chart may very well be used only for internal individuals. Overall, a RAM is valuable for all team members to understand the role and responsibility each team member has on the project. Table 23.2 displays a matrix that clearly defines who on the project team is *responsible* and *accountable* to be *consulted* and to be *informed* (RACI) about different tasks. The RACI matrix is also mentioned in Chapter 2. This tool can be used instead of the RAM chart as it is very similar since both tools display which team member is *responsible* for performing the task. The difference is just that the RACI breaks out different team member’s roles more by displaying who may be responsible but still who is ultimately *accountable*. Also, it identifies who on the team may hold a particular expertise and therefore must be *consulted* to make sure the task is carried out correctly and successfully. Furthermore, it states who on the team is to be *informed* of any task that possibly does not fit well into the project schedule and yet still needs to be accomplished. Overall, a PM may choose the RACI over the RAM because of the details it provides.

Another way to further clarify responsibilities for team members is to provide each individual with their responsibilities sheet. This sheet is generally shared only between the PM and team member as it contains more specific definition of each work task. This prevents misunderstandings later as it serves as a document where both the PM and the team member can be sure that both are on the same page in terms of what the task involves. Another benefit of this sheet is that it can also serve to evaluate the individual’s performance with regard to the progress made within each of the responsibilities assigned. Therefore, it provides not only guidance to the team member, but also as a way for both the PM and the team member to check-in with each other to be sure that the task is understood. Table 23.3 displays an example of roles and responsibilities for a team member. An individual responsibility sheet provides clear roles and responsibilities for each team member. The RAM and individual responsibility sheet together provides guidance and direction for each team member and the team as a whole.

Table 23.2 RACI Matrix

Task number	Tasks	Completed	Date task identified Month/ day/year	Task due date Month/ day/year	Richie	Craig	Natalie	Mark	Ryan	Lindsay
1	Develop the database	X			A	R	C	I		C
2	Perform the statistical analysis				A		R		I	C
3	Develop the website	X				R	C	A	R	I
4	Create the training manual	X			C	I		R	A	
5	Create the training survey					A	R		C	I
6	Conduct the training				R	I	I	C	A	R

Table 23.3 Examples for Roles and Responsibilities for a Team Member

Mark Bell's responsibilities	Task	Subtask
Task 1	Serve as a lead database designer responsible for assigning work and monitoring the work of other team members with a database role	• Identify database tasks • Assign database tasks to team members • Monitor each team member's progress on tasks weekly
Task 2	Serve as a lead website developer responsible for assigning work and monitoring the work of other team members with a website role	• Identify website tasks • Assign website tasks to team members • Monitor each team member's progress on tasks weekly • Update the website in terms of information • Design the website in terms of function • Arrange access for all team members to the employee login of the website and shared drive • Arrange access for all team members to the employee login of the shared drive

A staff management plan is another tool for the PM with the purpose of assisting in the management of project resources from the beginning to the end of a project. This plan helps in identifying the skill set needed within the project team so that the project can be staffed appropriately. The content of a staff management plan can vary depending on an organization but the main categories of this plan are listed in Table 23.4. The introduction section will contain general information on the purpose and scope of the plan. Different processes, procedures, or documentation that will be used in managing the staff will also be discussed in this section. The second section is centered on the process for managing the staff. This section contains everything from the planning of the staff to what is involved in getting the staff on the project team. It also includes how the staff will be trained and how the team member's performance will be monitored. Finally, it discusses how the staff will be transitioned off the project team as the project comes to a close. The third section identifies the different roles and responsibilities of every category of the staff such as engineering staff, technical staff, and so on. Included in this section is

Table 23.4 Staff Management Plan Template

Table of contents for a staff management plan	Description
Introduction	This section typically contains the purpose of the plan, scope of the plan and processes, and the procedures or documentation used as part of the management of the staff
Process for the staff management	This section will contain how the PM will conduct planning of the staff, acquiring of the staff, training of the staff, tracking of the staff member’s work and performance, and transitioning of the staff throughout the life cycle of the project
Roles and responsibilities	This section contains the specific roles and responsibilities of different categories of team members (the technical staff, the engineering staff, etc.), and different project stakeholders
Glossary/acronyms	A list of glossary terms specific to the project should be included in the plan as well as an acronym table
RACI (or RAM)	A RACI table or a RAM table should be included to ensure that this all the staff-related material is in the plan

the description of the project stakeholders and the role these stakeholders play in the project such as providing equipment, facilities, and so on for the team. Examples of stakeholder categories may be an advisory team to the project, project sponsor, specific management, or department. The fourth section of the staff management plan is a glossary of all terms specific to the project and an acronym table. The RACI displayed in Table 23.2 or the RAM displayed in Table 23.1 will make up the last section. This plan must be a comprehensive reference document to consult throughout the life cycle of a project.

Tracking tools and techniques

Different tracking tools and techniques exist to help the PM and team to keep an ongoing status of different versions of documents or even commitments promised by the team such as the promises of a demonstration of the team deliverables. The commitment-tracking document helps the PM track the commitments made by the team members. Table 23.5

Table 23.5 Commitment-Tracking Document

Commitment	Date of commitment	Person making the commitment	Person to which the commitment was made	Date commitment is to be completed	Comments
Demonstration of the website prototype	Month/day/year	Project team member Mark Bell	Customer Stan Thomas	Month/day/year	Team member Mark Bell will present the demonstration
Quarterly status review to the management	Month/day/year	Project team member Joseph Jones	Customer Norma Smith	Month/day/year	Team member Joseph Jones and the PM to present

displays an example of a filled-out commitment-tracking document. It is a great organization tool so that every commitment is logged and tracked through to fruition. The communication-tracking document is another tool for helping keep track of the schedule for different forms of communication regarding the project, both internal and external to the project team. An example of this tool is in Table 23.6. The project description document displayed in Table 23.7 provides information on the creator of the document and reviewer of the document. It also provides information on the individuals who have received a copy of the document and the date of the document. Again, this is just another tool to be used to gain information quickly and accurately. Lastly, there is a revision-tracking

Table 23.6 Communication-Tracking Document

Type of communication	Schedule	Communication initiator	Communication recipient	Communication format
Weekly status review	Every Thursday at 10 a.m.	Project Manager	Project team	Meeting/teleconference
Weekly team progress report	Close of business on Monday	Project Manager	Program Manager	Email
Monthly team progress report	First Monday of every month at 2 p.m.	Project Manager	Program Manager	Meeting
Project review	First and third Monday of every month at 10 a.m.	Project Manager	Project team	Meeting
Customer reviews	Second Monday of every month at 2 p.m.	Program Manager Project Manager	Customer	Meeting containing the customer and the responsible team members

Table 23.7 Project Description Document

Document name	Document developer	Document reviewer	Document distribution date	Distribution list
Commitment-tracking document	Project Manager	Program Manager Project team	Month/day/year	Program Manager Project team
Communication-tracking document	Project Manager	Program Manager Project team	Month/day/year	Program Manager Project team

document displayed in Table 23.8, which provides information regarding which documents have had changes made to it. This keeps track of important project documentation as it provides the PM and the project team with information regarding the most updated copy of the document. It also provides a reminder statement as to why a document was accepted or rejected for modification. Documentation is an important tool in recording aspects of the project.

Staffing profiles are another useful tool for a PM to track resources. Staffing profiles as displayed in Figure 23.4 displays the amount of staff for any particular category that is needed during a specific time period. The amount of staff needed is categorized as “planned” and in this example,

Table 23.8 Revision-Tracking Document

Name of the person submitting the revision	Date the submission was received	Document affiliated with the submission	Submission accepted or rejected and reason	Date the submission was accepted or rejected	Reason for submitted change
Project team member John Smith	Month/day/year	Communication-tracking document	Accepted	Month/day/year	Provide an additional day of slack time between the team status review and the customer review
Project team member Alicia Gomez	Month/day/year	Commitment-tracking document	Rejected because the PM prefers items that occur less than monthly to remain on the commitment document	Month/day/year	Communication matrix may be an easier way to track the quarterly management status meeting

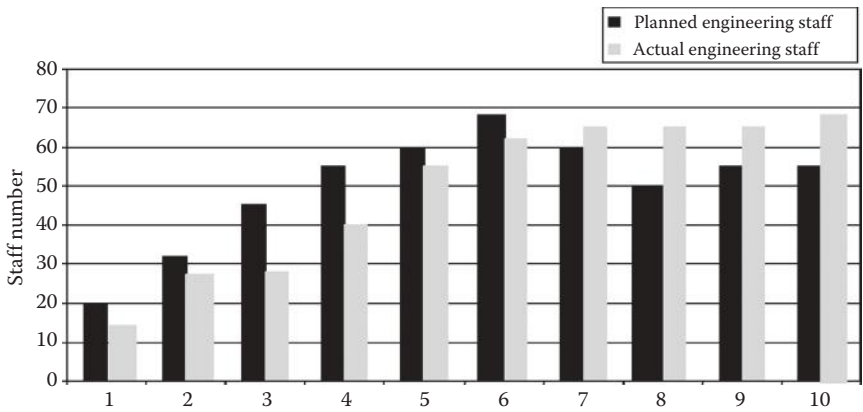


Figure 23.4 Staffing profiles.

the amount of engineering staff needed is graphically represented. The “actual” category is the amount of actual staff within that specific discipline that is available for the project. From this view it is possible to tell at a glance where the resource gaps exist throughout the life cycle of the project.

