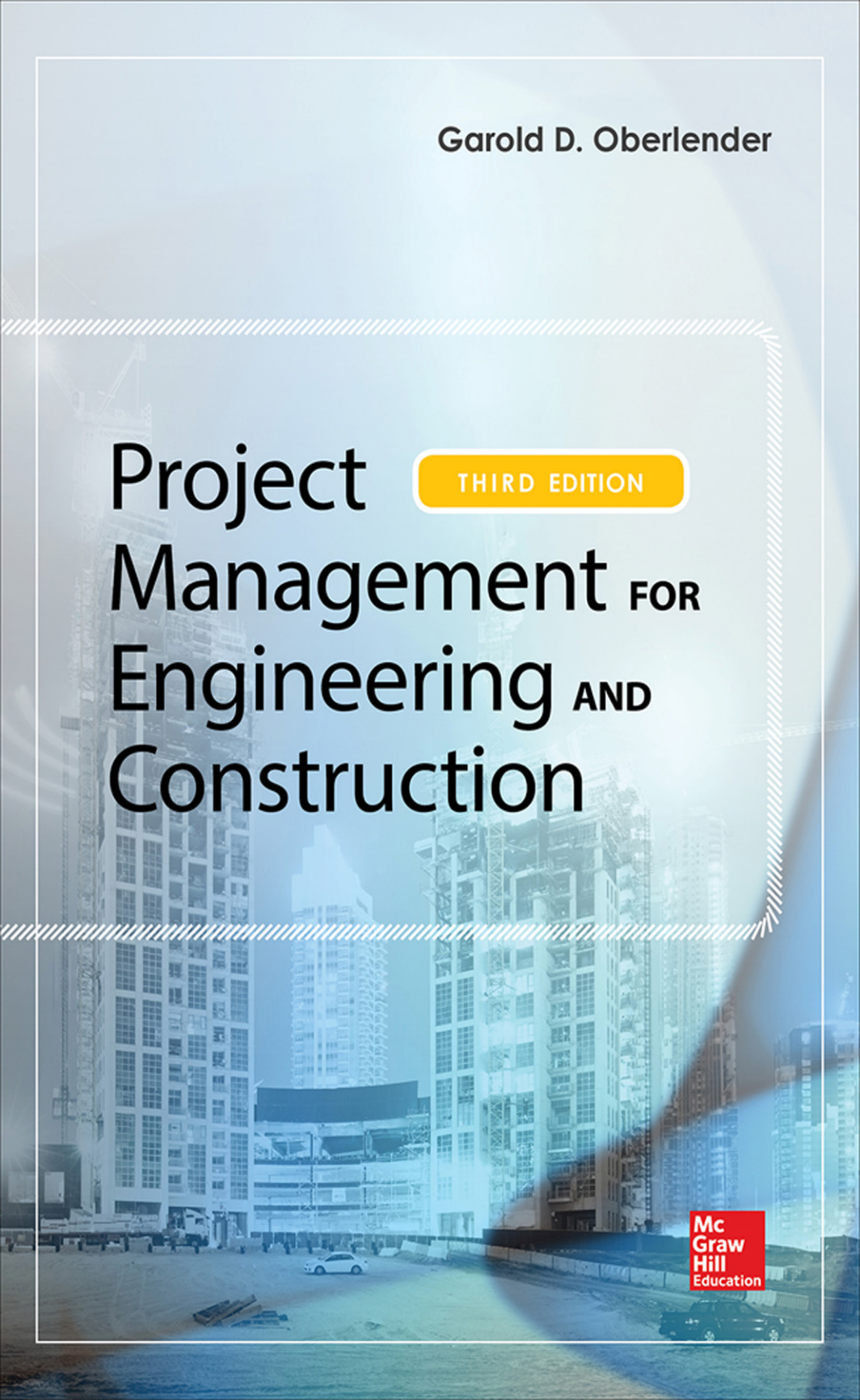
Garold D. Oberlender

Project Management for Engineering and Construction

THIRD EDITION



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Project Management for Engineering and Construction

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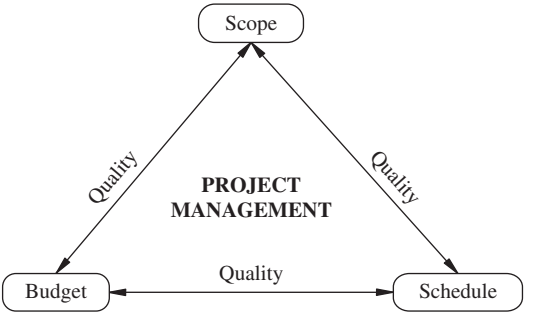

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Contents

Preface xi

Chapter 1. Introduction 1

Purpose of This Book 1
Arrangement of This Book 2
Definition of a Project 5
Ensuring Quality in a Project 7
Responsibilities of Parties 8
Who Does the Project Manager Work For? 11
Purpose of Project Management 12
Types of Management 13
Functions of Management 15
Key Concepts of Project Management 15
Role of the Project Manager 16
Professional and Technical Organizations 19
References 20

Chapter 2. Working with Project Teams 21

Project Teams 21
Teamwork 22
Teams for Small Projects 23
Working with Multiple Teams 24
Owner's Team 25
Design Teams 26
Construction Teams 27
Team Management 28
Teams and the Project Manager's Responsibilities 29
Key Factors in Team Leadership 31
Team Building 33
Motivating Teams 35
Conflict Management 36
Developing a Consensus 38

Team Conduct 39
References 40

Chapter 3. Project Initiation 41

Design and Construction Process 41
Advances in the Engineering and Construction Process 43
Private versus Public Projects 43
Contractual Arrangements 44
Phases of a Project 47
Owner's Study 49
Owner's Needs and Project Objectives 51
Project Scope Definition 53
Project Strategy 55
Selection of Design Firms and Construction Contractors 56
Partnering 58
References 59

Chapter 4. Early Estimates 61

Importance of Early Estimates 61
Importance of Estimator 61
Classification of Early Estimates 62
Estimating Work Process 63
Importance of Team Alignment in Preparing Early Estimates 65
Scope Definition and Early Estimates 67
Preparing Early Estimates 69
Organizing to Prepare Estimates 70
Establishing an Estimate Work Plan 70
Methods and Techniques 73
Cost-Capacity Curves 73
Capacity Ratios Raised to an Exponent 74
Plant Cost per Unit of Production 75
Equipment Factored Estimates 76
Computer-Generated Estimates 77
Estimate Checklists 78
Estimate Documentation 79
Estimate Reviews 81
Risk Assessment 82
Risk Analysis 83
Contingency 83
Traditional Methods of Assigning Contingency 84
Percentage of Base Estimate 84
Expected Net Risk 85
Simulation 86
Assessing Estimate Sensitivity 88
Estimate Feedback for Continuous Improvement 89
References 90

