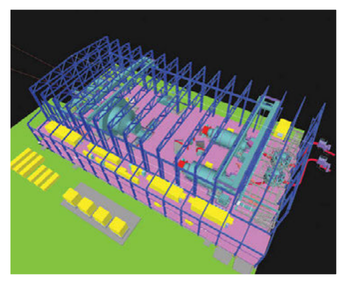
Project Management for Mining

Handbook for Delivering Project Success



by Robin J. Hickson
and Terry L. Owen

SME

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CHECKLISTS

FLOWCHARTS

Acknowledgments

Our combined experiences in the global minerals industry are the central source for the effective project management tactics and methods that we seek to convey within this book. We are forever indebted to the corporations who so generously employed us and to our colleagues who so patiently educated us over these past 50 years. This publication is a culmination of the wisdom we gleaned and gathered from so many others as we worked our way through almost 500 projects following our entry into the mining profession.

To single out (and please forgive omissions) in alphabetical order the corporate names that in one way or another helped frame the best practices that are captured within this book, we need to recognize Apex Silver, Asarco, Cyprus Amax, Freeport-McMoRan, Gold Fields, Kerr McGee, Inco, Kvaerner, McIntosh Engineering, New Jersey Zinc, Phelps Dodge, and Thompson Creek. While several of these names are no longer with us, at least not as standalone entities, it was their individual projects that, in large part, helped mold our collective knowledge and understanding on the subject of project management.

Some supporting material has been drawn from the works of others, and we are grateful to all those authors who put their knowledge into the public realm. The references section recognizes these sources.

It is also necessary to thank Ralph Barker, Richard L. Bullock, Jack de la Vergne, Eric Dudson, Stacey Graham, Apolinar Guzman, Patty Huntley, Jean Jenkins, Richard H. Johnson, Andrew Kaczmarek, Randy Lorance, Bruce Marsh, Bill McKenzie, Gerritt Morkel, George Stephan, Steve Stulock, Keith Vaananen, and Christa Zaharias for providing wisdom and invaluable unpublished background materials for the book. Their contributions and insights gave us the additional subject matter necessary to properly cover the full breadth of project management topics.

The authors would additionally like to recognize Richard C. Adkerson, president and CEO of Freeport-McMoRan Copper & Gold, for his generosity in granting permission to use the framework of the *1997 Cyprus Amax Minerals Company Project Management Manual* as a starting point for the creation of this book.

The 1997 Cyprus Amax manual was our first published project management guide, created as an internal document for Cyprus Amax project personnel. The feedback over the ensuing two decades from the Cyprus Amax, Phelps Dodge, and Freeport-McMoRan employees who used that publication has been appreciatively received, and their offered suggestions for improvement have been gladly incorporated into this book.

This book has been a complete joy to create. We will be forever grateful to Jane Olivier for allowing us to take on this longtime vision of ours under the SME banner.

We also need to give a special thank you to our supervisors, mentors, peers, and co-workers. Your guidance, support, and patience brought us to where we are today. We will be forever grateful for the most important thing that you each shared with us, your time.

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We also thank Chris McGoldrick for his meticulous diligence in reviewing our work and Richard Owen for showing us how to bring together the pages of this 4-year effort in a professional fashion. We also recognize Teresa Barensfeld and Diane Serafin, the brilliant editors with SME, who brought our ramblings into a coherent document, and Stephen Adams, the SME compositor for his artisitc wizardry.

Our biggest debts of gratitude must go to our two families, who trekked with us from mining camp to mining camp, never complaining about the uprooting, always being there for us, and focusing on the adventures in front rather than the moments left behind. Anne Hickson and Linda Owen, you are our inspirations; we owe this book's very existence to you. To our children, Richard H., Sharon, Nick, Steve, Richard O., and Russell, a heartfelt thank you. The joy that you bring into our lives as we grow together is never-ending.

Finally, any errors and omissions contained herein rest solely with the authors. Like all project managers we strive for success, but we take full responsibility for any shortfall in achievement.

About the Authors

Robin J. Hickson, primary author, is a mining engineer with 50 years of experience from building and operating mines around the world. Hickson earned his engineering degree from the Royal School of Mines in the United Kingdom and his MBA with honors from Tulane University. He is a Chartered Engineer and a certified Qualified Person in Mine Engineering. Hickson started in the mining industry as an underground laborer on the face of a UK longwall coal mine in 1963, and then acquired broad operations knowledge in the first half of his career as he progressed from engineer, shift boss, general manager, and vice president to president. His operations work took him into more than 100 mines in 25 countries in the Americas, Asia, Russia, Africa, and Europe.

Hickson's operations career was split between underground and surface as he worked for New Jersey Zinc, Kerr McGee, Asarco, Gold Fields, Freeport-McMoRan, Cyprus Amax, and Gabriel. He managed a variety of underground and surface mining operations encompassing gold, silver, copper, lead-zinc, molybdenum, limestone, aggregates, and uranium. He has also worked in nickel, soda ash, phosphate, potash, diamonds, coal, lithium, and iron ore operations.

Hickson's work took him to underground operations utilizing open stope, room-and-pillar, panel, block cave, shrinkage, cut and fill, vein, and longwall methods; and on the surface into open-pit, quarry, strip, heap leach, dredge, hydraulic, and in situ mines. All together, these experiences encompassed more than 20 different mining systems.

Projects occupied the second half of Hickson's career. He led the expansion programs for three of the world's major mining companies: Freeport-McMoRan, Gold Fields, and Cyprus Amax. He then moved on to serve as senior executive, global head of mining projects, for the international engineering and construction firms of Aker Kvaerner, McIntosh, and Stantec. During this 25-year span, Hickson established an unblemished record for project delivery, leading the building of 15 grassroots mines and nine brownfield plant expansions on six continents—all completed in budget and on schedule, and operating at design throughput.

As project manager, he took four grassroots mines from feasibility to production:

- Grasberg, Indonesia, built in 5 years, the world's lowest-cost copper and gold mine*
- El Abra, Chile, built in 3 years for $1.3 billion, the world's largest solvent extraction and electrowinning oxide copper mine*
- Mesquite, California, built in 4 years, at the time, the world's largest heap leach
- Ortiz, New Mexico, heap leach gold open pit, permitted and built in 2 years

As corporate projects executive, Hickson led the successful building of more than 20 other mining operations including Cerro Verde* and Tintaya (Peru); Kubaka* (Russia); American Soda, Big Springs, Fort Knox*, Henderson*, Pinal Creek, Santa Cruz, and Solvay (United States); Karonie and Bow River (Australia); Radomiro Tomic, El Tesoro, and El Teniente (Chile); and Nickel Rim (Canada).

Today, Hickson provides senior management advice to mining companies, engineering firms, and financial institutions involved in the development and operation of mining ventures.

Hickson has been responsible for the publication of 300 separate feasibility and prefeasibility studies, has co-authored three books for the mining industry, and has published numerous technical papers. In 1999 Hickson was honored with the AIME Robert E. McConnell Award "for innovation and creativity advances in the gold and copper industries."

Terry Owen, collaborative author, is a mining engineer with 35 years of experience in optimizing operating properties and building new mines throughout the world. Owen's proficiency in directing the development of complex international projects, from definition through engineering, construction, commissioning, and ramp-up into successful operation, has made him a recognized leader for the delivery of major mining ventures. Owen's projects, valued at more than $7 billion to date, have garnered stellar safety records.