A velocity diagram as shown in Figure 23.5 displays the amount of work completed versus the amount of work left to complete. This simple diagram also totals the amount of tasks for a project. A PM can use this display to track over a specific time period the progress made with completing tasks as well as the remaining work affiliated with a project.

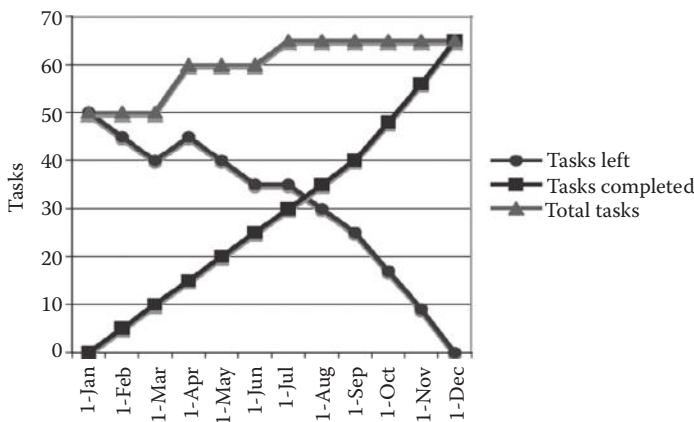


Figure 23.5 Velocity diagram.

Project close-out

As projects near the end of their existence, the PM should take responsibility to assist in reassignment of the staff. Each staff member within the organization will need to be reassigned to a new project once the current one ends. The reality of this process is that new projects may need team members before the current project has ended. This can result in many resource issues for the current project. Sometimes, it is possible to have project team members maintain some percentage of work with the current project while also beginning to take on their new role on their new project. These special activities may consist of a team member needing to begin attending team meetings for that soon-to-be new project team. The more organized a team is, the easier it will be when resources need to reduce their percentage of work on the current project. If different tasks are well documented, then a PM may be able to negotiate the addition of a new team member even as the project is coming to an end. Many times, individuals are between projects, and instead of being idle, they will be assigned to help a team with project close-out activities. Ideally, the same team that began the project will end the project but it is seldom the case.

Archiving data is another important aspect for project close-out. This takes the form of not just archiving all materials electronically but possibly even having a hard copy as well. Furthermore, an electronic backup is important as technology-based storage devices can become damaged; so, housing backup files is important. What types of data are needed to be archived? That may depend on the organization, project type, or other contractual requirements. Think in terms of a construction project where many different homes of the same model may be built over time. In that case, as much data as possible should be kept as it will reduce the learning curve involved with each additional house being built. However, a one-time type of project may not require as much of the project data to be archived. Generally, reports developed throughout the project along with different documents such as Gantt charts, project charter, RAM, and so on should all be maintained. The reason why a one-time-type project still requires archived data is because much of the documentation can still be recycled even if just partially for another project.

Another area of project close-out is the recording of metrics. It is important for an organization and even the PM to maintain metrics regarding the project to help estimate and plan future efforts. There are many different types of metrics that can be recorded depending on the project. Table 23.9 displays examples of some metrics that can be tracked. Evaluating a project retrospectively helps one to identify additional metrics and validate those identified.

Another aspect of project close-out is to prepare a final report and update any company documentation necessary. The report as a minimum

Table 23.9 Examples of Metrics

Types of metrics	Examples of different metric types
Financial metrics	• Inventory levels • Cost per unit • Activity-based costing (cost per each sub-subtask activity) • Cost of poor quality
Customer metrics	• Customer satisfaction • On-time delivery
Metrics for internal business processes	• Defects • Inspection data • Supplier quality • Cycle time • Rework hours
Organizational learning metrics	• Training effectiveness • Lessons learned • Project schedule versus actual date • Total project savings

should include summary, scope, cost, schedule and lessons learned sections. Some organizations even have entire lessons learned databases where employees can search in different problem areas from anything such as how to hold an effective meeting to how to effectively and efficiently get airplanes maintenance performed between flights. Metrics as discussed above that were maintained from the beginning to the end of a project should also be part of the final report. This is also the time to document in the report all project objectives that were successfully achieved. The final aspect of the report is to obtain the signature from the customer that project deliverables were received and accepted. As the team finalizes the report, identification of improvements or enhancements to company documentation is needed too. The team may realize that an organization's IT policies or any process, procedure, or technical documentation should be modified so that the documentation includes any important statements previously not included in the documentation. For instance, the project team may use a company system to house the meeting minutes of the project team. Therefore, an update to an IT or organizational policy may need to occur to account for system access by a consultant that is part of a future project team but an outsider to the company. Project close-out is an important tool for the survival and continuous improvement of organizations.

Summary

This chapter addresses the importance of an organizational chart as it provides all team members with an understanding of how each member

fits into the overall project. It also provides the internal and external team members with information regarding the different levels of authority individuals on the project team have. Different roles and responsibilities tables were discussed as a means for the PM and the team members to specifically identify different tasks that individuals have and which team members work together on specific tasks. Tracking tools were also discussed to help a PM and project team track the frequency of meetings, assignments, commitments and revised documentation. A staff management plan also provides information to the PM regarding which skill set is needed throughout the life cycle of a project for it to be successful. Lastly, the area of project close-out was discussed identifying the tasks that the PM and the team members need to complete prior to officially ending a project.

QUESTIONS

Review questions

1. What is the purpose of an organization chart for a project?
2. Describe and differentiate between the RAM, RACI, and the individual responsibility sheet.
3. What is the staff management plan?
4. Explain the role of each of the different tracking documents:
 - Commitment-tracking document
 - Communication-tracking document
 - Project description document
 - Revision-tracking document
 - Staffing profiles
 - Velocity diagram
5. Summarize the project close-out activities.

In-class questions

1. Compare the organization charts for two companies and/or project teams. What differences can be found in the organizations?
2. Discuss other tracking documents outside of those discussed in this chapter that may be useful.
3. Identify templates available online for the development of a staff management plan.

EXERCISES

1. For your student team, develop an organization chart, RAM, RACI, and the individual responsibility sheet for each team member.
2. Using the car project described throughout the textbook, create documentation for each of the tracking documents discussed in this chapter.

References

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Enterprise project management office

Introduction

The EPMO is created to assist in decisions related to making sure the right organizational projects are done at the right time, with the right tools and templates, and that they contribute to the organization's strategic plans. The fact is that most companies have a PMO-type organization that does not reach half of these lofty goals (Crawford 2011)! The following list summarizes 16 common reasons why this organizational initiative may suffer from mediocre success:

1. *Authority*—Many PMO managers' report to a functional manager who in turn reports to some higher-level executive. This multi-layer reporting situation increases the challenge in proving the worth of the organization. This can be enhanced if the PMO reports directly to the higher-level executive. PMOs vary in size, responsibilities, and structure, but if they are embedded in a functional unit such as IT, the odds are that it is not a real EPMO because its focus is more limited to that organizational subgroup. Also, the EPMO organization will be perceived as "just some IT thing" and as a result it will not be respected as having a more global role.
2. *Organizational alignment*—This problem occurs when the location or formal authority of the PMO function does not align or link with its design goals. For example, this can include the project scope, planning time frame, or overall business objectives (Crawford 2011). In addition to this, the PMO needs to align its key status measurements to business objectives that executives value the most (Crawford 2011).
3. *Process involvement*—It is imperative that the PMO function be actively involved in the project selection process. This will help to ensure that the correct projects are being pursued—in short, portfolio asset optimization
4. *Stovepipe view*—This management syndrome relates to the focus of the PMO organization. In essence, it means that the PMO function should spend most of its time on creating strategic organizational

synergy around the overall project portfolio that will add maximum business value.