Chapter 5. Project Budgeting 91

Project Budgets 91
Development of Project Estimates for Budgeting 91
Levels of Accuracy 93
Owner's Estimate for Budgeting 94
Weighted Unit Cost Estimating 95
Adjustments for Time, Size, and Location 97
Parametric Estimating 98
Economic Feasibility Study 101
Single Payments 101
Uniform Payment Series 102
Fundamental Equations of Time Value of Money 103
Design Budgets 106
Contractor's Bid 110
References 114

Chapter 6. Development of Work Plan 115

Project Manager's Initial Review 115
Owner's Orientation 116
Organizational Structures 117
Work Breakdown Structure 122
Formats for Work Breakdown Structures 124
Forming the Project Team 125
Kick-Off Meeting 129
Work Packages 130
Follow-Up Work 132
Project Work Plan 133
References 137

Chapter 7. Design Proposals 139

Evolution of Projects 139
Project Execution Plan 140
Project Definition 140
Problems in Developing Project Definition 142
Design Proposals 143
Engineering Organization 146
Scope Baseline for Budget 148
Design Work Package 152
Mini-Drawings 153
Development of the Design Work Plan 156
Engineering Project Controls 158
Progress Measurement of Engineering Design 159
References 163

Chapter 8. Project Scheduling 165

Project Planning and Project Scheduling 165
Desired Results of Planning 166

Benefits of Planning 167
Principles of Planning and Scheduling 167
Responsibilities of Parties 168
Planning for Multiple Projects 169
Techniques for Planning and Scheduling 170
Network Analysis Systems 171
Development of CPM Diagram from the WBS 175
Assigning Realistic Durations 178
Computer Applications 181
Schedule Coding System 185
Cost Distribution 188
Resource Allocations for Design 192
Resource Allocations for Construction 193
Calculations to Verify Schedules and Cost Distributions 194
Program Evaluation and Review Technique (PERT) 201
Successor/Predecessor Relationships 207
Problems Using Successor/Predecessor Relationships 209
References 215

Chapter 9. Tracking Work 217

Control Systems 217
Linking the WBS and CPM 218
Coding System for Project Reports 221
Control Schedules for Time and Cost 225
Relationships between Time and Work 233
Integrated Cost/Schedule/Work 238
Percent Complete Matrix Method 243
Progress Measurement of Design 246
Measurement of Construction Work 248
Project Measurement and Control 252
Earned-Value System 253
Earned-Value Analysis 253
Variances 253
Indices 253
Forecasting 254
Monitoring Project Performance 273
Interpretation of Performance Indices 274
Analysis Tree of Total Float (TF) and Schedule Performance Index (SPI) 276
Causes of Cost/Schedule Variances 277
Trend Analysis and Forecasting 277
Work Status System 281
References 284

Chapter 10. Design Coordination 285

Design Work Plan 285
Common Problems in Managing Design 286
Producing Contract Documents 286

Managing Scope Growth during Design 287
Managing Small Projects 288
Project Team Meetings 288
Weekly/Monthly Reports 290
Drawing Index 290
Equipment Index 292
Distribution of Documents 292
Authority/Responsibility Checklist 293
Checklist of Duties for Design 294
Team Management 296
Evaluation of Design Effectiveness 298
Constructability 301
Post Design Review 303
References 303

Chapter 11. Construction Phase 305

Importance of Construction 305
Assumptions for Construction Phase 306
Contract Pricing Formats 307
Design/Bid/Build Method of Project Delivery 308
Design/Build Method of Project Delivery 309
Construction Management Method of Project Delivery 310
Bridging Project Delivery Method 311
Build-Operate-Transfer 311
Fast-Track Projects 312
Turn-Key Projects 312
Design Development and Performance Specifications 312
Key Decisions for Project Delivery 313
Number of Contracts 313
Selection Criteria 313
Contractual Relationship 314
Terms of Payment 314
Prospective Bidders and Bidding 315
Qualification-Based Selection (QBS) 316
Checklist for Bidding 319
Keys to a Successful Project 319
Construction Schedules 322
Problems with Construction Schedules 322
Precautions for Construction Submittals 323
Delivery Dates of Owner-Furnished Equipment or Materials 324
Scheduling Contractor Procured and Installed Equipment 325
Contract Schedule Constraints 325
Sequestering Float 326
Schedule Updates 327
Relations with Contractors 327
Checklist of Duties 328
Quality Control 328
Dispute Resolutions 331

Job-Site Safety 334
Management of Changes 335
Resource Management 336
References 338

Chapter 12. Project Close Out 341

System Testing and Start-Up 341
Final Inspection 342
Guarantee and Warranties 343
Lien Releases 343
Record and As-Built Drawings 344
Checklist of Duties 344
Disposition of Project Files 344
Post Project Critique 345
Owner's Feedback 346
References 346

Chapter 13. Personal Management Skills 347

Challenges and Opportunities 347
Using New Innovations 347
Human Aspects 351
Assignment of Work 353
Motivation 354
Decision Making 355
Time Management 356
Communications 357
Presentations 359
Meetings 361
Reports and Letters 362
References 364

Chapter 14. Risk Management 365

Introduction 365
Risk Management Process 366
Guidelines for Risk Management Process 367
Risks of Owner, Designer, and Contractor 368
Precautions for Owners 369
Precautions for Designers 371
Precautions for Contractors 373
Risk Assessment 374
Risk Analysis 376
Risk Analysis of Costs 376
Risk Analysis of Schedule Using PERT 378
Risk Analysis Using Simulation 381
Risk Analysis of Schedule Using Simulation 381
Risk Analysis of Costs Using Simulation 383

Mitigation of Risk 385
Project Risk Register 386
Development of the Initial Project Risk Register 388
Strategies to Mitigate a Risk 389
Methods to Prevent or Mitigate Risks 390
Development of a Risk Mitigation Plan 390
References 392

Appendix Example Project 393
Index 413

ABOUT THE AUTHOR

GAROLD D. OBERLENDER is professor emeritus of civil engineering at Oklahoma State University, where he served for 35 years as coordinator of the graduate program in construction engineering and project management. Prior to joining the faculty at Oklahoma State University, he lived nine years in the Dallas area and worked in the engineering and construction industry. He holds B.S., M.S., and Ph.D. degrees in civil engineering.