Owen received his mining degree from the University of Idaho, and he started his mining life in that same state at the deep underground Sunshine mine. His career progressed rapidly, with increasing responsibilities from tenures at Kerr McGee, Freeport-McMoRan, Cyprus Amax, Inco, Apex Silver, Golden Minerals, and Thompson Creek Metals. In between these appointments, Owen successfully runs his own consulting company. His operational and project experiences encompass block cave, vertical crater retreat, and narrow vein underground mines; open-pit; longwall and surface coal mines; and process and infrastructure facilities.

While working for Freeport Indonesia (FI), Owen had a direct leadership role in the highly successful $3 billion development of one of the world's great ore deposits, expanding the original Ertsberg open pit which processed 6,800 tons per day, into multiple underground

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* Projects completed in partnership with Terry Owen.

mines and the Grasberg open pit to produce a combined 125,000 tons per day. Owen's pivotal role in the delivery of these FI projects and his subsequent management of their operations and infrastructure provided the solid project management foundation that was a catalyst for his next career phase.

Owen went on from FI to develop a strong tactical background in the turnaround management of operations and projects in the remote settings and multicultural environments of Australasia, the Russian Far East, Africa, and North and South America. Owen's project know-how allowed him to develop and install project delivery, project control, and management control systems in each of his organizations. His capabilities enable him to successfully transition from boardroom to field—forming, aligning, and directing project and operating teams while working through the challenges of mineral extraction, Mother Nature, local cultural expectations, environmental issues, and government and corporate demands.

Owen's work with both stressed and successful projects resulted in a suite of best practices that can serve as the foundation for successful projects in any environment. His more recent mandates to turn around a succession of failing projects and operations led Owen to create his treatise on Greenfield Mine Development Best Practices, along with the defining of a new type of project leadership in the persona of the Development Leader (both unpublished collections). Together these works provide a path to manage a project's development from feasibility into ongoing operations.

Along with his successful FI projects, Owen directly developed with Hickson the projects of El Abra, Cerro Verde, Kubaka, Fort Knox, Henderson, and Willow Creek Coal. Owen separately held project leadership positions at San Cristobal in Bolivia and Mount Milligan, Voisey's Bay, and Endako in Canada. Owen has been involved in more than 50 feasibility studies from exploration to brownfield revitalizations, and has managed projects with all the world's leading engineering, procurement, and construction management firms. Owen is currently consulting for the mining industry.

Opportunity Stage

CHAPTER 1

Introduction

> *Begin with the end in mind.*
> *— Stephen R. Covey, in* Seven Habits of Highly Effective People, *1989*

OBJECTIVE OF THIS BOOK

The book has been written to help miners succeed in the exceedingly challenging world of project management. Mining projects are complex. The path to successful project completion is imbedded with situational uncertainties and strewn with obstacles. These pages offer practical solutions to remove the obstacles and provide sound insight to cope with the uncertainties. The goal is to bring the project management world into better focus, to place project managers in positions where they can anticipate rather than respond, and to lay out the project execution path in straightforward patterns with understandable success strategies that will achieve the desired outcome.

More specifically, *Project Management for Mining* provides the originator of a mining idea or mineral opportunity with the necessary guidance to develop that idea or opportunity into a well-defined project that will successfully meet the corporation's business objectives. This book presents a best practice process for steering development of the project through senior management approval and on-site execution.

The intent is for this book to serve as a handy reference of proven techniques and winning approaches for effective project management within the mining industry, and to impart knowledge to all those who seek to manage mining project work, not just the project manager. The reason this book is titled *Project Management for Mining* rather than something like *A Project Manager's Manual* is because it is a manifestation of the authors' goal to create a go-to handbook that will be drawn from on a regular basis, rather than a little-used textbook lying on a dusty library shelf.

The book identifies the roles, responsibilities, and accountabilities of the individuals involved in the development and execution of the project. It provides a skeleton for, and reference to, the various documents that compose the mining industry's soundest practices, and it identifies the interrelationships between the parties and disciplines in a typical project. By following the procedures contained within this book, a mining organization can be assured that the project is properly characterized, project viability has been adequately challenged, the correct questions are being answered, and the appropriate process is being implemented.

BOOK SCOPE

The book provides a standardized approach to the project management process for mining projects, regardless of magnitude or location. The practices described here address international and domestic projects, grassroots and brownfield, with capital costs ranging from a few million dollars to multibillions.

Although the emphasis in this book and the examples drawn are mostly from metal mining, the intent is that the information herein will be similarly valuable to mining personnel serving the energy, industrial, and agricultural mineral worlds. The book clarifies what should be done regardless of who does it. Using the practices presented in this book, the project manager can control and coordinate the project activities. In addition to acting as a reference text for the participants involved in a project, the book also provides a basis for training project personnel in setting up and managing mining projects. Thus, this book serves as a one-stop guide to the project team with these questions:

- Why do it?
- Which path should be chosen?
- What has to be done?
- Where?
- When?
- In what sequence?
- How?
- By whom?

The book is a tool for the project team to draw from when facing unfamiliar problems, and to provide project staff with a fuller understanding of how to achieve project effectiveness. When applied with creative thinking and good judgment, the procedures described herein are—together with experience, leadership, and dedicated people—the necessary ingredients for quality project performance.

TARGET AUDIENCE

The target audience of this book includes not only the project manager but also all those mining personnel with an interest in or responsibility for successful project execution, for example,

- Corporate leaders who have to approve the project;
- Project sponsors who have to keep stakeholders satisfied with project progress;
- Geologic discoverers, developers, and entrepreneurs who want “their baby” built;
- Project team members who have to execute the project; and
- Mine operators who have to take delivery of the completed project.

While the prime target audience of this book consists of mining company project personnel (i.e., the Owner’s project management team), this book should also provide assistance to project management personnel from within the engineering, procurement, and construction management (EPCM) community who serve the minerals industry. This book can be a source of understanding for these EPCM organizations about what their client organization is typically seeking.

Whenever knowledge within this book is applied, the guiding axiom is to *keep it as simple as possible* and do not overcomplicate the project. Keep the fun in the journey.

DEFINITION OF A PROJECT

A project is a time-limited, goal-directed undertaking that requires a combination of human, mechanical, technical, and financial resources brought together in a temporary organization to achieve a specified purpose. A project has a single set of objectives that takes the status quo and changes it into something better. When these goals are reached, the project is complete. The ultimate goal is to bring economic benefit to the corporation, that is, to reduce cost, expand production, add revenue, and/or extend property life.

Mining projects are mostly unique and fall outside of the normal course of business routine or operational services. To successfully achieve project completion, a series of nonrecurring but connected events have to be properly managed within a finite and well-defined life span. In other words, to create a successful outcome for a project, a definite path with a defined strategy has to be organized within a formal framework. For most mining corporations, this formal framework means a development program under an assigned leader, backed by an approved Authorization for Expenditure (AFE), and accompanied by supporting documents, a feasibility study, and a Project Execution Plan (PEP). The defined life span has an identifiable start point, a fixed boundary, and an equally identifiable end point.

WHAT IS PROJECT MANAGEMENT?

Project management is the process by which a team of people successfully guide a project using the elements of planning, analyzing, directing, monitoring, problem solving, and communicating. They take an idea from the opportunity stage through development to the achievement of specific, established corporate objectives within set cost, schedule, and quality constraints. Figure 1.1 illustrates, in a flowchart format, how these various project management activities all tie together.