5. *Comparing projects*—To evaluate both proposed and in-work projects, it is necessary to develop a common evaluation measurement system. Failure to accomplish this goal will limit the ability to compare current projects against each other and also to compare current projects against new project requests and strategic goals.
6. *Leadership turnover*—Organizations are dynamic entities and key leadership roles often change. Therefore, having a high personnel turnover in various organizational or PMO roles can negatively impact the value and stability of the PMO. The importance of good and consistent leadership cannot be overstated. The elements of quality and stability are the key considerations linked to PMO success.
7. *It takes time to mature*—Starting up a PMO is not an overnight event. This process requires a total commitment by the entire organization (Crawford 2011). It must be recognized that it takes multiple years for a PMO to mature, have repeatable processes, and to fully add value to the overall organization. If management is expecting quick results, they are often disappointed.
8. *No methodology*—The value of a standard development process has been mentioned previously. Organizations that have ad hoc processes or static ones generally do not profit from standardization and reusability. A methodology should always be viewed as a living organism that constantly needs to be reviewed and updated. If this is done, it has the result of producing valuable lessons learned and harvesting best practices from industry (Smith 1981; Whitten 1995).
9. *Not all projects are equal*—In many cases, a PMO will develop a standard methodology and then require that all projects are executed in the same way. This creates the image of excessive bureaucracy and reflects negatively on the perceived value of the PMO. Small projects should have fewer required steps to reflect their smaller scope and lower complexity. The decisions, regarding how to customize the management of various projects, are a key success element for the PMO. If it is viewed as creating excessive overhead for no value, the organization will be shut down as a failure.
10. *Keep projects under a year*—Projects that last longer than one year suffer a host of change dynamics that can negatively impact success. Scope control is often lost as a result of these dynamics, as well as organizational interest in the goal. If possible, projects scheduled for longer than a year in duration should be broken down into phases. This minimizes the change dynamics and reduces the risk of failure.
11. *Training is important*—The quality movement of the 1940s highlighted the productivity value of training and that lesson is still valid. If the organization does not invest sufficient resources in training to

support the formal project management or PMO initiatives, the overall operational maturity value gained will be lost. Also, having an effective training program can help reduce employee turnover and employee satisfaction and loyalty. Another HR enhancement strategy is to support various certification initiatives for employees for increased professionalism. Supporting membership in professional organizations such as PMI should be considered. In all of these examples, the idea is to make the employee more aware of the underlying theory that improves technical success.

12. *Using contractors*—The practice of using contractors on project teams is controversial. In some cases, an outside contractor can bring increased maturity to the management or technical process. On the negative side, once they leave, that knowledge goes with them. So, if supplemental contractors are used, the goal should be to transfer as much of that knowledge to the permanent work force as possible.
13. *Sponsorship is important*—Many projects have no active sponsorship or have weak sponsorship (i.e., lack of participation). There is a high correlation between poor project sponsorship and project failure. If the sponsor is not actively involved in the project, the project will often drift away from current goals and result in lower success, or even outright failure.
14. *Canceling projects*—Project managers and stakeholders often get so locked into a project objective that they do not see that its value has eroded because of the changing environment. In this situation, they often resist canceling a failing or redundant project (Crawford 2011). One of the key roles of the PMO is to bring a more rational evaluation approach to the ongoing value analysis for the selected portfolio.
15. *Resource management*—The process of helping in managing the overall project resource pool is one of the most valuable aspects of the PMO role. Resource management is one of the most complex challenges for both the PM and PMO. Many would consider failures in this area as the Achilles' heel of project management. Failure to successfully link appropriate constrained resources to project needs is a core PMO objective.
16. *Risk identification*—The Gartner Group estimates that poor risk management will result in the future cancelation of about 20% of all projects and that number may be conservative. Since individual projects may not have access to this skill base, the PMO organization can provide this across the total portfolio and add increased value.

There are certainly many more reasons why deficiencies in the PMO organization can result in its demise, but this list gives a good overview of the typical shortcomings.

Project, program, and portfolio management

Tables 24.1 and 24.2 show a comparative analysis of project managers, program managers, and portfolio managers that may be found within an IT-run PMO (usually will not find program and portfolio managers). All

Table 24.1 Part 1—Breakdown of Project, Program, and Portfolio Responsibility Areas

Areas	Project managers	Program managers	Portfolio managers
Scope	Project scope must be clearly translated into work (i.e., work included and work excluded). Strive to control scope creep, which is the dreaded scourge for most projects. It is vital to have a good change control process	The scope is larger and provides important benefits. Responsible for on-time delivery of projects that fall within the domain. To be successful, always provide support, assistance, guidance, and mentoring to the PMs	The portfolio view is a top-level view of every project an organization is engaged in and should be closely aligned with the direction of the business. Scope will always change when there are changes to the strategic goals and it is always important to work on the right projects
Planning	Elaborate the high-level project charter and scope into detailed plans to be executed	Create high-level plans to help guide the overall descriptions of the WBS work packages	Create and maintain processes to show you are meeting the aggregate goals
Management	Need to manage the project team to meet its deliverables	Need to manage the staff, including PMs, and provide vision and leadership	Need to coordinate staff and participate in communicating the organization's goals
Change	Change will always happen and it needs processes to keep change under control	Change will happen inside and outside the program and it needs processes to keep change under control	Monitor the constantly changing environment

Source: Adapted from PMI. 2008. *PMBOK® Guide*, 4th ed. Newton Square, PA: PMI.

Table 24.2 Part 2—Breakdown of Project, Program, and Portfolio Responsibility Areas

Monitoring	Monitor/manage the work to provide the expected results. This includes measuring progress regularly to identify variances within the plan, so corrective actions can be taken	Monitor progress of components, overall budgets, goals, schedules, and benefits to make sure they are being met	Monitor aggregate performance and key indicators, especially the financial ones
Success	Is measured by timeliness, quality, being within budget, and client satisfaction	Is measured by the degree of meeting its projected needs and benefits	Is measured by meeting its total needs and aggregate performance
Other	Less uncertainty to manage and project may or may not satisfy the strategic goals of the organization ————— Keep in mind that about 70–75% of all projects come in late or are canceled ————— Say “No” to unrealistic deadlines and propose realistic goals ————— Always make sure the project objectives are well defined—clear, realistic and measurable, and frequently reviewed ————— Communication is critical!	This is usually about satisfying strategic goals and delivering a business vision ————— Greater diligence is needed when chasing a new technology strategy ————— Typically, a program is made up of a group of related projects. It is possible to have such a large and technical project (i.e., ERP implementation) that this single project should be considered a program ————— Communication is critical!	Execution processes must be reviewed and updated annually to stay relevant and useful to the organization ————— The cornerstone of IT portfolio management is the selection process. Prioritization and optimization are vital for all aspects of portfolio management ————— Involvement of key stakeholders is essential to establish, confirm, and focus on business priorities ————— Communication and training are needed to develop stakeholders buy-in and to educate the portfolio management teams

Source: Adapted from PMI. 2008. *PMBOK® Guide*, 4th ed. Newton Square, PA: PMI.

three areas will be found in an EPMO that reports to the business side of the organization.

Prioritize projects to align with strategic plans

Every project should support the organization's strategic plans! But how can we ensure this linkage? This integration requires a process for prioritizing projects that contribute to these plans. In customer-driven companies, the missions and goals focus heavily on meeting the needs of customers. The goals translate the higher-level mission (i.e., what we want to be) into specific tangible and measurable terms. From these guiding definitions, the strategic management process and its relationships to projects use the following steps:

1. Define and review mission
2. Analyze external and internal environments
3. Identify goals and objectives
4. Formulate strategies to achieve objectives
5. Implement strategies through projects

To produce the desired project goal linkage, a formal evaluation process is needed. The following four templates are shown as examples that could be used in obtaining consensus as to which projects have the goal alignment and/or chances of success.

1. Success-based projects—see Table 4.2

Table 4.2 is intended to help in drilling down and performing a quick risk assessment to determine the probability of success on a current or new project. Anything less than 75% suggests that you could be headed for trouble. Other critical success questions can be added to better match the profile. Be sure to add corresponding success weights and then recalculate.

2. Criteria-based projects—see Table 4.3

Table 4.3 is intended to help in comparing different projects based on certain criteria. The criteria shown are competitive advantage, customer satisfaction, potential cost, potential revenue, and ease of implementation.

3. Weighted-based projects—see Table 2.7

Table 2.7 is intended to help in ranking different projects based on weighting them by different criteria. These include supporting company's strategy, potential to increase revenue, likelihood of success, readiness, level of urgency, and potential to decrease costs.

4. Technology-based projects

Considering how much and how rapidly technology has evolved since the start of the millennium, one would think that the ability to implement successful enterprise projects would have improved at a comparative pace. However, it has not, according to a 2006 report by the Standish Group, a Boston-based research firm. The study found that IT project delays and cost overruns have not improved much since 2000: 47% of projects are over budget, and 72% do not meet projected timelines, compared with 45% and 63%, respectively, in 2006.