In addition to authoring this book, Dr. Oberlender is the coauthor with Robert L. Peurifoy of *Estimating Construction Costs,* Sixth Edition, and *Formwork for Concrete Structures,* Fourth Edition. His books are adopted by universities around the world and widely used by practicing civil engineers.

Dr. Oberlender is a fellow member of the American Society of Civil Engineers (ASCE) and has been inducted into the National Academy of Construction (NAC). He is also a fellow member of the National Society of Professional Engineers (NSPE). He has served as chairman of the Construction Engineering Division of the American Society for Engineering Education (ASEE). Currently he is a writer of construction engineering PE exam questions for the National Council of Examiners for Engineering and Surveying (NCEES).

Dr. Oberlender is frequently an invited speaker on the subject of project engineering and management by companies in industry and professional and technical organizations in the United States and other countries. He served on the Academic Council of the Construction Industry Institute (CII) and was principal investigator for several CII research teams. He was selected for the CII Outstanding Researcher Award for his research on improving early estimates.

In addition to his teaching and research, he maintained a consulting engineering practice for engineering and construction projects in the petrochemical and electrical power industries. Dr. Oberlender is a registered professional engineer in Oklahoma and Texas and a member of numerous honorary societies, including Chi Epsilon, Tau Beta Pi, Sigma Xi, and Phi Kappa Phi.

Preface

This book presents the principles and techniques of managing engineering and construction projects from the initial conceptual phase, through design and construction, to completion. It emphasizes project management during the early stages of project development because the ability to influence the quality, cost, and schedule of a project can best be achieved during the early stage of development. Most books discuss project management during construction, after the scope of work is fully defined, the budget is fixed, and the completion date is firm. It is then too late to make any significant adjustments to improve the quality, cost, or schedule of the project.

Although each project is unique, there is certain information that must be identified and organized at the beginning of a project, before any work is started. Numerous tables and graphs are presented and discussed throughout this book to provide guidelines for management of the three basic components of a project: scope, budget, and schedule. Throughout this book, achieving project quality to meet the owner's satisfaction is emphasized as an integral part of project management.

This third edition has a new chapter that addresses risk management. This topic is extremely important because owners, designers, and contractors are all exposed to risk from the start of a project through its completion. Risk assessment, analysis, and mitigation are key factors in project management of engineering and construction projects.

In preparing this third edition, the author has updated example problems in all chapters and added examples in many chapters. New sections have been added, including: ensuring quality in a project, the owner's team, the importance of the estimator, formats for work breakdown structures, design work packages, benefits of planning, and build-operate-transfer delivery methods.

The intended audience of this book is engineers in industry who aid the owner in the feasibility study, coordinate the design effort, and witness construction in the field. It is also intended for students of university programs in engineering, architecture, and construction because

graduates of these programs usually are involved in project management as they advance in their careers.

This book is based on the author's experience in working with hundreds of project managers in the engineering and construction industry. Much of the material in this book is based on formal and informal discussions with these project managers, who are actively involved in the practice of project management. Although the author has observed that no two project managers operate exactly the same, there are common elements that apply to all projects and all project managers. The author presents these common elements of effective project management that have been successfully applied in practice.

The author would like to thank Glenn Barin and Rock Spencer for their careful review, helpful comments, and advice in the development of the new risk management chapter in this third edition. The author would also like to thank the many project managers in industry who have shared their successes, and problems, and who have influenced the author's thoughts in the development of this book.

Finally, the author greatly appreciates the patience and tolerance of his wife, Jana, and her support and encouragement during the writing and editing phases of the third edition of this book.

Garold D. Oberlender, Ph.D., P.E.

Chapter

1

Introduction

Purpose of This Book

The purpose of this book is to present the principles and techniques of project management beginning in the conceptual phase by the owner, through coordination of design and construction, to project completion. Emphasis is placed on managing the project in its early stage of development, during the owner's study and design. It is presented from this perspective because the ability to influence the overall quality, cost, and schedule of a project can best be achieved early in the life of a project. Most books and articles discuss project management during the construction phase, after design is completed. At this time in the life of a project the scope of work is fully defined, the budget is fixed, and the completion date is firm. It is then too late to make any significant adjustments to improve the quality, cost, or schedule of the project.

Experienced project managers agree that the procedures used for project management vary from company to company and even among individuals within a company. Although each manager develops his or her own style of management, and each project is unique, there are basic principles that apply to all project managers and projects. This book presents these principles and illustrates the basic steps, and sequencing of steps, to develop a work plan to manage a project through each phase from conceptual development to completion.

Project management requires teamwork among the three principal contracting parties: the owner, designer, and contractor. The coordination of the design and construction of a project requires planning and organizing a team of people who are dedicated to a common goal of completing the project for the owner. Even a small project involves a large number of people who work for different organizations. The key to a successful project is the selection and coordination of people

who have the ability to detect and solve problems to complete the project.

Throughout this book the importance of management skills is emphasized to enable the user to develop his or her own style of project management. The focus is to apply project management at the beginning of the project, when it is first approved. Too often the formal organization to manage a project is not developed until the beginning of the construction phase. This book presents the information that must be assembled and managed during the development and engineering design phase to bring a project to successful completion for use by the owner.

The intended audience of this book is students enrolled in university programs in engineering and construction. It is also intended for the design firms which aid the owner in the feasibility study, coordinate the design effort, and witness construction in the field. This book is also for persons in the owner's organization who are involved in the design and construction process.

Arrangement of This Book

A discussion of project management is difficult because there are many ways a project can be handled. The design and/or construction of a project can be performed by one or more parties. Regardless of the method that is used to handle a project, the management of a project generally follows these steps:

Step 1: Project Definition (to meet the needs of the end user)
Intended use by the owner upon completion of construction
Conceptual configurations and components to meet the intended use

Step 2: Project Scope (to meet the project definition)
Define the work that must be accomplished
Identify the quantity, quality, and tasks that must be performed

Step 3: Project Budgeting (to match the project definition and scope)
Define the owner's permissible budget
Determine direct and indirect costs plus contingencies

Step 4: Project Planning (the strategy to accomplish the work)
Select and assign project staffing
Identify the tasks required to accomplish the work

Step 5: Project Scheduling (the product of scope, budgeting, and planning)
Arrange and schedule activities in a logical sequence
Link the costs and resources to the scheduled activities

Step 6: Project Tracking (to ensure the project is progressing as planned)
Measure work, time, and costs that are expended
Compare "actual" to "planned" work, time, and cost

Step 7: Project Close Out (final completion to ensure owner satisfaction)
Perform final testing and inspection, archive documents, and confirm payments
Turn over the project to the owner

These steps describe project management in its simplest form. In reality there is considerable overlap between the steps, because any one step may affect one or more other steps. For example, budget preparation overlaps project definition and scope development. Similarly, project scheduling relates project scope and budget to project tracking and control.