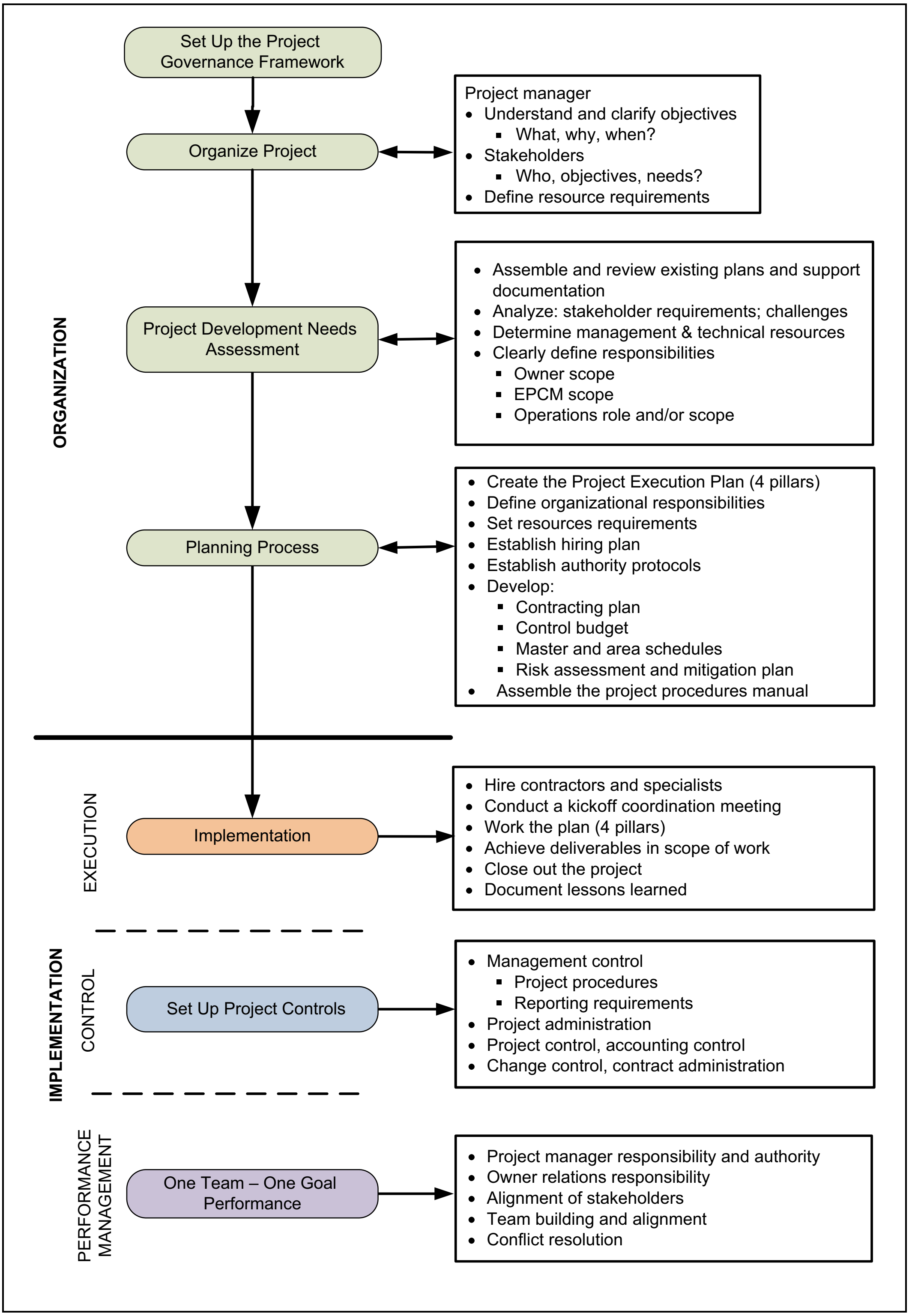
The preceding paragraph defines project management within the North American and U.K. cultural contexts, in which the two authors have been nurtured. As Crawford, Pollack, and England (2007) point out in their examination of global project management standards and terminologies, there are variations in the understanding of the term *project management* even though it is an extremely common, profession-specific term. The influence of various cultures places different emphases on the practice of project management within the countries of the world, along with different bases of knowledge and diverse understandings by practitioners.

So while it is recognized that there are subtle variants within the global community about what project management should entail, the authors have found that there are far more similarities than differences. Hence this book should be capable of usefully serving the mining community both within and beyond the American shores.

PURPOSE OF PROJECT MANAGEMENT

Project management is not a complex process. There are four basic steps to a successful project outcome:

1. Develop a definitive project scope and a project-specific execution plan.
2. Use qualified management personnel.
3. Create the project control mechanisms up-front (documents, tools, and procedures).
4. Control engineering, construction, and start-up activities during project execution.



Project manager
- Understand and clarify objectives
  - What, why, when?
- Stakeholders
  - Who, objectives, needs?
- Define resource requirements

- Assemble and review existing plans and support documentation
- Analyze: stakeholder requirements; challenges
- Determine management & technical resources
- Clearly define responsibilities
  - Owner scope
  - EPCM scope
  - Operations role and/or scope

- Create the Project Execution Plan (4 pillars)
- Define organizational responsibilities
- Set resources requirements
- Establish hiring plan
- Establish authority protocols
- Develop:
  - Contracting plan
  - Control budget
  - Master and area schedules
  - Risk assessment and mitigation plan
- Assemble the project procedures manual

- Hire contractors and specialists
- Conduct a kickoff coordination meeting
- Work the plan (4 pillars)
- Achieve deliverables in scope of work
- Close out the project
- Document lessons learned

- Management control
  - Project procedures
  - Reporting requirements
- Project administration
- Project control, accounting control
- Change control, contract administration

- Project manager responsibility and authority
- Owner relations responsibility
- Alignment of stakeholders
- Team building and alignment
- Conflict resolution

FIGURE 1.1 Project management activities

The more emphasis placed on the first three steps, the easier it is to manage the last step. Figure 1.2 illustrates management's greater ability to meaningfully influence the outcome of a project during front-end activities. What follows in this book is a logical course of procedures that will enable the reader to successfully execute these fundamental steps.

A simplistic mining industry definition of the *project management function* is "to manage, control, coordinate and schedule a project and to report on its progress" (Hickson and Owen 1997). The goal of this book, however, is much more: to describe the processes, personnel skills, tools, techniques, and devices that enable project management to be both effective and efficient.

Using this book will help to ensure that the original idea will be turned into a well-defined project with specifically stated goals; that the project goals are aligned with corporate goals; that the project is properly approved; and that when completed, the finished project actually meets the stated goals. Observance of the processes in this book should prevent a misguided project advocate from causing the company to pursue an idea that does not add corporate value.

PROJECT RESPONSIBILITY AND ACCOUNTABILITY

Those who initiate a project and then retain control of the project's development must realize that they have assumed total responsibility and accountability for its ultimate success or failure. The appointed project manager is fully accountable to corporate management for all aspects of the project. (Occasionally, it may be necessary for different people to be named project manager for various stages of the project, but if at all possible, this should be avoided.)

This book uses the term *project manager* for the appointed leader responsible for the work performed and accountable for project outcome. Some organizations use the title *project director* or even *project vice president* for this same leadership position, but changing the title does not change the role (it just changes the salary paid).