Because technology advances so rapidly—with significant revisions every 6–12 months—IT projects tend to have high degrees of uncertainty. Methodologies change, personnel turnover can be high, and there are not any standard benchmarks for evaluating abilities and skill levels. A project's success ultimately depends on people, not technology or tools. This holds true for all industries, from manufacturing to financial services.

Table 24.3 will help one perform a quick assessment to determine the chances of success for implementing a technology project.

Moving to the enterprise project management office (or the rough road going from point “A” to point “B”)

The process of starting a PMO in an organization is quite complex and this would generally suggest a modest beginning step. It is best to start small, evolve, and mature at least 2–3 years before expanding to an enterprise view. An EPMO organization should report to the business side of the organization (e.g., CFO or CEO) and not to a functional department.

The mature PMOs must have established standard IT policies, processes, procedures, change control, and a scalable project methodology for developing new systems that can be easily updated for small and large projects when the times change. The standard project methodology must cover initiating, planning, executing, monitoring and controlling, and closing phases. Internally, all required tasks and activities within the project plan need appropriate tools and techniques to support those work activities. Moving to an EPMO will be a significant culture change to the organization and it will require top management support and commitment. The following is a high-level overview of what needs to be done before considering moving to an EPMO.

What is the organization maturity baseline?

It is important to perform a health check! What is the inventory of the currently run systems (including equipment) and systems being developed? How many new systems are being developed and what are their statuses? How does the current development portfolio match to organization goals?

Table 24.3 Project Success Assessment

		Oracle upgrade		The project	
		Risk scale	Score	Risk scale	Score
Top 10 reasons	Success value	0 = Minor	Value ×	0 = Minor	Value ×
Projects fail	Total = 100%	5 = High	Risk	5 = High	Risk
1. Incomplete or changing requirements	25	5	125		
2. Low end-user involvement	15	3	45		
3. Low resource availability	10	1	10		
4. Unrealistic expectations	10	2	20		
5. Little executive support	10	1	10		
6. Little IT management support	5	3	15		
7. Lack of planning	5	4	20		
8. System/application no longer needed	5	1	5		
9. Bleeding-edge technology	5	2	10		
10. Other miscellaneous	10	0	0		
Total score			260		
What the total score means:					
1–125: High probability of success					
Review weak areas if any.					
126–250: Low probability of success					
Work on weak areas.					
251–500: Cancel project					
It will most likely fail.					

Source: Published in *Baseline Magazine*—June 2008, p. 57 by Ron Smith.

Another important question is “how well are the company’s short-term and long-term strategies communicated to employees?” One can do a portfolio health check by utilizing interviews and questionnaires to find out what their organization process strengths and weaknesses are (Crawford 2011). This assessment is vital before moving forward.

Since every organization is different, it would be wise to phase in the EPMO by having pilot tests to gain experience. Key activities in this phase

are lessons learned, benchmarks, checklists, and review of organizational culture. These pilots include developing business-oriented metrics to be able to properly report desired project status. To do all this and be successful, it is vital to have the right people involved, including key stakeholders and/or executive sponsorship.

If the organization has “trusted” management and open communications culture, it will go a long way toward successfully implementing an EPMO with sound repeatable processes. The last thing desired is to make this important endeavor look like the “flavor of the month” for IT or the organization, which will leave most people skeptical. Too often, these “silver bullet” solutions fall under the critical microscope of the employees.

Steering committee

The EPMO must have a management-level steering committee for selecting and monitoring strategic and nonstrategic projects and the members would consist of at least

- EPMO director (i.e., provides meeting agendas and a list of decisions that must be made)
- VP of business, CFO, and/or CEO
- Key members from each one of the businesses (could be high-level and/or middle management)
- CIO or key VP and a few key support members from IT
- SMEs who would be added for key projects when expertise is needed

One of the most important roles the steering committee will play is in the realm of culture change that includes changes to various HR, payroll, and procurement systems (Crawford 2011). These changes in thinking and implementation processes will not happen overnight.

The steering committee needs to define what projects belong to what programs and what programs belong to what portfolios. Also, they need to define what projects meet short-term and long-term strategic goals and be able to prioritize the aggregates since there are limited resources available. The selection goal is to pursue high-value priority projects first before the lower-value (or no value) projects, which would quickly drain the resource pool (Biafore 2010). Lower-value projects could be dropped or moved to the future.

One of the tougher roles of the steering committee is to decide to kill a project that is underway because it is not evolving as planned, or the environment has changed since it started (Crawford 2011). This should not be looked at as an admission of failure but seen as improving the pursuit of organizational goals by reallocating project resources to more important projects that have a bigger impact and/or payback.

Summary

Finally, when initiating an EPMO, do not expect immediate overnight success—start out with small-duration projects and build up process maturity to show value to the organization. In the long run, this approach will pay off and people will realize the many benefits of having an EPMO.

QUESTIONS

Review questions

1. What are the disadvantages in using contractors?
2. Why is it smart to try to keep projects under a year?
3. Why is having a project methodology so important?

In-class questions

1. Why is moving to an EPMO so difficult?
2. What are the advantages for an organization to move to an EPMO?

EXERCISE

1. Why is it important to align projects with the organization's goals?

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Appendix A: MS Project lab assignment: A life cycle view

The purpose of this assignment is to provide a sufficiently complex data set to illustrate project planning and tracking. This covers a full life cycle example under a controlled process. Embedded in the simulated project phases are key steps required to develop a project plan and migrate it through the execution phase. The instructions are designed to guide the proper steps for each phase and these steps must be followed carefully in order to arrive at the defined solution values. For each logical grouping, try to understand why the sequence indicated is important to the output.

Supporting data files

The following data files are to be used to feed the plan at various points. Use these data only as instructed and do not jump the sequence suggested. These data are provided to help save time in creating and updating the plan. However, realize that MSP is somewhat picky about the various process sequences, so be sure to check the imported values before moving forward.

The two raw XLS data files used in the case are

1. Project resources: RESOURCES.XLS (the project resource pool)
2. Project activity list and resource allocation data: PLAN.XLS

These two data sources can be retrieved from the publisher's website and will be used in various places throughout the assignment to supply needed values. Data element definitions for each file are summarized below.

Resources data elements

The following data elements are provided in the RESOURCES.XLS data file:

Resource name	Type	Material label	Initials	Group	Max. units	Std. rate	Ovt. rate	Cost/use	Accrue at	Base calendar

Plan data elements

The following data elements are provided in the PLAN.XLS data file:

WBS	Task name	Duration	Predecessors	Resource names	Actual duration	%Comp

Specific importing instructions are embedded in the dialog below for each step. It is important to only extract the data defined elements in each segment. Failure to follow this rule will negatively affect the outcome values.

It is also advisable to have the MSP keystroke summary sheet handy throughout this exercise (see Appendix B). There are instructions to save interim versions are contained throughout to help in case it is necessary to back up and recover from a processing error. Failure to do this can result in having to start all over again. The bolded values are used to highlight these critical milestone points. Also be sure to check the summary values at these points.

Execution sequence

Phase I. Project plan development

The goal for this step is to create the initial project schedule from the defined scope data.

1. Open MS Project and select File/Options/Display. Change “Decimal digits” to “0.”
2. Select File/Options/Schedule and change “New tasks created” option to “Auto Scheduled.”
3. Insert a Task at the top row to represent the total project. Label this as “Total Project <your name>.” Its WBS code should be “1.”
4. Import the following data elements from PLAN.XLS: *Task Name, Duration, and Predecessor* columns—Note: be sure to check for copy/paste issues with this process, so the incoming data should be checked for accuracy. Manually repair any import errors. “Paste Special” with data option recommended.
5. Save this version as “**Case File 1.1.**”
6. Hide the Start, Finish, and Resource Names columns.
7. Verify that the tasks are being scheduled by Automatic Mode—It will help to see this whether the Task Mode column is opened.
8. Indent the activity structure to obey the WBS codes. Check the indentions to see that the summary tasks show properly. The total project duration should now show as **130.9**. If the value is not shown, do not go further until the error is found.

9. Define the Critical Path—[Format/Critical Tasks].
10. Set the project start date to **4/2/2012** [Project/Project Information].
11. Insert Start and Finish dates columns. The project completion date should now be **10/1/2012** (see task 30).
12. The Gantt Chart Wizard would be the easiest way to do this, but the Format/Format/Bar Styles option will also work.
13. Go to Format/Format/Bar Styles and change the labeling on summary bars. Use any other format changes that make the output cleaner.
14. Delete task #30 and insert a Project Buffer on line #30 with **25-day** duration and predecessor of #29.
15. Reinsert the Project Completion milestone task at line #31. The two tasks should now have WBS values of 1.8 and 1.9, respectively. If not, the indentation level is wrong. Go to the Project Buffer task (#30) and change its color to bright green—[right click on bar/Format Bar/...]. The project duration should now show as **155.9**.
16. Save this version as "**Case File 1.2.**"

Phase II. Resource allocation

The goal for this step is to allocate resources to the defined schedule and generate a first cut project budget.