The topic of project management is further complicated because the responsibility for these steps usually involves many parties. Thus, the above steps must all be integrated together to successfully manage a project. Subsequent chapters of this book describe each of these steps.

Chapter 1 defines general principles related to project management. These basic principles must be fully understood because they apply to all the remaining chapters. Many of the problems associated with project management are caused by failure to apply the basic management principles that are presented in Chapter 1.

Chapter 2, Working with Project Teams, presents the human aspects of project management. The project team is a group of diverse individuals, each with a special expertise, that performs the work necessary to complete the project. As leader of the project team, the project manager acts as a coach to answer questions and to make sure the team understands what is expected of them and the desired outcome of the project.

Chapter 3, Project Initiation, presents material that is generally performed by the owner. However, the owner may contract the services of a design organization to assist with the feasibility study of a project. The project manager should be involved at the project development or marketing phase to establish the scope. This requires input from experienced technical people that represent every aspect of the proposed project.

Chapter 4, Early Estimates, presents the techniques and processes of preparing estimates in the early phase of a project. Preparation of early estimates is a prerequisite to project budgeting. For engineering and construction projects, the early cost estimate is used by the owner in making economic decisions to approve the project. The early cost estimate is a key project parameter for cost control during the design process.

Chapter 5, Project Budgeting, applies to all parties in a project: the owner, designer, and contractor. The budget must be linked to the quantity, quality,

and schedule of the work to be accomplished. A change in scope or schedule almost always affects the budget, so the project manager must continually be alert to changes in a project and to relate any changes to the budget.

Chapter 6, Development of Work Plan, applies to the project manager who is responsible for management of the design effort. Generally, he or she is employed by the professional design organization, which may be an agency of the owner or under contract by the owner to perform design services. The material presented in this chapter is important because it establishes the work plan which is the framework for guiding the entire project effort. The information in this chapter relates to all the project management steps and chapters of this book.

Chapter 7, Design Proposals, presents the process of preparing proposals from the design organization to the owner. After the owner has defined the goals, objectives, intended use, and desired outcome of the project, a request for proposals is solicited from the design organization. The design organization must convert the owner's expectations of the project into an engineering scope of work, budget, and schedule.

Chapter 8, Project Scheduling, provides the base against which all activities are measured. It relates the work to be accomplished to the people who will perform the work as well as to the budget and schedule. Project scheduling cannot be accomplished without a well-defined work plan, as described in Chapter 6, and it forms the basis for project tracking, as described in Chapter 9.

Chapter 9, Tracking Work, cannot be accomplished without a well-defined work plan, as described in Chapter 6, and a detailed schedule, as described in Chapter 8. This chapter is important because there is always a tendency for scope growth, cost overrun, or schedule delays. A control system must simultaneously monitor the three basic components of a project: the work accomplished, the budget, and the schedule. These three components must be collectively monitored, not as individual components, because a change in any one component usually will affect the other two components.

Chapter 10, Design Coordination, applies to the project manager of the design organization. The quality, cost, and schedule of a project is highly dependent on the effectiveness of the design effort. The end result of the design process is to produce plans and specifications in a timely manner that meet the intended use of the project by the owner. The product of design must be within the owner's approved budget and schedule and must be constructable by the construction contractor.

Chapter 11, Construction Phase, is important because most of the cost of a project is expended in the construction phase, and the quality of the final project is highly dependent upon the quality of work that is performed by the construction contractors. Most of the books that have been written on project management have been directed toward a

project in the construction phase. This book emphasizes project management from the initial conception of the project by the owner, through coordination of design and development of the construction documents, and into the construction phase until project close out.

Chapter 12, Project Close Out, discusses the steps required to complete a project and turn it over to the owner. This is an important phase of a project because the owner will have expended most of the budget for the project, but will not receive any benefits from the expenditures until it is completed and ready for use. Also it is sometimes difficult to close a project because there are always many small items that must be finished.

Chapter 13, Personal Management Skills, addresses the human aspects of project management. Although the primary emphasis of this book is on the techniques of project management, it is the project manager working with his or her people who ensures the successful completion of a project.

Chapter 14, Risk Management, presents the process of assessing potential risks and methods of analyzing risks in engineering and construction projects. The design and construction is a risk endeavor through all phases of a project, beginning with the owner's feasibility and economic study, through preliminary engineering and final design, procurement of materials and equipment, and the many field operations during construction.

Definition of a Project

A project is an endeavor that is undertaken to produce the results that are expected from the requesting party. For this book a project may be design only, construction only, or a combination of design and construction. A project consists of three components: scope, budget, and schedule. When a project is first assigned to a project manager, it is important that all three of these components be clearly defined. Throughout this book, the term *Scope* represents the work to be accomplished, that is, the quantity and quality of work. *Budget* refers to costs, measured in dollars and/or labor-hours of work. *Schedule* refers to the logical sequencing and timing of the work to be performed. The quality of a project must meet the owner's satisfaction and is an integral part of project management as illustrated in Figure 1-1.

Figure 1-1 is shown as an equilateral triangle to represent an important principle of project management: a balance is necessary between the scope, budget, and schedule. For any given project, there is a certain amount of work that must be performed and an associated cost and schedule for producing the work. Any increase in the scope of work requires a corresponding increase in budget and schedule. Conversely, any decrease in scope of work results in a corresponding decrease in budget and schedule. This principle applies between any and all of the three components of a project. For example, any adjustment in budget

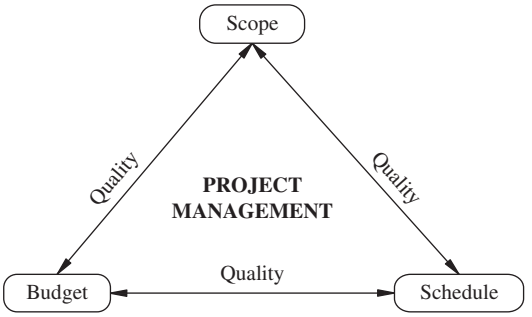

Figure 1-1 Quality is an integral part of scope, budget, and schedule.

and/or schedule requires a corresponding adjustment in scope. This simple concept of a balance between scope, budget, and schedule is sometimes not fully recognized during early project development as well as during design and construction.

The source of many problems associated with a project is failure to properly define the project scope. Too often the focus is just on budget or schedule. Not only should the scope, budget, and schedule be well defined, but each must be linked together since one affects the other, both individually and collectively.