The duties of the project manager position are described throughout this book, and while these duties may sometimes be delegated to other project team members, project responsibility and accountability always stays with the project leader. For example, hiring contractors to perform work elements does not relieve the assigned project manager of the accountability or responsibility of ensuring a good project outcome.

THE SUCCESSFUL PROJECT MANAGER

It would be nice to be able to insert a list of ingredients that make up the perfect project manager for a mining project; but reality is that no such recipe exists. Examination of the makeup and resumes of the more successful mining project leaders does, however, reveal some common characteristics:

- Experience, experience. This is not their first "rodeo." The successful, effective project manager will have served in the same role on numerous, similar projects.
- The best project managers have taken their projects through the complete project journey, from scoping study, data gathering, feasibility, board approval, hiring of staff and contractors, residence in the engineering office, building the plant in the field, through to commissioning and operations start-up.
    - The project manager understands the balance and trade-offs that engineers have to make in order to design an operable and maintainable plant.

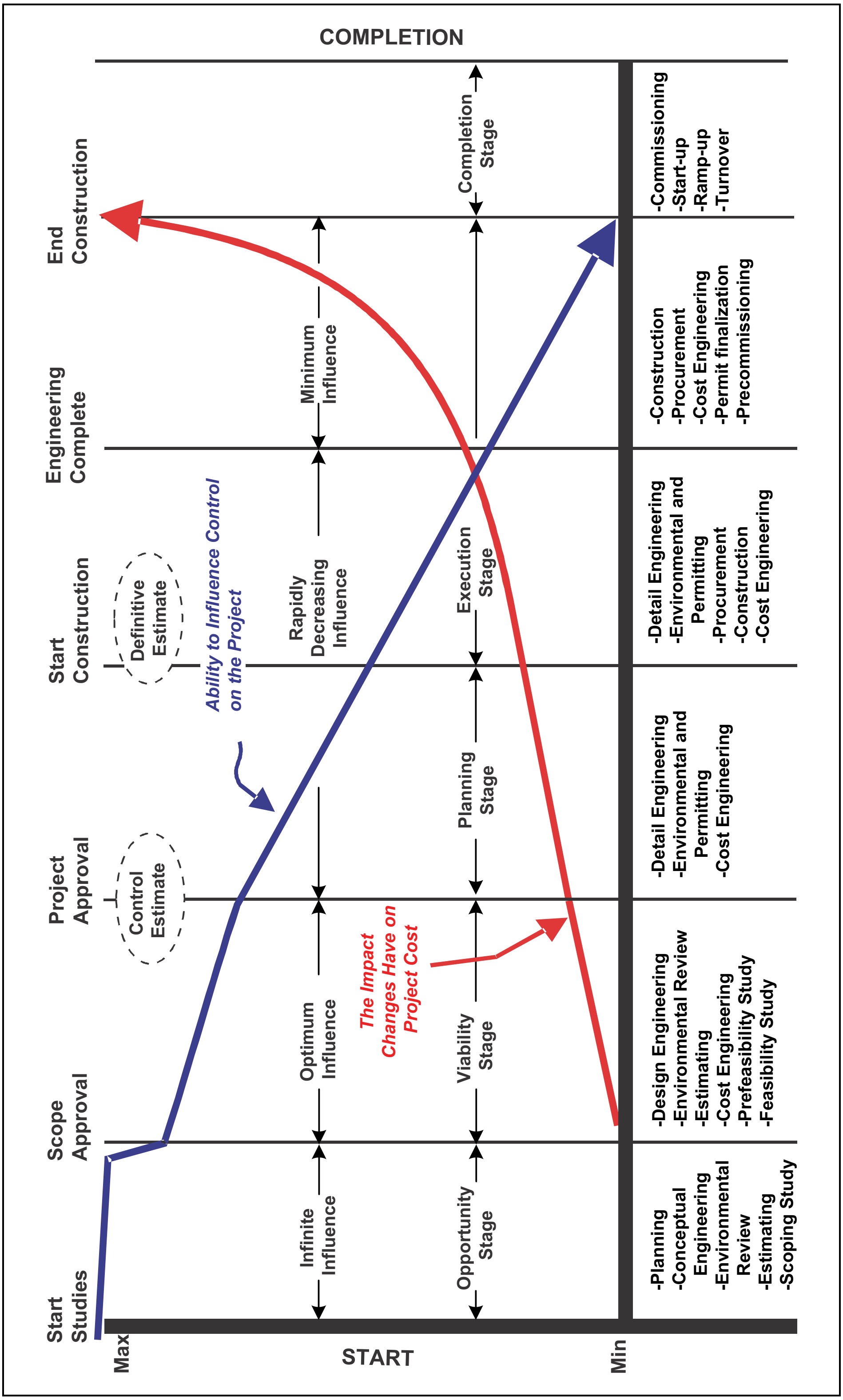


FIGURE 1.2 Profile of project management control influence

    - The project manager has dealt with the logistics issues that accompany materials and equipment deliveries in harsh, remote locations.
    - The successful project manager has lived in the construction camp world, from mobilization day to demobilization, and understands the rigors.
- The project manager is a leader who can motivate all members of the project team.
- The project manager can create and maintain an enabling work environment.

Project management is not a technical science; it is a behavioral science. The project manager requires business acumen and people skills to accomplish the project goals. Sophisticated programs for cost estimation, scheduling, procurement tracking, status analysis, and communications all facilitate the execution of project management, but they do not supplant it—they are no more than the tools of the project manager's trade.

In summary, successful project managers are motivational leaders with significant relevant project experience who can immediately take on the mantle of project champion. They are the ones willing to "eat, breathe, and sleep" the project. They commit to completing the job.

While one cannot teach experience from a book, an individual striving to be a competent project manager can do things to gain leadership abilities and help improve the odds of success:

- Bolster your project management education. This could take several forms:
    - Join the Project Management Institute (PMI). Absorb their *Guide to the Project Management Body of Knowledge* (PMBOK Guide) book of project management knowledge (PMI 2008). Take their Certified Associate in Project Management (CAPM) exam. Then get certified with PMI's Project Management Professional (PMP) credential.
    - Attend project management seminars. While few focus on mining, a course such as The Effective Project Manager from PSMJ Resources in Newton, Massachusetts, coupled with the information in its companion book, *Ultimate Project Management Manual* (PSMJ Resources 2004), is centered sufficiently on engineering and construction to be useful for beginners.
    - Earn a project management degree. Today, these are available from 2- and 4-year colleges. No such degree was available 50 years ago.
- Take a position on a remote location project. Experience the hardships and the joys.
- Be willing to work the 80-plus-hour weeks for years in a row that projects demand.

MEASUREMENT OF A PROJECT'S SUCCESS

The following standards have become established as measures of mining project success:

Feasibility Study Success

The project feasibility study is considered to be a success when it has been deemed "bankable" by external financial institutions.

Project Success

A project can be called successful if it has met the following criteria:

- The project has been completed within the approved capital budget.
- Handover to Operations is on or ahead of schedule.

- There are no surprises or unanticipated issues for the project team during project execution.
- Sustained design annual production and quality are achieved at the constructed facility.
- Operational unit cash costs are as predicted in the feasibility study.
- Construction has been conducted safely, with no lost time accidents (LTAs) and zero citations.
- Compliance with sound international environmental and sustainability standards has been met.
- Social acceptance has been achieved from stakeholders and the neighborhood communities.
- Admiration and pride are invoked throughout the mining community.