17. Open the MS Project Resource Sheet view [View/Gantt Chart/Resource sheet] and import the resource plan from the RESOURCES.XLS. Beware that some of the data may not import properly, so manually correct any data import errors. Save the file as "**Case File 2.1.**"
18. Go back to Gantt chart view and insert a column titled "Cost." Values should be zero (\$0) at this point.
19. Insert a column titled "Resource Names."
20. Import the Resource Allocation values from the PLAN.XLS column titled "Resource Names" into the MS Project Resource Names field. These data can be copied and pasted, but be sure to check the values to ensure that they copy correctly. Remember that these resource allocations create the direct project cost.
21. Note that WBS items 1.4.6 and 1.4.7 do not have resources assigned. Right click on these and assign the following:
 - 1.4.6 Two field workers and five rolls of carpet
 - 1.4.7 Four painters
22. Save this version as "**Step 1.**" This is an important step because the baseline will be set next and it will be difficult to back it up after that point.
23. Set project baseline—[Project/Set Baseline].

24. Use the Gantt Chart Wizard and choose "Other," then "**Baseline Style 3**" and "dates." And then show the link lines, by checking "Yes" and exit the wizard by clicking "Format it."
25. As a result of the step above, there should now be an indication that the baseline is in place. Black bars appear in parallel to the regular red and blue bars on each task. Save this version as "**Step 2.**"

Discussion questions (Phase II)

These questions are designed to see if there is understanding regarding what this stage of the plan represents.

- a. Are there resource allocation issues with this plan? If so, where?
- b. How many field workers are needed at the max point?
- c. Why are the baseline costs and cost column values the same at this point?

Phase III. Tracking actual status

The goal of this phase is to track simulated actual task completion.

26. *Table formatting:* Hide the columns for Predecessors, Task Mode, and Resource Names. Add new columns for Baseline Cost, Baseline Duration, and %complete. Clean up all columns by centering data and shrinking column width as appropriate.
27. Import Actual Duration data from PLAN.XLS into the Duration column.
28. Import %complete data from PLAN.XLS. As in other cases, check the pasted values to ensure that they imported correctly. Save this version as **Step 3.**
29. The project plan should now show **53% complete, 148.93 days Duration, and Cost of \$36,416.**

Phase IV. Rescheduling tasks based on a status date

The goal for this section is to reschedule the project based on current task status and a defined status date.

- a. Set project status date to **09/3/2012** (ensure that the proper year is entered).
- b. Set a *Red* status gridline [Format/gridlines/status date]. If a red line does not show on the screen at the proper date, a data entry was likely made in one of the two previous steps. Check the calendar year to confirm that the status date has been set properly.
- c. Save this as **Step 4.**

30. This step will reschedule the project (Gantt bars and data) by moving the unfinished work downstream past **09/3/2012** (the defined status date).

Go to Project/Update Project and select the “Reschedule uncompleted work” check box. Click OK. Note that all Gantt bars with unfinished work have now been moved past the status date (even partial bars are moved).

31. Save this version as **Step 5**.

Discussion questions (Phase IV)

These questions are designed to see if there is understanding of what this stage of the plan represents.

- a. Describe the mechanics of project rescheduling?

- b. If the previous durations have an overrun, would there be anticipation that similar behavior would also occur later in the project?

Phase V. Calculating EV parameters

As described in the EV chapter, MS Project handles EV parameters in a somewhat obtuse and complex way. The example here is designed mostly to provide guidance through that process and show that the software can perform these calculations. The real issue is “does it perform them correctly for your project model?” One of the key issues is “how does MSP calculate actual cost for its use in the parameter calculations?” For the example used here, Actual Costs will be manually fed to the program. This simulates the interface role that the accounting system would have to the project.

32. Open up columns (Unhide) for BCWS (PV), BCWP (EV), SPI, CPI, EAC, and VAC. Organize the table layout with any other desired status data that can fit. Move the Gantt bar section out of the screen view. This segment will essentially be all table data and no Gantt graphics.
33. The Baseline cost should now be **\$32,304** and Cost equals **\$36,416**.
34. Save this version as **Step 6**.

Discussion questions (Phase V)

Interpret the resulting parameters from **Step 6** and answer the following:

- a. What is the projected project cost?
- b. What is the projected cost overrun?
- c. What is the projected project duration?
- d. How much of the project has been completed at this point?
- e. The cost performance figures for each task are not impressive; however, the overall difference in cost versus baseline values do not seem so bad. What might be hiding this?

Review

Go back through the major steps and review results of each iteration. Note the output goals for each of the following milestones:

- a. Create the basic plan
- b. Update the plan with actual durations
- c. Reschedule the plan at a defined status date
- d. Compute EV parameters to assess performance and forecast completion.

Appendix B: MSP 2010 commands

This appendix contains a condensed summary of MSP 2010 commands and reference materials. Various sections of the book focus on subsets of this material. A copy of this can be obtained from the ProjectNMotion website (see Appendix F for details).

I. Basic formatting keystrokes

The 14 keystrokes defined below are considered to be the basic literacy steps for MSP. It is possible to create a reasonable project schedule using these instructions. A companion lesson illustrating these steps is available in ProjectNMotion.

1. Hide and Insert data columns—Right click/Hide & Insert {many variables to choose from}
2. Insert WBS column—Right click/Insert column; also, Format/WBS
3. Cut-and-paste raw activity data—Standard Windows operation (check import results to ensure proper values since the project does logical screening on this operation)
4. Indent structure to obey WBS—Task tab/green arrows to enforce WBS structure
5. Task scheduling option—Recommend Task/Automatic Schedule (or through File/Options)
6. Generate WBS schematic—View/macros/View macros/; Select WBSChartPro macro (third-party add-on); also, the Visio add-in utility will create a comparable view
7. Format Gantt bars—Right click on timeline/Zoom
8. Critical Path (red bars) definition—Format/check Critical Task box
9. Project/Project Information—Set start date, calendar, and status dates
10. Recurring task (PM)—Task/Task/recurring
11. Setup Options—File/Options {look through these as basic profile-type variables}
12. Gantt Chart Wizard for general formatting (add icon through the File/Options)
13. Bar labels—Format/Format {dates}; Use Gantt chart wizard first
14. Insert Task Mode column—Right click/Task mode (this confirms scheduling logic)

II. Cost commands

- 1. Cost values—Cost should be generated by allocating resources to the task
- 2. Cost through resource allocation—Right click on task/Assign resources or Resource/Assign Resources (easiest)
- 3. Define project buffers—Use green (or another color) bars to distinguish—right click on bar for single bar format
- 4. Set Baseline—Understand importance of backup file—Project/ Set baseline
- 5. Formatting a single Gantt bar—Right click on bar and use format commands
- 6. Capacity Management—Resource leveling—Format/View {select option}
- 7. Resource Sheet—defines project resources {resource pool}
- 8. Resource Graph—shows individual resource status in bar graph form
- 9. Resource Usage table—Table B.1 shows detailed work allocations and overallocations by task and individual
- 10. Showing Baseline bar—Use the Gantt Chart Wizard (Other, Baseline style 3); Use Format/Format/Bar Styles for refinement from here

Table B.1 MSP 2010 Commands and Add-Ons

Tabs	Groups	Functions
File	Operations	Save/Save As—Open/Close—Info/Recent/ New—Print/Page Setup—Save/Send—Options/ Exit
	View	Gantt chart
	Clipboard	Paste—Cut—Copy—Format painter
	Font	Font—Size—Colors
Task	Schedule	%Completion—Indenting—Linking/Unlinking tasks
	Tasks	Manually Schedule or Auto Schedule—Inspect Task—Move Task—Schedule Task
	Insert	Task—Recurring/Summary/Milestone
	Properties	Task Information—Notes—Details
	Editing	Scroll—Find—Clear—Fill
	View	Team Planner—Resource Usage—Resource Sheet— Other Views
	Assignments	Assign Resources—Resource Pool
	Insert	Add Resources
Resource	Properties	Information—Notes—Details
	Level	Leveling Options