Since the project scope defines the work to be accomplished, it should be the first task in the development of a project, prior to the development of either the budget or the schedule. Experienced project managers agree that the budget and schedule are derived from the scope. Too often, top management specifies a project budget or schedule and then asks the project team to define a scope to match the budget. This is the reverse order of defining a project and is not a good project management practice. It is the duty of a project manager to ensure that the project scope, budget, and schedule are linked together.

Budgeting is important because it establishes the amount of money the owner will spend to obtain the project and the amount of money that the design and construction organizations will be compensated for performing the work. Each party is concerned about project cost overrun because it adversely affects profitability and creates adverse relationships between the parties.

Scheduling is important because it brings together project definition, people, cost, resources, timing, and methods of performing work to define the logical sequencing of activities for the project. The schedule is the final product of scope definition, budgeting, and planning and forms the base against which all activities are measured. Project tracking and control cannot be accomplished without a good plan and schedule.

Quality is an element that is integrated into and between all parts of a project: scope, budget, and schedule. It should not be construed as merely creating drawings with a minimum number of errors, furnishing equipment that meets specifications, or building a project to fulfill the requirements of a contract. Certainly these factors are a part of quality, but it involves much more. Quality is meeting the needs and satisfaction of the ultimate end user of the project, the owner.

Quality is the responsibility of all participants in a project, including all levels of management and workers in each of the principal parties. An attitude of achieving quality must be instilled in everyone and perpetuate throughout the work environment. The attitude should not be "what can we do to pass quality control or final inspection?" Instead, it should be "what can we do to improve our work and what is the best way we can furnish a project that meets the needs and satisfaction of the owner?"

Ensuring Quality in a Project

Ensuring quality is the responsibility of all parties in a project: the owner, designer, and contractor. It is the owner's duty to define and communicate the desired level of quality in a project. The designer is responsible for producing contract documents that ensures the owner's level of quality will be achieved during construction. The contractor is responsible for providing the materials, equipment, and labor skills to ensure the work will be performed in accordance with the design drawings and specifications.

Early in the project, before contracts are signed and commencing design, the owner's organization needs to hold a meeting to discuss, and agree upon, the end product and the level of quality the project is to provide. Although upper management in the owner's organization is responsible for final approval of the level of quality, it is the end user of the project in the owner's organization that should be involved in defining the level of quality. The end user is the party that will use and maintain the project after it is completed. Members of the owner's staff that should be involved in defining quality should include financing, engineering, operations, and maintenance personnel. This group must separate "what the owner needs" from "what the owner wants," while ensuring the completed project can be used as intended by the owner. If the owner does not have staff that is able to identify the desired quality, it may be necessary to involve the design team or outside consultants to assist the owner in defining the level of quality that can be achieved within the constraints of budget and schedule. It is important to maintain continuous communications with the owner throughout the project, so the owner understands the total affect quality can have on the cost and schedule of a project.

The design organization plays a major role in quality. The owner's level of quality must be communicated to the design team, so the proper

level of quality is translated into the design drawings and specifications. The project manager of the design team must ensure the level of quality is clearly defined in the designer's project proposal, which requires the designer to explain "design quality" in terms the owner can understand. The designer must develop a complete, and as error free as possible, set of contract documents that ensure the level of quality that is expected from the owner. Regularly scheduled meetings should be held to ensure the design team is on track regarding the expected level of quality, because it is often too easy for project participants to get distracted by costs and schedule, and forget that quality is a "must" in a project. There needs to be a thorough review of plans and specifications by experienced field construction personnel, before release to the contractor, to ensure constructability of the design. The design team should remain involved in the project during construction, to ensure the plans and specifications are being turned into a quality project during construction.

To ensure quality the contractor must have a quality control system that is workable and understood by all parties. To work effectively, any quality control system requires a buy-in by all parties involved in a project. Quality control should concentrate on those parts of a project where quality is important and not get consumed in expending large amounts of effort inspecting work that has only a small impact on the performance of a project when it is completed and in use by the owner. Contractors, subcontractors, and suppliers should be carefully selected based on their record of quality work, rather than selecting them solely on the lowest cost they quote. A work environment should be established that promotes quality and pride in workmanship among all parties in the project. There must be sincere interest in the importance of quality and it should be expected in all aspects of the project. Management needs to instill an attitude of achieving quality work by everyone in the project by recognizing and rewarding good quality work. Regularly held meetings need to be scheduled to address quality, just like meetings that are held to review budgets, schedules, and safety. Quality should be unique, tied to each specific project, rather than a standardization.

Responsibilities of Parties

Each of the three principal parties in a project has a role to fulfill in the various phases of design development and construction. A team approach between the owner, designer, and contractor must be created with a cooperative relationship to complete the project in the most efficient manner. Too often an adverse relationship develops that does not serve the best interest of anyone.

The owner is responsible for setting the operational criteria and level of quality for the completed project. Examples are usage of a building,

barrels per day of crude oil to be refined, millions of cubic feet per hour of gas to be transported in a pipeline, and so on. Any special equipment, material, or company standards that are to apply to the project must also be defined. Owners also need to identify their level of involvement in the project, such as, the review process, required reports, and the levels of approval. The owner is also responsible for setting parameters on total cost, payment of costs, major milestones, and the project completion date.

Many problems can be created when owners fail to fulfill their responsibility of clearly defining the operational criteria of a project. If the operational criteria is not clearly defined, it will have to be defined as the project progresses through design and/or into construction, which causes confusion for all parties. The owner may end up paying for things in a project that are not needed, because participants in the project do not clearly understand the operational criteria of the project. The owner runs the risk of receiving a project that is within approved budget and on schedule, but may not be useable as intended. The designer may over-design the project, trying to second-guess what the owner wants, which may cause the project to be more expensive than necessary. Or, the designer may under-design the project, not realizing what the owner expects in the project, which can lead to expensive additions during construction. Changes of the owner's operational criteria during design cause rework for the designer, which will increase the cost of the design effort and may adversely affect the budget and schedule of the project.

The probability of rework during construction is greatly increased when the owner has not adequately defined the operational criteria of the project. Timely responses to contractors questions may be impaired because the owner is not sure of what they want in the project. The number of change orders are likely to increase, which may result in cost overruns, schedule delays, and claims against the owner by the contractor. The productivity and morale of construction workers may be impaired because of continuous changes by the owner to adjust the project during construction so it will meet the operational needs of the owner.

The designer is responsible for producing design alternatives, computations, drawings, and specifications that meet the needs of the owner. In addition there may be other duties that are delegated to the designer by the owner, such as, on-site or periodic inspection, review of shop drawings, and in some instances the acquisition of land and/or permits. It is the duty of the designer to produce a project design that meets all federal, state, and local codes; standards; and environmental and safety regulations. In addition a budget for the design should be prepared, along with a design schedule that matches the owner's schedule. The design schedule should be directly correlated to the construction schedule so the project can be completed by the construction contractor when the owner needs it.