These accomplishments can only be effectively measured at project completion. Consequently, additional procedures and gauges are necessary to assess the project during its life stages and to determine the real likelihood of the goals being met, that is, whether the project is truly on a path to a successful conclusion.

Thus, a formal evaluation process measuring project performance, and by extension project success, is required throughout the project life and after the project's completion. The processes laid out in this book provide the tools to not only manage the project but also measure its real progress toward success at any point in time.

ORGANIZATION OF THE BOOK

Immediately after the table of contents is a list of the figures, checklists, and flowcharts. Then, the main part of the book has been organized by the sequential stages of a typical project. Each of the five major project stages is broken out as a section within the book:

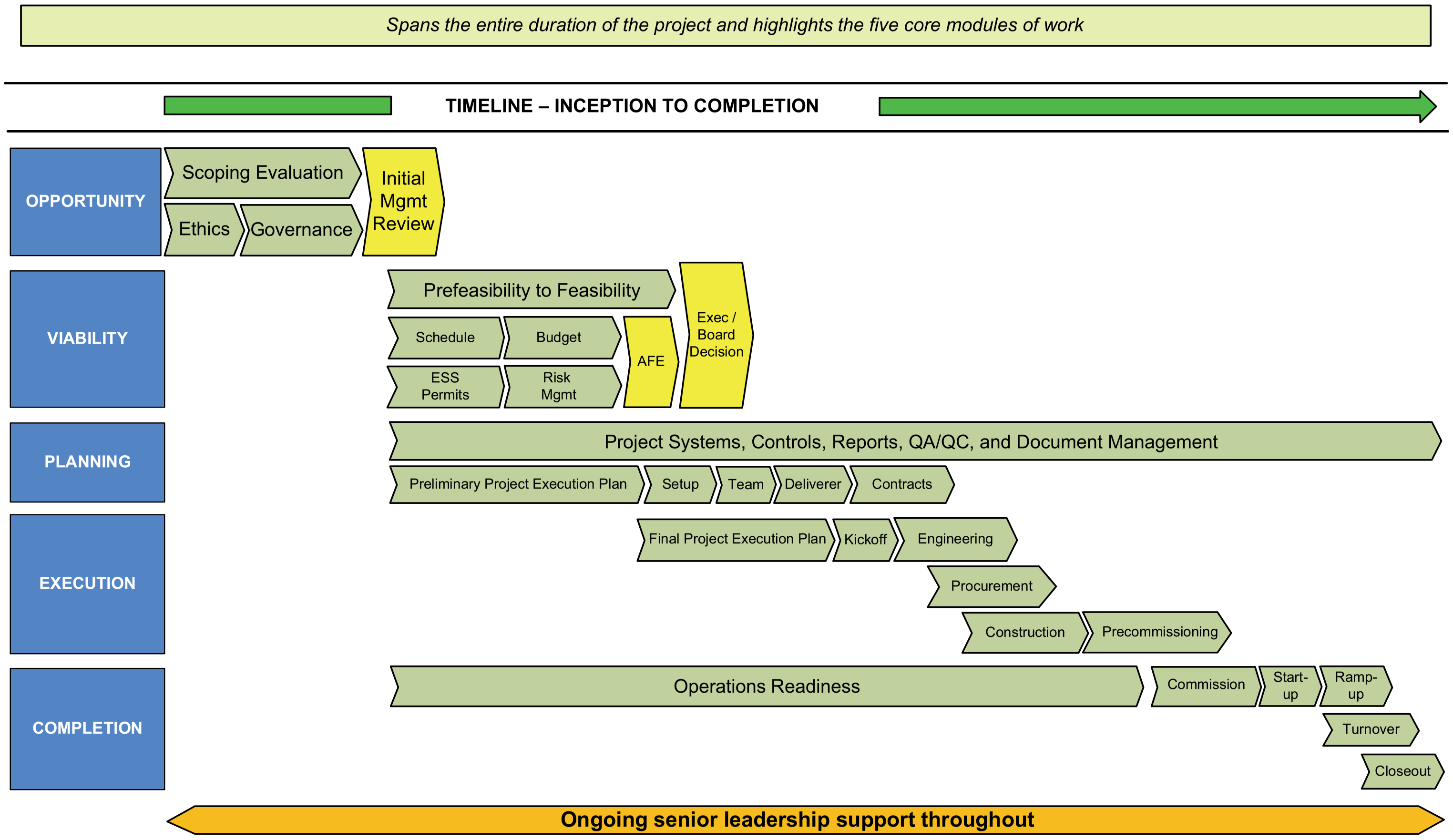
1. Opportunity
2. Viability
3. Planning
4. Execution
5. Completion

All projects are generally executed in this sequence from the idea stage through closeout. Each major stage is distinct, and each stage serves a different purpose.

Before the planning and execution stages can be carried out, the early opportunity development and proof of viability stages must be done. These two stages are each followed by a management review (or a "stage gate" review, in the parlance of Rio Tinto and Newmont) in which the project is vetted and has to be confirmed as meeting the corporate goals and financial hurdles required by the mining company executive body before it can be formally approved to enter the next stage.

Each major stage in the project development process further comprises a unique set of substages or activity phases, each with its own deliverables. In recognition of these unique project activity phases, the chapters are laid out to each represent one of the phases (or steps). Figure 1.3 depicts these sequential project stages and phases (i.e., the chapters) in Gantt chart form.

Some mining organizations have recently elected to dispense with the historic names of the various project stages and phases, that is, those of scoping evaluation, prefeasibility, feasibility study, and so forth, and have introduced their own new phraseology, for example, Class



Note: ESS = environmental impact, permits, social acceptance, and sustainability

FIGURE 1.3 Project stages timeline

4 through 1, Stage 1 through 5, or Phase 1 through 6, in differing orders of progression. The authors reject the usage of these nondescriptive terminologies. They add nothing but confusion to project participants. The authors retain the traditional industry nomenclature throughout the text, following the same logic as Canadian National Instrument classification NI 43-101.

As a guide for the reader, the chapters are laid out as follows.

Opportunity Stage

Chapter 1—Introduction

The introduction provides an overview of the project management process. (For clarity, only one currency, the U.S. dollar, is used throughout the book.)

Chapter 2—Ethics

This chapter apprises the project manager of the conflicts that can arise within a project and how best to approach these issues and "do the right thing" from an ethics viewpoint.

Chapter 3—Governance

The role of project governance is to provide a decision-making framework that is logical, robust, and repeatable for the control of an organization's capital investments.

Chapter 4—Scoping Evaluation

In the scoping evaluation, the project originators identify and nurture ideas that could enhance and forward the corporation's development goals. Following validation, the idea is expanded into a formal, presentable opportunity to see if the idea makes sense. Thus, the first encompassing look at the major facets of the potential project is set in motion. The goal is to present the opportunity to management in a format that allows either rejection or further pursuit.

Chapter 5—Management Review

This initial company management review analyzes the results of the scoping evaluation. The project potential is then sufficiently described in a Management Review Submission to allow management to reach a yes or no decision on whether to proceed to the next stage.

Viability Stage

Chapter 6—Prefeasibility Study

A prime purpose of the prefeasibility study is to undertake all possible trade-offs on the different options that can be sensibly postulated for achieving the project's goals. If there are no alternatives to the scoping evaluation path, then the prefeasibility study may be optional.

A prefeasibility study needs to be conducted when sufficient information is simply not available to proceed directly to a feasibility study from the opportunity stage, yet there is a strong belief that the project has a chance of meeting corporate objectives. The prefeasibility study is the first comprehensive appraisal of the project. All areas of the project are identified and a risk evaluation is made, albeit many details may still be conceptual.