Table B.1 (continued) MSP 2010 Commands and Add-Ons

Tabs	Groups	Functions
Project	Insert	Subproject
	Properties	Project Information—Custom Fields—Links between Projects—WBS—Change Working Time
	Schedule	Calculate Project—Set Baseline—Move Project
	Status	Status Date—Update Project—Sync to Project Actuals
	Reports	Visual—Reports—Compare Projects
	Proofing	Spelling
	Task views	Gantt Chart—Task Usage—Network Diagram—Calendar—Other Views
View	Resource views	Team Planner—Resource Usage—Resource Sheet—Other Views
	Data	Sort—Outline—Tables—Highlight—Filter—Group By
	Zoom	Timescale—Entire Project—Selected Tasks
	Split view	Timeline—Details
	Window	New—Switch—Arrange—Hide
	Macros	Macros
	Format	Text Styles—Gridlines—Layout
Format	Columns	Insert—Settings—Custom
	Bar styles	Format—Baseline—Slippage
	Gantt chart wizard	Global bar formatting; add icon through File/Options
	Show/Hide	Outline Number—Project Summary Tasks—Summary Tasks
	Drawings	Modifying Shapes/Forms
	Add-on tools	Useful add-on utilities to expand functionality
	WBS chart pro	Download a demo version from www.criticaltools.com
Add-Ins	WBS visio	See www.microsoft.com for download details
	PERT Chart EXPERT	Create PERT schematic diagrams; download a demo version from www.criticaltools.com
	Full Monte simulation	Creating time and cost simulations; download a demo version from www.barbecana.com . See Chapter 21 for further details
	At risk for Project	Simulation utility; download a demo version from www.palisade.com

Note: Additional MSP reference materials are available from www.microsoft.com, www.mpug.com, and many other Internet sources. A complete desktop reference summary of MSP commands can be retrieved from the Microsoft Project User Group (MPUG) website www.mpug.com.

III. Status tracking commands

1. Set status date—Project/Project Information
2. Status gridline—Format/Gridlines/status date (be sure to select a line type and color)
3. Start and Finish dates—Unhide the columns to show planned and baseline Start and Finish
4. Tracking status—%Complete column, Baseline column, adjust durations as needed, watch Smart Tags
5. Status gridline—Format/Gridlines/Gridlines/status date {select red and dotted}
6. Showing Baseline Gantt bar versus plan—Format/Format/Bar styles {remember baseline start and baseline finish}; Row number may be changed for appearance
7. Showing Baseline data in table—All Baseline data use “baseline” to define {Baseline start}

IV. Rescheduling commands

1. Recording actual start and finish times for tasks—use Actual Start and Actual Finish
2. Set status date—Project/Project information/{set status date}
3. Project/Update project—causes bars to move past status date

V. Customizing Gantt bar formatting notes

1. It is easier to work with bar formatting if the Gantt Chart Wizard is first ran to establish the base bar formats and then customize them as desired.
2. In the Gantt Chart Wizard, select “Other and Baseline style 3” to get red and gray bar formats for critical and baseline activities, respectively. Also, select dates as an option.
3. To further customize the bars, go to Format/Format/Bar styles.
4. Set task and critical task bars to full size with proper colors for better readability.
5. Set baseline to row 2 in order to show more separation between plan and baseline bars.
6. Within the Format/Format Bars option, go to text tab and open up bar labeling (dates are one common item to show on the bars, but other variables may be appropriate for specific views. These are informational items to show status).

Note: Date labels for baseline items are all prefixed with “baseline,” (This can be confusing and just remember that Baseline dates are different from current plan dates.)

VI. Resource allocation status evaluation notes

1. Learn to navigate through Gantt, Resource usage, Resource sheet, and Resource Graph views to collect the overall status picture of resources.
2. The Resource Sheet is basically the project resource pool that can be used to allocate into specific project tasks. As a result of that allocation, costs are created based on the attached rate information.
3. “Red man” symbols in the information column of the Gantt view will indicate an overallocation. The same overallocation view can be seen from the Resource Sheet.
4. Resource usage—Table B.1 provides a detailed look at time allocation for each resource. The status analysis problem involves finding resource overallocations. The options below will aid in that process:
 - a. Open a new column next to Resource Name by right clicking and inserting a Start column. This will show the dates in which a line item starts. This information can be used to provide guidance on where to scroll on the timeline.
 - b. Right click on a “work” cell. Select “overallocation.” These new rows will show in red where there is an overallocation and by how much. The challenge here is to figure out how to resolve that overallocation.
 - c. Go to View/Other views and select Resource Graph.
 - d. There is an automatic leveling utility built into Project. It may be able to resolve the overallocation, but the underlying result may not be desirable. Always try to resolve the situation manually before turning it over to the utility. Also, it is wise to save a backup version in case the results cannot be used. To invoke this utility, go to the Resource ribbon and review the various leveling options on this menu.

VII. EV data elements

EV variables must be “opened” manually. The following list contains the variables related to this topic. Values within parentheses related to the modern notation, while all others relate to the standard MSP notation. See Chapter 15 for more details.

Definitional variables—BCWS (PV), BCWP (EV), ACWP (AC), CPI, SPI, EAC, VAC, TCPI.

VIII. Menu ribbon summary

Appendix C: Templates

Templates are a good way to keep from reinventing project document formats. There are many template sources on the Internet and these can be browsed through search engines. This section will highlight a few of those. They are outlined here in no particular priority order.

TenStep.com—TenStep is a good source for various project management resources, including free and for-fee templates. See

<http://www.projectmanager.com/project-management-templates>

One of the more complete sets of free templates comes from the Tasmania Government Project Management guidelines. See

<http://www.projectmanagement.tas.gov.au>

A suite of financially oriented Excel® spreadsheet-type templates can be found at the Matt H. Evans website. See

http://www.exinfo.com/free_spreadsheets.html

<http://www.examiner.com/project-management-in-miami/how-to-get-300-free-project-management-templates>

Examples of Risk Matrices are listed below:

http://deanofstudents.utexas.edu/sald/downloads/Risk_Assess_Matrix.pdf

<http://www.corporater.com/en/products/showcase/risk-management/>

<http://www.mtpinnacle.com/pdfs/RiskMatrix.pdf>

Online Project Management Resources

These URL sources may change from time to time

http://www.oregon.gov/DHS/admin/bpm/tools_templates.shtml
{Process Center of Excellence (PCoE)}

<http://www.theicpm.com/download/free-pm-documents> {41} (Page moved)

<http://www.pmlinks.com/information/templates> {62}

http://www.cvr-it.com/PM_Templates (non-profit use/personal only)

<http://www.pm-essentials.com/2000-pm-templates.html> (register for each template)

<http://www.projectmanagementdocs.com>—Project Management Documents

<http://www.e-projectmanagers.com> (requires subscription and profile creation)
<http://www.projectconnections.com/templates/detail> (mix of free and pay)
<http://www.pmhut.com> (requires registration)
<http://www.projectwizards.net/en/macpm/merlin/pm-templates-for-merlin> (Merlin application)
<http://pmtemplates4u.com> {required registration}
<http://pm411.org/templates>
<http://www.brighthub.com/office/project-management.aspx> (BrightHub)
<http://office.microsoft.com/en-us/templates/CT001226193.aspx> (Microsoft®)
<http://www.vertex42.com/ExcelTemplates/excel-project-management.html> (project templates for Microsoft Excel)
<http://dijest.editthispage.com/tools/pm> (Tools: Project Management checklists and templates)
http://www.consulting.ky/free_project_management_templates.php (Key Consulting)
<http://dcarc.pae.osd.mil/default.aspx> (Defense Cost and Resource Center)

Others

41 Project Management Templates at *The International Community of Project Management*—very rich source of free project management templates, including project templates for: Project Charter, Template, Applicant Interview Template, Client Satisfaction Survey Template, Business Case Template, Status Report Template, Issue Submission, Issue Log Template, Lessons Learned Template, Project Management Plan Template, Quality Plan, Scope Change.