Many problems may arise when a designer fails to give adequate attention to the impact of design alternatives on the cost or schedule during construction. Sometimes a design alternative is selected that may cause restrictions in the method of construction that a contractor may want to use during construction, which can adversely affect the contractor's operations. The selection of design alternatives also can impact the procurement of major equipment required in a project, which can influence the scheduling of construction work. Also, lack of attention to details in the design drawings may cause erection problems at the job-site, which can lead to delays in work, increased costs, and claims from the construction contractor. Inadequate attention to details during design can cause confusion during construction, including delays in work in the field and unnecessary rework.

Designers also need to make a special effort to eliminate poor wording in the written specifications that can cause misinterpretation of the requirements of the work to be performed, which can lead to poor quality work or costly changes orders. Overly restrictive wording in the specifications may place restraints on the contractor's operations and/or sequencing of construction work, which can affect costs and schedules. Designs that are poorly assembled can impair productivity of crafts, morale of workers on the job-site, and lead to legal claims against the designer and/or owner from the contractors. The quality of design documents has a significant impact on the quality of construction and the long-term maintenance and operations after the project is completed.

Generally the designers are not obligated under standard-form contracts to guarantee the construction cost of a project, although there have been some cases where the designer has been held legally responsible for the construction price. As part of their design responsibility, designers usually prepare an estimate of the probable construction cost for the design they have prepared. Major decisions by the owner to proceed with the project are made from the designer's cost estimate.

The cost and operational characteristics of a project are influenced most, and are more easy to change, during the design phase. Because of this, the designer plays a key role during the early phase of a project by working with the owner to keep the project on track so the owner/contractor relationship will be in the best possible form.

The construction contractor is responsible for the performance of all work in accordance with the contract documents that have been prepared by the designer. This includes furnishing all labor, equipment, material, and know-how necessary to build the project. The construction phase is important because most of the project budget is expended during construction. Also, the operation and maintenance of the completed project is highly dependent on the quality of work that is performed during

construction. The contractor must prepare an accurate estimate of the project, develop a realistic construction schedule, and establish an effective project control system for cost, schedule, and quality.

Serious problems can arise when contractors fail to perform their work in accordance with the contract documents. If the contractor does not perform work as specified in the contract, the owner has the option to call the performance bond, which brings a new contractor to the job to complete the project. The quality of the project may be impaired when another construction contractor must be brought to the job-site to properly redo the defaulting contractor's work. When the owner calls the performance bond on a defaulting contractor, the ability of the defaulting contractor to acquire future contracts is greatly impaired. The contractor may be disqualified from bidding future work of the owner, and the designer may discourage other owners from allowing the contractor to bid on the designer's work. Also, the bonding capacity of the defaulting contractor may be reduced, or completely eliminated, by the bonding company. Adverse publicity may damage the reputation of the construction contractor, which can adversely affect the success of the contractor in securing future work.

Who Does the Project Manager Work For?

The project manager works for the project, although he or she may be employed by the owner, designer, or contractor. Therefore, for any project there are at least three project managers. Although these three individuals work for a different organization, they must develop methods to ensure good working relationships. At the beginning of a project, all project managers should meet together to define and agree upon the authority and responsibility of each party. They need to agree on procedures for review and approval of documents and the distribution of documents between the parties of each organization. There needs to be regularly scheduled joint project managers' meetings, with a set agenda to share information and coordinate the work in an organized manner. Sharing information in a timely manner is necessary for a successful project. Each project manager needs to make a special effort to work together as a team to help each other. They need to show trust, respect, and confidence in the work of others with an attitude of finding solutions instead of finding blame.

The Construction Industry Institute (CII) has sponsored research and published numerous papers on a variety of topics related to project management. *Organizing for Project Success,* a CII publication, provides a good description of the interface between project managers for the owner, designer, and contractor. The following paragraphs are a summary of the project management teams that are discussed in the publication.

After commitment has been made by an owner to invest in a project, an Investment Management Team is formed within the owner's organization to provide overall project control. The major functions, such as marketing, engineering, finance, and manufacturing, are usually represented. A Project Executive usually leads the team and reports to the head of the business unit which made the decision to proceed with the project. A member of this team is the Owner's Project Manager.

The Owner's Project Manager leads a Project Management Team which consists of each Design Project Manager and Construction Project Manager that is assigned a contract from the owner. Their mission is to accomplish the work, including coordinating the engineering, procurement, and construction phases. The Owner's Project Manager leads this team, which is one of the most important management functions of the project. The Owner's Project Manager is responsible for the accomplishment of all work, even though he or she has limited resources under his or her direct control because the work has been contracted to various organizations.

Reporting to each Design Project Manager and Construction Project Manager are the Work Managers who fulfill the requirements of their contracts. Each Design and Contractor Project Manager reports to the Owner's Project Manager for contractual matters and to his or her parent organization for business matters.

The Work Managers are the design leaders and supervisors who lead the teams actually accomplishing the work. They are directly responsible for the part of the contract assigned to them by their Project Manager. They must also communicate and coordinate their efforts with Work Managers from other organizations. Usually this communication does not flow vertically through a chain of command, but instead flows horizontally between people actually involved in the work. It is their responsibility to also work with their Project Manager and keep them informed. This is further discussed in Chapters 2 and 11.

Purpose of Project Management

For the purpose of this book, project management may be defined as:

> The art and science of coordinating people, equipment, materials, money, and schedules to complete a specified project on time and within approved cost.

Much of the work of a project manager is organizing and working with people to identify problems and determine solutions to problems. In addition to being organized and a problem solver, a manager must also work well with people. It is people who have the ability to create

ideas, identify and solve problems, communicate, and get the work done. Because of this, people are the most important resource of the project manager. Thus, the project manager must develop a good working relationship with people in order to benefit from the best of their abilities.

It is the duty of a project manager to organize a project team of people and coordinate their efforts in a common direction to bring a project to successful completion. Throughout the project management process there are five questions that must be addressed:

1. Who will do the work?
2. What work will be performed?
3. When will the work be done?
4. How much will the work cost?
5. What can go wrong?

The work required often involves people outside of the project manager's organization. Although these individuals do not report directly to the project manager, it is necessary that effective working relationships be developed.

A manager must be a motivated achiever with a "can do" attitude. Throughout a project there are numerous obstacles that must be overcome. The manager must have perspective with the ability to forecast methods of achieving results. The drive to achieve results must always be present. This attitude must also be instilled in everyone involved in the project.