Chapter 7—Feasibility Study

The feasibility study is the final, definitive proof of viability, that is, preparation of a bankable quality study that meets all the external financing requirements. The feasibility study is more detailed than the prefeasibility study, providing a more accurate estimate and a higher level of confidence in the probability of project success. The complete project and the installations to be built are fully described. The major risks and the steps for their mitigation are assessed. If approved, the feasibility study and the PEP become the primary control documents for the project.

Chapter 8—Environmental Impact, Permits, Social Acceptance, and Sustainability

This chapter lays out the steps that are required for the project to earn acceptance and approval from those external entities that affect and/or control project progress.

Chapter 9—Risk Management

Risk management encompasses the steps for identification, assessment, and prioritization of project risks. Following these steps is the key follow-up action for coordinated and economical application of resources to mitigate the probability and/or impact of unfortunate events and to maximize the realization of any opportunities.

Chapter 10—Schedule

The increasing levels of effort required to create the different levels of schedule as the project progresses in complexity from scoping though feasibility into construction are described in this chapter.

Chapter 11—Budget

This chapter lays out the steps needed to produce a good project budget. The effort levels required to create accurate cost estimates for the different project stages are portrayed.

Chapter 12—Contingency

Project contingency is detailed in this chapter and can be defined as “an amount of money for goods and services which at the current state of project definition cannot be accurately quantified, but which history and experience show will be necessary to achieve the given project scope” (Lawrence 2007). The chapter also reveals misconceptions about the composition and use of contingency.

Chapter 13—Comparison of Project Stage Work Efforts

A comparison of the different levels of effort required at the various stages of project life that precede project execution are presented in tabular form.

Chapter 14—Authorization for Expenditure

As long as the details and estimate accuracy of the feasibility study are such that a preliminary PEP can be developed, then an AFE document can be created to permit a corporate decision on the sensibility of approving capital expenditures for project development. A preliminary PEP is a necessary precursor to the project AFE.

Chapter 15—Executive and Board Decision

The process to gain final corporate approval for the project to proceed and the typical requirements for satisfying the rules of disclosure for the Board of Directors are laid out.

Planning Stage

Chapter 16—Project Execution Plan

The production of the PEP (in preliminary form) facilitates the final step of the viability stage, that is, the board's decision. The subsequent update and finalization of the PEP to comply with any management or board requests is the initial effort of the planning and execution stages. The PEP document identifies project objectives, scope of work, schedule milestones, key project personnel, and the project risks, and it provides a description of how the project engineering, construction, and start-up will be executed, managed, and controlled.

Chapter 17— Project Setup

The project setup effort goes beyond the completion of the PEP. It includes assembly of the project procedures manual; project philosophies and strategies are set; and project systems and procedures are established. Consensus is arrived at for the disciplines needed within the project team, and a determination is made of the process to select the entities for delivering the engineering, procurement, and construction phases.

Chapter 18—Team Organization

Assembly of the project team requires laying out the organization matrix, identifying project leadership and key personnel, and assigning responsibilities and accountabilities.

Chapter 19—Selection of Project Delivery Provider (Owner, EPCM, or EPC)

The philosophy behind and the methodology for selection of the appropriate project delivery provider(s) for engineering, procurement, construction, and commissioning are set.

Chapter 20—Contract Agreement

The basis for choosing the appropriate contract type to be entered into with the delivery contractor is identified.

Chapter 21—Project Controls

Project control parameters for effectively executing the project are established, and project controls team responsibilities are defined.

Chapter 22—Reports and Progress Reviews

Project reports and progress reviews provide timely, concise informational data and metrics to those project stakeholders who have a legitimate need-to-know of project status.

Chapter 23—Quality Assurance and Quality Control

The quality assurance protocols and quality control processes necessary to ensure successful project quality delivery are described.

Chapter 24—Document Management and Document Control

The suite of document management policies and document control rules necessary for efficient document administration over the project's life are clarified.

Chapter 25—Project Pitfalls

The various maladies that can befall and/or sidetrack a project are highlighted, along with suggested remedies and recovery strategies.

Execution Stage

Chapter 26—Kickoff Coordination

At the kickoff to the execution stage, project goals are confirmed and communicated, and buy-in to the suite of project objectives is established. The kickoff coordination session inaugurates the "partnering" alignments and sets roles and responsibilities for all players. The project procedures that were established following project approval are now implemented.

Chapter 27—Engineering

The engineering chapter covers the execution of project design and the production of the detail engineering drawings and specifications that allow the construction effort to begin.

Chapter 28—Procurement

The procurement effort encompasses the sourcing, purchasing, expediting, and logistics scheduling for all the materials, equipment, and services necessary to support construction.

Chapter 29—Construction

Construction is the heart of the project effort. Everything undertaken within the project to this point has been done with the goal of facilitating construction. This chapter discusses the selection and management of the field team necessary to carry out the construction effort and its support services, along with the safety program and project controls that are required to keep it on track. The tasks and duties of the personnel charged with executing and completing the construction effort are laid out.

Completion Stage

Chapter 30—Precommissioning

Precommissioning is the preliminary dry testing of individual units of the plant systems without ores or process fluids (other than water). Precommissioning involves testing single areas or subsystems to ensure that components perform as anticipated. Precommissioning ends with practical completion by the construction contractor, and with care, custody, and control responsibility for the facility being taken by the Owner.

Chapter 31—Commissioning, Start-Up, and Ramp-Up

Commissioning involves running and testing all areas of the plant systems individually, then together "wet" (i.e., with ore and process fluids) to ensure that the integrated systems can perform as anticipated and to correct any remaining problems before start-up.

Start-up is the beginning of actual plant operations. This chapter covers the start-up and then ramp-up of the project facility to full design operational mode. First product output occurs with the end of start-up and the beginning of ramp-up.

Chapter 32—Turnover and Closeout

The project turnover and closure process is a multistep procedure that actually begins during the start-up stage. Formal turnover of all the project documents, warranties, test records, and inventories to the Owner's operators establishes that project completion has taken place, the project has been built, punch lists have all been worked off, and the construction effort is over. Project turnover activity must be complete before project closeout can be achieved.

The project closeout phase records the level of success achieved in meeting the project's objectives, and it mandates that the project AFE be closed out, that is, no further ability to charge to the project. Project accomplishments and lessons learned are documented.

Chapter 33—Operations Readiness

Operations readiness actually starts months before project completion. A synopsis of the operations readiness plan actually accompanies the AFE submission for project approval.

The operations readiness plan lays out how the project will be phased into the operating business. It describes what will be done, how it will be done, in what sequence it will be done, and who will do it. The plan is an integrated summation of the individual functional (departmental) operational readiness plans, which provides proof that each operational function has adequately planned for the people, training, systems, processes, and services required to run a fully operating facility.

Chapter 34—Epilogue

The epilogue attempts to be a pithy wrap-up of the contents of the book, with the personal truths that the position of project manager for a major mining project will be one of the most satisfying roles that a person can undertake and that utilization of the collected wisdom within these pages will help deliver project success.

Glossary and References

A glossary of key terms can be found at the end of the book, followed by the reference section that lists, in alphabetic order, the sources that the book drew upon.

CHAPTER LAYOUT

Each chapter begins with a statement about the objective of the chapter and the project phase that it covers. A narrative then follows with descriptive details of the elements of that particular phase. Pertinent figures for each particular stage are found within the relevant chapter.