62 Project Management Templates at www.PMLinks.com —another source of free project management templates and project plans. Some of their templates include:	Risk Statement Report Template Risk Worksheet Template Requirements Tracking Template Project Closure Template Project Initiation Project Planning 1: Risk Project Planning 2: Budget, Schedule, and Scope—7 templates Project Planning 3: Change, Quality, and more—10 templates Project Execution and Control—12 templates Project Close—5 templates

112 Project Management Templates at *CVR/IT Consulting*—a full library of Project Management Templates, free for Not for Profit purposes. Resources include:

23 Project Management Templates at *KeyConsulting*—another source of project templates and diagrams such as:

8 Project Management Templates at *Project KickStart*—looking for start a project, launch a new product, or make a high-impact corporate presentation? These templates are great source to assist you with your goals. Some of the template you will find here are:

17 Project Management Templates at *PM Docs*—great site to download free project templates organized by the PMBOK Process Group. The samples of project templates include:

10 Project Management Templates at *Project Place*—well put together project templates to help project managers when needing:

6 Project Management Templates at *Project Management Informed Solutions*—site with project management templates aimed more at commercial environments, where processes tend to focus on fundamentals. Resources include:

Project Essentials: All Core Project Documents—19 templates Business Analysis—17 templates PMO and Program Management—14 templates Contracts and Contractors—10 templates Project Management Methodology

Project Initiation Phase Exit Review Checklist Project Planning Phase Exit Review Checklist Project Control Phase Exit Review Checklist WBS Checklist Risk Analysis Template Project Team Member Peer Evaluation Form

Corporate Presentation Template Product Development Template Product Requirements Document Template Construction Tasks and Gantt Chart Software Installation Plan

Project Initiating Process Group Templates Project Planning Process Group Templates Project Executing Process Group Templates Project Monitoring and Controlling Process Group Templates Project Closing Process Group Templates Project Document Templates

Communication plan Delivery acceptance Final report Project budget Project charter Project organization Project plan Requirement specification Risk analysis Stakeholders

Business Case Template Business Requirements Template Risk Register Template Delivery Plan Template Status/ Issue/Risk Log Template Acceptance Planning: Test Issue; Test Sequence; Test Control templates

30 Project Management Templates at *Cornell University CPMM*—very comprehensive site that includes free project templates such as:

Project Initiation Charter Template Project Initiation Checklist Template Systems Project Approval Template Project Planning Project Initiation Plan Template Project Kickoff Meeting Agenda Template Communications Guide Template Roles and Responsibilities Template Project Schedule Template Project Transition Planning Checklist Template Project Execution and Control Risk Management Plan Template Change Order (Internal) Template Request for Change (RFC) Log Template Issues Log Template Project Acceptance Form Template Project Closeout Post Implementation Report Template Project Closeout Checklist Template

For Fee Sources

<http://www.method123.com> price: \$129.00

<http://www.projecttemplates.co.uk> \$99.00 (Prince 2 Accredited){ProjectTemplates List}

<http://www.westwindconsulting.com/PMG.htm> {Project Management Guide}

<http://www.getprojecttemplates.com> \$44.95 {40 project management templates}

<http://www.docstoc.com> \$69.95 {Project Management Starter Kit}

<http://www.projectkickstart.com/downloads/prxdownload.cfm> (Project Management Templates for Project KickStart{Free Trial})

Appendix D: MS Project add-in utilities

Gantt Chart Wizard: Global bar formatting

The Gantt Chart Wizard is a handy utility to help perform basic Gantt bar formatting quickly. Unfortunately, this utility is by default buried in a list of hidden commands. To surface it to the menu, follow the commands outlined below.

Step 1. The Quick Access menu (see gray circle in Figure D.1a).

In the top left corner of the main menu ribbon, find a small drop down arrow (indicated). Click on this and a list of commands pop up. Open up the “Choose commands from” box to show “All commands.”

Step 2. Scroll down to find the Gantt Chart Wizard (Figure D.1b).

Select the Gantt Chart Wizard option and then select Add to move it over to the Quick Command menu list. Select OK to leave this screen. When returning to MS Project, the wizard icon should now be added to the Quick Access menu. See Step 1 menu above and note the wizard icon wand icon. Clicking on this while in Project will activate the command. Follow the instructions to globally format basic Gantt bars. This is a good starting point for bar formatting. From this base point, other formatting can be added by selecting Format/Format/Bar Styles.

WBS Chart Pro: Creating WBS graphics from Project

This utility from www.CriticalTools.com is a handy tool for creating WBS diagrams from inside the MSP. A free 30-day demo is available, so wait until it is needed before installing it. Once installed, this utility is accessed within the Project as a macro (e.g., View/Macros/View macros/Run). This will create a WBS schematic based on the current Project model. Refer to the User Manual for details regarding further formatting.

Visio add-in WBS modeler: Uses Visio to produce WBS diagrams

This Microsoft utility is designed to create WBS charts inside Visio. Effective use of this tool requires facility with Visio instructions to take

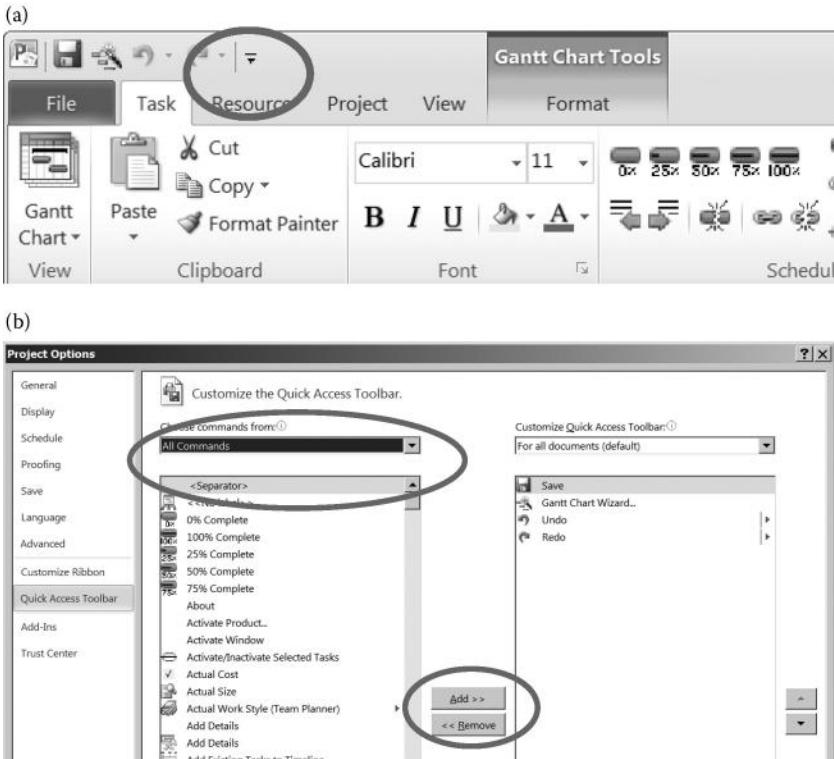


Figure D.1 (a) Gantt Chart Wizard. (b) Quick Access menu.

full advantage of the capabilities and it is harder to use than WBS Chart Pro for that reason. The URLs below can be used to download the tool and associated user manual. A copy of Visio must also be loaded for this to work. The following URLs will assist in the download process:

Microsoft Project 2010 Visio download URL

[http://visio.microsoft.com/en-us/Samples_and_Downloads/
Software_Add-ins/Pages/Visio_2010_Add-in_for_WBS_Modeler.
aspx](http://visio.microsoft.com/en-us/Samples_and_Downloads/Software_Add-ins/Pages/Visio_2010_Add-in_for_WBS_Modeler.aspx)

X86 download URL

<http://www.microsoft.com/download/en/details.aspx?id=26229>

User Guide URL

<http://www.microsoft.com/download/en/details.aspx?id=26229>

Full Monte simulation add-in

Full Monte is a compatible add-in to MSP that is useful for analyzing project time and cost using simulation technology. To download the academic version of this utility, go to www.barbacena.com/fullmonteacademic-download. The old version will need to be uninstalled before installing a new version (e.g., using control panel/programs and features in Windows).

Appendix E: Variable time macro

Microsoft omitted built-in PERT-type calculations from the basic menu of the 2010 version. This gap has caused several independents to create macros to handle this calculation. Internet search engines will identify at least three of these macros. Source references for these are summarized here:

1. The most recognized public PERT macro was written by Brian Kennemer. Details regarding it can be retrieved from <http://blogs.technet.com/b/projectified/archive/2009/11/24/3296207.aspx>

A modified version of this macro is used in this chapter to produce the variable time examples. Code for that macro is described below and the Visual Basic instructions can be retrieved from the publisher website.

2. Glenn Searle of Pcubed offers a similar macro code set. Its URL reference is http://www.pcubed.com/bulletins/2012.03/files/Pcubed_MSPProject2010_PERT_Macro.txt
3. Andre Xavier advertises a zip file download for this purpose at <http://archive.msdn.microsoft.com/projectpert/Release/ProjectReleases.aspx?ReleaseId=5785>

An alternative to using a macro for this purpose is to perform the needed calculations in a spreadsheet and load the computed values into MSP.