Good communication skills are a must for a manager. The management of a project requires coordination of people and information. Coordination is achieved through effective communication. Most problems associated with project management can be traced to poor communications. Too often the "other person" receives information that is incorrect, inadequate, or too late. In some instances the information is simply never received. It is the responsibility of the project manager to be a good communicator and to ensure that people involved in a project communicate with each other.

Types of Management

Management may be divided into at least two different types: functional management (sometimes called discipline management) and project management. Functional management involves the coordination of repeated work of a similar nature by the same people. Examples are management of a department of design engineering, surveying, estimating, or purchasing. Project management involves the coordination of one time work by a team of people who often have never

previously worked together. Examples are management of the design and/or construction of a substation, shopping center, refinery unit, or water treatment plant. Although the basic principles of management apply to both of these types of management, there are distinct differences between the two.

Most individuals begin their career in the discipline environment of management. Upon graduation from college, a person generally accepts a position in a discipline closely related to his or her formal education. Typical examples are design engineers, estimators, schedulers, or surveyors. The work environment focuses on how and who will perform the work, with an emphasis on providing technical expertise for a single discipline. Career goals are directed toward becoming a specialist in a particular technical area.

Project management requires a multi-discipline focus to coordinate the overall needs of a project with reliance on others to provide the technical expertise. The project manager must be able to delegate authority and responsibility to others and still retain focus on the linking process between disciplines. Project managers cannot become overly involved in detailed tasks or take over the discipline they are educated in, but should focus on the project objectives.

A fundamental principle of project management is to organize the project around the work to be accomplished. The work environment focuses on what must be performed, when it must be accomplished, and how much it will cost. Career development for project managers must be directed toward the goal of becoming a generalist with a broad administrative viewpoint.

The successful completion of a project depends upon the ability of a project manager to coordinate the work of a team of specialists who have the technical ability to perform the work. Table 1-1 illustrates the relationship between project management and discipline management.

TABLE 1-1 Distinguishing between Project Management and Discipline Management

Project management is concerned with	Discipline management is concerned with
What must be done	How it will be done
When it must be done	Who will do it
How much it will cost	How well it will be done
Coordinating overall needs	Coordinating specific needs
Multi-discipline focus	Single-discipline focus
Reliance on others	Providing technical expertise
Project quality	Technical quality
Administrative viewpoint	Technical viewpoint
A generalist's approach	A specialist's approach

Functions of Management

Management is often summarized into five basic functions: planning, organizing, staffing, directing, and controlling. Although these basic management functions have been developed and used by managers of businesses, they apply equally to the management of a project.

Planning is the formulation of a course of action to guide a project to completion. It starts at the beginning of a project, with the scope of work, and continues throughout the life of a project. The establishment of milestones and consideration of possible constraints are major parts of planning. Successful project planning is best accomplished by the participation of all parties involved in a project. There must be an explicit operational plan to guide the entire project throughout its life.

Organizing is the arrangement of resources in a systematic manner to fit the project plan. A project must be organized around the work to be performed. There must be a breakdown of the work to be performed into manageable units, which can be defined and measured. The work breakdown structure of a project is a multi-level system that consists of tasks, subtasks, and work packages.

Staffing is the selection of individuals who have the expertise to produce the work. The persons that are assigned to the project team influence every part of a project. Most managers will readily agree that people are the most important resource on a project. People provide the knowledge to design, coordinate, and construct the project. The numerous problems that arise throughout the life of a project are solved by people.

Directing is the guidance of the work required to complete a project. The people on the project staff that provide diverse technical expertise must be developed into an effective team. Although each person provides work in his or her area of expertise, the work that is provided by each must be collectively directed in a common effort and in a common direction.

Controlling is the establishment of a system to measure, report, and forecast deviations in the project scope, budget, and schedule. The purpose of project control is to determine and predict deviations in a project so corrective actions can be taken. Project control requires the continual reporting of information in a timely manner so management can respond during the project rather than afterward. Control is often the most difficult function of project management.

Key Concepts of Project Management

Although each project is unique, there are key concepts that a project manager can use to coordinate and guide a project to completion. A list of the key concepts is provided in Table 1-2.

TABLE 1-2 Key Concepts of Project Management

1. Ensure that one person, and only one person, is responsible for the project scope, budget, and schedule
2. Don't begin work without a signed contract, regardless of the pressure to start
3. Confirm that there is an approved scope, budget, and schedule for the project
4. Lock in the project scope at the beginning and ensure there is no scope growth without approval
5. Make certain that scope is understood by all parties, including the owner
6. Determine who developed the budget and schedule, and when they were prepared
7. Verify that the budget and schedule are linked to the scope
8. Organize the project around the work to be performed, rather than trying to keep people busy
9. Ensure there is an explicit operational work plan to guide the entire project
10. Establish a work breakdown structure that divides the project into definable and measurable units of work
11. Establish a project organizational chart that shows authority and responsibilities for all team members
12. Build the project staff into an effective team that works together as a unit
13. Emphasize that quality is a must, because if it doesn't work it is worthless, regardless of cost or how fast it is completed
14. Budget all tasks; any work worth doing should have compensation
15. Develop a project schedule that provides logical sequencing of the work required to complete the job
16. Establish a control system that will anticipate and report deviations on a timely basis so corrective actions can be taken
17. Get problems out in the open with all persons involved so they can be resolved
18. Document all work, because what may seem irrelevant at one point in time may later be very significant
19. Prepare a formal agreement with appropriate parties whenever there is a change in the project
20. Keep the client informed; they pay for everything and will use the project upon completion

Each of the key concepts shown in Table 1-2 is discussed in detail in subsequent chapters of this book. It is the responsibility of the project manager to address each of these concepts from the beginning of a project and through each phase until completion.

Role of the Project Manager

The role of a project manager is to lead the project team to ensure a quality project within time, budget, and scope constraints. A project is a single, non-repetitive enterprise, and because each project is unique, its outcome can never be predicted with absolute confidence. A project manager must achieve the end results despite all the risks and problems that are encountered. Success depends on carrying out the required tasks in a logical sequence, utilizing the available resources to the best advantage. The project manager must perform the five basic functions of management: planning, organizing, staffing, directing, and controlling.