A checklist of the activities covered in each chapter precedes a flowchart. Together with the flowchart, the checklist provides a quick reference to the key project management elements covered within the chapter. The checklists serve an additional purpose in that, together, they form the starting point of the project audit process.

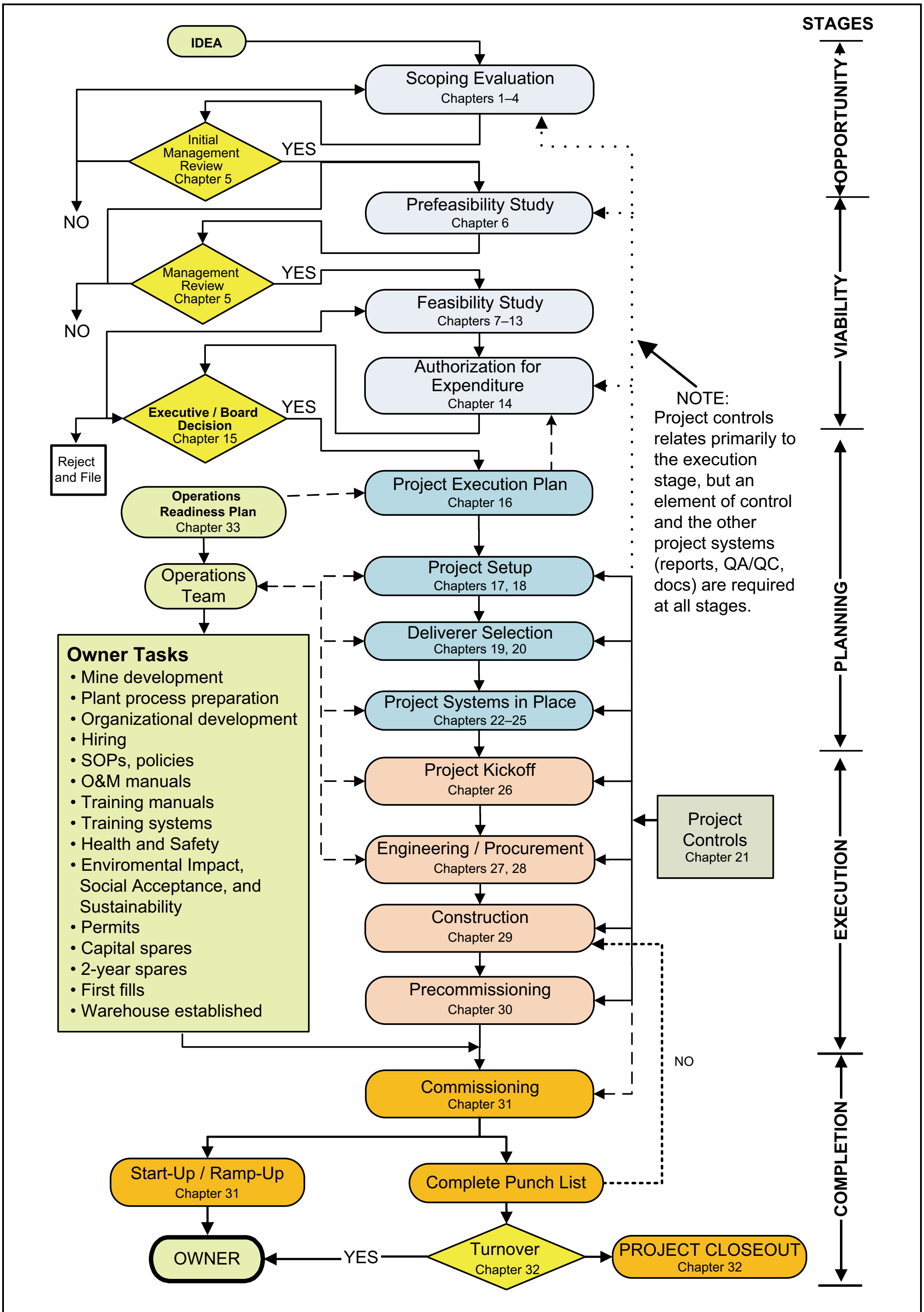
At the end of each major chapter, a flowchart shows the process flow for the activities described within the chapter. Generally, the flowchart will commence with the result of the previous chapter. The conventions used are (1) a rectangle indicates an action required, and (2) a diamond indicates a decision point.

At the end of this introductory chapter is a master flowchart, which ties together the 33 project phases described within the book.

PROJECT BOOK PHILOSOPHY

Within the pages of this book, the reader will find the answers to the questions posed in the "Book Scope" section:

- Why do it?—The scoping evaluation answers this; the project meets corporate goals.
- Which path should be chosen?—The prefeasibility study sorts through the alternatives.
- What has to be done?—The feasibility study defines the project scope.
- Where?—The feasibility study establishes the project footprint.
- When?—The feasibility study sets the master schedule.
- In what sequence?—The schedule establishes the sequence of project activities.
- How?—The PEP lays out the development process.
- By whom?—The PEP fixes the path for selecting the project team and project deliverer.



Note: O&M = operations and maintenance; SOPs = standard operating procedures.

FLOWCHART 1.1 Introduction

CHAPTER 2

Ethics

The ultimate measure of a man is not where he stands in moments of comfort and convenience, but where he stands in moments of challenge and controversy.
— Martin Luther King Jr., 1963

OBJECTIVE

What makes mining projects so exciting is that each one is an unusual, unique event in the continuum of life. But these projects can come with a downside. The project manager may encounter pressure, often internal, to spin, mischaracterize, or even misstate project information in a positive but unrepresentative manner to advance the project to fruition.

The purpose of this chapter is to describe the conflicts—real or perceived—that may occur and explore how project managers can best approach these issues from an ethics viewpoint. More importantly, this chapter seeks to bolster the project manager's resolve to do the right thing.

Conflicts may arise among various competing interests: the project manager's employer, the client, the profession, one's colleagues, the public, and even within oneself. The project manager is the person being paid to find ways to resolve conflicting issues, and he or she must always choose the honorably proper — that is, the ethical — course of action.

RIGHT AND WRONG

An old saying, mistakenly attributed to Mark Twain at a gathering of gold miners in Red Dog, California, in 1866, is that a mine is best described as "a hole in the ground owned by a liar at the top." True project success will not be achieved if such a statement characterizes the project manager, the mining company, or the project.

Being honest is not always straightforward, though. The increasing globalization of today's business has introduced conflicting cultures with different values, beliefs, and traditions. The Judeo-Christian concept of right and wrong that governs most of Western society does not always apply in other cultures that may have religious and cultural norms that can condone the misstatement of facts in pursuit of a business end.

COMPANY CODE OF CONDUCT

Ideally, the project manager's employer (or the Owner) will already have in place a global code of conduct, a clearly worded standard stating that if the company's chosen policies cannot be upheld, then the company will walk away from the business rather than compromise and do something inappropriate. (Please note that "Owner" is capitalized throughout this book when referring to the Owner that the project manager is working for, as is standard in the industry.)

It is the responsibility of each individual in a project organization, and particularly the project manager, to embrace the ethical fabric of the establishment and to live its values daily. It needs to be made clear to all members of the project team that illegal or unethical payments (offering or receiving) will not be tolerated, including bribes, kickbacks, and illegal gratuities to or from any person, organization, or government official to secure improper advantage for the project. This does not mean that the organization should impose U.S. or Western values on other societies, but rather that the company has chosen what it believes to be a globally acceptable code of conduct, a culture of integrity for all involved (Beta Gamma Sigma Center for Ethical Business Leadership 2011).