Adapted macro

The macro used in Chapter 20 is adapted from the original by Brian Kennemer VB code by Chandramouli Gajaphy (University of Houston grad student). It is designed to compute either PERT or triangular distribution task duration times and can be easily modified to calculate other variable time parameters. Both of these distribution types use three time estimates for each task. These times are labeled a , m , and b for optimistic, most likely, and pessimistic, respectively. In this version, the PERT expected activity duration is calculated by

$$\text{Duration} = (a + 4m + b)/6.$$

Task standard deviation and variance is also needed for each activity. The standard deviation is calculated using the classic PERT empirical

formula for both distribution types. The empirical formula for PERT standard deviation is

Std Dev (σ) = $(b - a)/6$
and
Variance (σ^2) = Std Dev ^{2} (i.e., the square of the Std Dev value).

Another alternative calculation option is to use a triangular distribution instead of the PERT beta model. The comparative $T(E)$ and variance formulas for PERT versus triangular distributions are:

$T(E) = (a + 4m + b)/6$ (PERT Beta model)
 $\sigma_{PERT} = (b - a)/6$
 $T(E) = (a + 4m + b)/3$ (Triangular model)
 $\sigma_{\Delta} = (a^2 + m^2 + b^2 - a*m - a*b - m*b)/18$.

The University of Virginia has published a more accurate formula for the triangular distribution formula as follows (University of Virginia 2008):

$\sigma_{\Delta} = [(b - a)^2 - (m - a)(b - a) + (m - a)^2]/18$

Both of these distribution types are used for variable time calculations, but the classic PERT model will be illustrated in this documentation.

Sample data

See Table E.1 calculation sequence

Step 1. Activity duration estimate data must be setup to drive the macro calculations. From the three time estimates, a value for MSP duration will be calculated by the macro. This is equivalent to $T(E)$ in the formulas outlined above. The following dummy data fields are used to hold the input and output variables.
Dur1—used to contain data element “a” input values for all work packages

Table E.1 Sample Data

Task	Pred	<i>a</i>	<i>m</i>	<i>b</i>	Duration	Variance
A		1	4	7	4	1.00
B	2	2	2	2	2	0.00
C	3	2	5	8	5	1.00
D						
E	4	3	4	5	4	0.33
F	4	4	6	12	6	1.33
G	6	3	6	9	6	1.00

Dur2—used to contain data element “*m*” input values for all work packages

Dur3—to contain data element “*b*” input values for all work packages

Dur4—contains the results of Std Dev calculations for all work packages

Dur5—contains the results of Variance calculations for all work packages

Number1—used to hold the weighting factor for *a* (1 for PERT, 2 for triangular)

Number2—used to hold the weighting factor for *m* (4 for PERT, 2 for triangular)

Number3—used to hold the weighting factor for *m* (1 for PERT, 2 for triangular)

Text30—contains a status message for results of macro execution

Step 2. Using the dummy variables outlined above, a PERT model setup would look as shown in Figure E.1.

Note in line #1 how the weighting factors (1,4,1) are defined for the model. If this were a triangular setup, these weights would be 2,2,2, respectively.

Use the Field settings option to create built-in formulas for Sigma and Variance as follows:

Dur 4 formula ([Duration3]-[Duration1])/6

Dur 5 formula ([Duration4])^2/480 {480 correction needed to convert minutes to days}

Project table data values would look as follows after invoking the macro (see Figure E.2).

Note that the Duration column is now populated with the calculated value of $T(E)$ as are values for Sigma (Std Dev) and Var (Variance).

If a triangular distribution is used, the setup would require changing the weighting values in Number1, Number2, and Number3 to “2.” Also, the Sigma formula internal to MSP would need to be

	Task Name	Duration	Predecessor	Duration	Duration	Duration	Opt. Wel	Mr. Lik. Wt.	Pe. Wt.	Duration	Sigma	Var	PERT State
1	Total	0 days		0 days	0 days	0 days	1	4	1	0 days	0 days	0 days	
2	A	0 days		1 day	4 days	7 days	0	0	0	4 days	0 days	0 days	
3	B	0 days		2 days	2 days	2 days	0	0	0	2 days	0 days	0 days	
4	C	0 days		2 days	5 days	8 days	0	0	0	5 days	0 days	0 days	
5	D	0 days	4	3 days	4 days	5 days	0	0	0	4 days	0 days	0 days	
6	E	0 days		4 days	6 days	8 days	0	0	0	6 days	0 days	0 days	
7	F	0 days	6	3 days	6 days	9 days	0	0	0	6 days	0 days	0 days	

Figure E.1 Macro layout fields.

	Task Name	Duration	Predecess	Dur1	Dur2	Dur3	a	m	b	Sigma	Var	Calc State
1	Total	23 days		0 days	0 days	0 days	1	4	1	0 days	0 days	
2	A	4 days		1 day	4 days	7 days	0	0	0	1 day	1 day	Duration Calc'd: 8/3/2010 11:11:29 AM
3	B	2 days	2	2 days	2 days	2 days	0	0	0	0 days	0 days	Duration Calc'd: 8/3/2010 11:11:29 AM
4	C	5 days	3	2 days	5 days	8 days	0	0	0	1 day	1 day	Duration Calc'd: 8/3/2010 11:11:29 AM
5	D	4 days	4	3 days	4 days	5 days	0	0	0	0.33 days	0.11 days	Duration Calc'd: 8/3/2010 11:11:29 AM
6	E	6 days	4	4 days	6 days	12 days	0	0	0	1.33 days	1.78 days	Duration Calc'd: 8/3/2010 11:11:29 AM
7	F	6 days	6	3 days	6 days	9 days	0	0	0	1 day	1 day	Duration Calc'd: 8/3/2010 11:11:29 AM

Figure E.2 Macro execution results.

modified using one of the triangular formulas defined above. The execution process remains the same.

Step 3. Macro Invocation

The Visual Basic macro code is supplied in the publisher website as a Word file and this represents the macro logic. The steps to load that set of instructions into the Project model is as follows:

1. At the menu View Tab select Macros | Macro security; enable macros
2. At the menu View Tab select Macros | Visual Basic
3. Select Visual Basic
4. Insert Module; name the module
5. Paste the macro code into the empty pane
6. Close the Visual Basic editor and return to MSP
7. After the table values are setup the macro is invoked
8. To execute: View | Macros | Visual Basic | Run
9. Check the Text30 field for execution status
10. The calculated table values should now be in place

Interpretation of the results can now proceed according to the standard process outlined in the Variable Time discussion in Chapter 20.

Appendix F: Text support systems

The level of data detail in this text is higher than the normal book. To provide maximum focus on the tool aspects, two supplementary web-based support systems have been created. These are

1. ProjectNMotion: This is a custom audio–video site containing tutorials related to various aspects of the project life cycle. The first lesson in each phase discusses the brief theory, while the remaining lessons focus on more syntactical issues of MSP that where new users tend to have the most trouble. Where applicable, the text references selected lessons from this site that will support the tool discussions in that area. The audio from this website can be accessed through any Internet-compatible device; however, the screen display needs to be large enough to see the font sizes for some examples. The URL for access to this library is: www.tech.uh.edu/projectnmotion.
2. Taylor & Francis publisher website: Various examples throughout the text show reasonable large sets of data. In most cases, it would not be reasonable to use examples of this size; however, these are good working examples so long as the reader does not have to reproduce them. To solve that issue, the Taylor & Francis (publisher) website is used to store these examples. This allows the reader to extract working examples and incrementally deal with them.

CRC Press Publisher website URL contains various support materials useful to the reader in exploring many of the chapter problems. This repository can be accessed at:

<http://www.crcpress.com/product/isbn/9781466515628>

The authors believe that these two online Internet access sites will allow the reader greater engagement in the text mechanics by providing access to various visual tutorial and data sets that collectively would be feasible in pure text format.

Project Management Tools and Techniques

A PRACTICAL GUIDE

A combination of art and skill that results in the balancing of project objectives against restraints of time, budget, and quality, effective project management requires skill and experience as well as many tools and techniques. **Project Management Tools and Techniques: A Practical Guide** describes these tools and techniques and how to use them, giving students the strong foundation they need to develop the skills and experience needed for a successful career in project management.

The first five sections discuss a typical project life cycle, and beginning with an introduction to project management in terms of the role it plays in the organization and how a business case drives the process. From this starting point, the various planning and control-oriented techniques described evolve this process through the life cycle from scope development to completion. The final section closes the discussion with a group of more contemporary topics labeled “Advanced.” These are essential tools that need to be in wide use but are still evolving in practice. Most of the chapters include sample questions and exercises to help with a review of the material.

With a combined experience of about 100 years, the authors have extensive real-world experience in her or his respective professional areas. They have selected topics based on their valuation of the tool and its project management value. They present the material in ways that the concepts can be applied to any project. Once this material is mastered, students will have a good overview regarding the basic planning and control actions required by a project manager. Also, this book will make a great reference guide that can be used by project managers and team members for years to come.

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