Project planning is the heart of good project management. It is important for the project manager to realize that he or she is responsible for

TABLE 1-3 Project Manager's Role in Planning

1. Develop planning focused on the work to be performed
2. Establish project objectives and performance requirements early so everyone involved knows what is required
3. Involve all discipline managers and key staff members in the process of planning and estimating
4. Establish clear and well-defined milestones in the project so all concerned will know what is to be accomplished, and when it is to be completed
5. Build contingencies into the plan to provide a reserve in the schedule for unforeseen future problems
6. Avoid reprogramming or replanning the project unless absolutely necessary
7. Prepare formal agreements with appropriate parties whenever there is a change in the project and establish methods to control changes
8. Communicate the project plan to clearly define individual responsibilities, schedules, and budgets
9. Remember that the best-prepared plans are worthless unless they are implemented

project planning, and it must be started early in the project (before starting any work). Planning is a continuous process throughout the life of the project, and to be effective it must be done with input from the people involved in the project. The techniques and tools of planning are well established. Table 1-3 provides guidelines for planning.

A project organizational chart should be developed by the project manager for each project. The chart should clearly show the appropriate communication channels between the people working on the project. Project team members must know the authority of every other team member in order to reduce miscommunications and rework. Organized work leads to accomplishments and a sense of pride in the work accomplished. Unorganized work leads to rework. Rework leads to errors, low productivity, and frustrated team members. Table 1-4 provides guidelines for organizing.

Project staffing is important because people make things happen. Most individuals will readily agree that people are the most important resource on a project. They create ideas, solve problems, produce designs, operate equipment, and install materials to produce the final product. Because each project is unique, the project manager must understand the work to be accomplished by each discipline. The project manager should then work with his or her supervisor and appropriate discipline managers to identify the persons who are best qualified to work on the project. Table 1-5 provides guidelines for project staffing.

TABLE 1-4 Project Manager's Role in Organizing

1. Organize the project around the work to be accomplished
2. Develop a work breakdown structure that divides the project into definable and measurable units of work
3. Establish a project organization chart for each project to show who does what
4. Define clearly the authority and responsibility for all project team members

TABLE 1-5 Project Manager's Role in Staffing

1. Define clearly the work to be performed, and work with appropriate department managers in selecting team members
2. Provide an effective orientation (project goals and objectives) for team members at the beginning of the project
3. Explain clearly to team members what is expected of them and how their work fits into the total project
4. Solicit each team member's input to clearly define and agree upon scope, budget, and schedule

The project manager must direct the overall project and serve as an effective leader in coordinating all aspects of the project. This requires a close working relationship between the project manager and the project staff to build an effective working team. Because most project team members are assigned (loaned) to the project from their discipline (home) departments, the project manager must foster the development of staff loyalty to the project while they maintain loyalty to their home departments. The project manager must be a good communicator and have the ability to work with people at all levels of authority. The project manager must be able to delegate authority and responsibility to others and concentrate on the linking process between disciplines. He or she cannot become overly involved in detailed tasks, but should be the leader of the team to meet project objectives. Table 1-6 provides guidelines for directing the project.

Project control is a high priority of management and involves a cooperative effort of the entire project team. It is important for the project manager to establish a control system that will anticipate and report deviations on a timely basis, so corrective action can be initiated before more serious problems actually occur. Many team members resist being controlled; therefore the term *monitoring a project* may also be used as a description for anticipating and reporting deviations in the project. An effective project control system must address all parts of the project: quality, work accomplished, budget, schedule, and scope changes. Table 1-7 provides guidelines for project control.

TABLE 1-6 Project Manager's Role in Directing

1. Serve as an effective leader in coordinating all important aspects of the project
2. Show interest and enthusiasm in the project with a "can do" attitude
3. Be available to the project staff, get problems out in the open, and work out problems in a cooperative manner
4. Analyze and investigate problems early so solutions can be found at the earliest possible date
5. Obtain the resources needed by the project team to accomplish their work to complete the project
6. Recognize the importance of team members, compliment them for good work, guide them in correcting mistakes, and build an effective team

TABLE 1-7 Project Manager's Role in Controlling

1. Maintain a record of planned and actual work accomplished to measure project performance
2. Maintain a current milestone chart that displays planned and achieved milestones
3. Maintain a monthly project cost chart that displays planned expenditures and actual expenditures
4. Keep records of meetings, telephone conversations, and agreements
5. Keep everyone informed, ensuring that no one gets any "surprises," and have solutions or proposed solutions to problems

Professional and Technical Organizations

Due to the increased cost and complexity of projects, the interest in developing and applying good project management principles has gained considerable attention by owners, designers, and contractors. Numerous organizations have made significant contributions related to project management by conducting research, sponsoring workshops and seminars, and publishing technical papers. The following paragraphs describe some of these organizations.

The American Society of Civil Engineers (ASCE), founded in 1852, is the oldest national engineering society in the United States. Membership consists of civil engineers working in government, education, research, construction, and private consulting. The construction division of ASCE has many councils and technical committees that have published technical papers related to project management in its *Journal of Construction Engineering and Management.*

The National Society of Professional Engineers (NSPE), founded in 1936, is the national engineering society of registered professional engineers from all disciplines of engineering. NSPE membership includes engineers who are organized in five practice divisions: construction, education, government, industry, and private practice. The construction practice division has numerous committees that have contributed to contract documents and legislation related to engineers in the construction industry.

The Project Management Institute (PMI), founded in 1969, consists of members from all disciplines and is dedicated to advancing the state-of-the-art in the profession of project management. PMI has a certification program for project management professionals and publishes a *Project Management Book of Knowledge* (PMBOK).

The Association for Advancement of Cost Engineering-International (AACE-I), founded in 1956, is an organization of worldwide members. It serves total cost management professionals in disciplines such as cost engineering, cost estimating, planning & scheduling, decision and risk management, project management, project control, cost/schedule control, earned value management, claims, and more. Since 1976 AACE has administered a certification program for individuals as Certified Cost

Consultant, Certified Cost Engineer, Certified Estimating Professional, Earned Value Professional, Planning & Scheduling Professional, and others.

The Construction Management Association of America (CMAA), founded in 1981, is an organization of corporate companies, public agencies, and individual members who promote the growth and development of construction management (CM) as a professional service. CMAA publishes documents related to CM, including the *Standard CM Services and Practice.*

The Construction Industry Institute (CII), founded in 1983, is a national research organization consisting of an equal number of owner and contractor member companies, and research universities from across the United States. CII is organized into committees, councils, and research teams which are comprised of owners, contractors, and academic members who work together to conduct research and produce publications on a variety of topics related to project management.

The following list of organizations is provided to the reader as sources for information related to project management:

American Institute of Architects

American Society of Civil Engineers

American Society of Military Engineers

Association for Advancement of Cost Engineering-International

Construction Industry Institute

Construction Management Association of America

Design Build Institute of America

National Society of Professional Engineers

Project Management Institute

Society of American Value Engineers

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