PROFESSIONAL CODES OF ETHICS

Virtually all professional organizations have codes of professional ethics. Although these are helpful in laying out fundamental canons, rules of practice, and professional obligations, none are legally binding. Most are just guides of conduct within a given profession, such as the Hippocratic Oath of 3,000 years ago for physicians (Ramani 2011). Common to most of these codes is the responsibility to consider the welfare, health, and safety of the workforce, general public, and community; to take on and perform work only in one's area of competence; to compete fairly; to avoid deceptive practices; to be objective and truthful in public statements; and to advance the profession.

A succinct and useful example for mining professionals comes from the Institute of Materials, Minerals and Mining (IOM3 2014). In its Code for Professional Conduct, the section on Ethical Behaviour states:

> Members should always be aware of the overriding responsibility to the public good. A member's obligation to the client can never override this, and members should not enter undertakings which compromise this responsibility. The "public good" encompasses care and respect for the environment, and for humanity's cultural, historical and archeological heritage, as well as the primary responsibility members have to protect the health and wellbeing of present and future generations.

PERSONAL CODE OF ETHICS

Corporations for the most part demand integrity and ethics, and they expect the same from their personnel. Thus, when appointing the project manager, the Owner needs to be absolutely sure that the person selected comes with the right ethical fiber. Because the reality is, as James Turley, chairman and CEO of Ernst & Young, stated in the February 22, 2013, Global Business Ethics forum at Tulane University, "If someone doesn't have it [ethics] by the time they come here, it's going to be really hard to convince them they should have it [ethics]."

On the flip side, again to quote Turley, "If you're in an environment where [the project manager] comes in and they think 'I play by the rules,' and they see everyone around them cheating, [the company] can un-teach [ethics] pretty quickly." It places the project manager in a difficult position if the corporation issues a strong, clear statement of what is meant by ethical behavior, and then the organization does not consistently follow its own published code of conduct.

The answer for the project manager, however, is clear. The project manager has to develop and rely upon his or her own personal code of ethics, in other words, a strong enough commitment to one's moral beliefs that will naturally lead to choosing the right course of action. A project manager's personal code of ethics needs to embrace the personal traits of integrity, fairness, faithfulness, and honesty.

SITUATIONAL ETHICS

Conditions for ethical lapses are ever-present in a mining project. In the best situations, the project manager will have wise company counsel available as an internal resource for advice and support in choosing a proper course of action. But sometimes the project manager will find her- or himself alone. Sometimes what is legal may be unethical; and sometimes what is ethical is not the course that is being demanded of the project manager. At such times, moral courage is needed (Kidder 2008). Doing the right thing when nobody is looking is an essential part of personal ethics. Not overlooking unethical behavior in others is equally important.

To put all of this in context, the following situations are provided for the reader to ponder. The following are real project situations that have confronted project managers in the mining industry:

- The project manager was asked by the Owner to replace a properly calculated, risk-aware contingency amount with a lower dollar figure to achieve a more robust economic outcome in the company publication. This course was rejected.
- To improve revenue flow on paper, the very highest recovery rather than the median recovery from a suite of statistically representative metallurgical tests was advocated for the feasibility study. The project manager correctly rejected this data-skewing suggestion for recovery overstatement.
- A request was made to extend the geostatistical search distance of a mineral reserve to include values beyond those that were statistically relevant and thus improve the overall reserve grade. The project team rejected this inappropriate stretch.
- Craft productivity multipliers for construction were proposed for a feasibility study at levels never achieved in the state. The project manager rejected this major understatement of labor cost and used real productivities instead.

The following events were faced by actual project managers on the job. Other real, ethical dilemmas will likely similarly confront project managers in the field.

- A check drill hole came in with mineral grades significantly below that of its twin. It was not, as suggested by the Owner's business partner, removed from the data bank. The results were reported, and follow-up activity ultimately killed the project.
- A heap leach under-soil liner and a crusher facility foundation both failed their compaction tests. The improperly compacted soils were removed and replaced, not buried under another layer, and the test data were not destroyed, as suggested by the contractor; but these proper actions resulted in an unbudgeted $250,000 capital cost increase.
- A concrete cylinder and its follow-up repeat cylinder failed the quality test. The concrete was replaced, even though this delayed the overall schedule and caused the loss of the project team bonus.
- A reportable, mandated environmental test on a protection device failed. The failed test was not, as suggested, deleted from the record. It was reported, and a fine ensued.

Data reporting can also present difficult ethical decisions:

- If a feasibility study is claimed to be complete, but there is insufficient engineering performed to support the design or costs, the study should not be accepted.
- When schedule delays can no longer realistically be made up, they need to be reported immediately, even if this results in negative consequences for the reporter.
- When capital items come in so significantly beyond original estimation that it is inappropriate for them be covered from contingency, the overruns need reporting, even if they will take the capital cost beyond the approved amount.

The key point is that the project manager's conduct needs to be based on integrity, fairness, and honesty at all times. Generally, the consequences will be acceptable for the project and the project manager, but not always. Regardless, that is the conduct required. If the project manager is not willing to display this moral courage, then he or she should not take the job.

BUILDING TRUST AND OVERCOMING HURDLES

To build a mine in today's increasingly connected world, one first has to build trust. A common thread found within projects that fail to win regulatory or social approval to go forward is that the key stakeholders do not trust each other.

Decrying media bias, consumer ignorance, nongovernmental organizations' (NGOs') misstatements, or governmental folly may make a mining company's internal audience feel good, but it does absolutely nothing for moving a project forward. In fact, such comments raise additional barriers. We need to recognize that society comes to the discussion table with a much greater confidence in the utterances of the environmental lobby and media than those of the mining business community. This negative perception of mining is not new (Maxey 1997). Georgius Agricola spends Book 1 of his 1556 treatise *De Re Metallica* methodically answering "the misrepresentations" of his century's mining detractors and their claims that "mining is not useful" or that "metals offer to men no advantages" (Agricola 1556/1912).

While we are no longer in the 16th century, Agricola's ideas on enlightenment still hold. A project will move forward if we engage the external stakeholders at the project's inception, if we are honest and transparent about the project's differing facets, and if we engage the public and bring their expectations realistically along during the permitting process.

Too many of our mining projects today are being surrounded by company spin that all too frequently borders on misrepresentation—a boatload of exaggerated benefits coupled with understated impacts. These only serve as easy fodder for the NGOs and media to "expose," allowing true project benefits to become marginalized and risks to become unnecessarily inflated in the public's mind. Thus the public all too frequently sees the project as a sustainer of corporate greed, rather than societal benefit.

But this all-too-prevalent viewpoint can be changed. By being honest, open, and ethical, a project manager can successfully deliver a mining project. To arrive at that endpoint, the project must do more than meet the corporate rate of return. It must visibly benefit the local community; it must be transparently clear of any corrupt practices (real or perceived); it must demonstrably do no environmental harm; and it must help decrease wealth disparities. These are the ethical yardsticks of today's public. If each project can meet these 21st-century standards, then it will go forward. Each time a project delivers on its promises, another segment of the public will become educated about the real value of our industry, just as Agricola's readers were enlightened in 1556 on how mining provides "the necessaries of life."

CHAPTER 3

Governance

Be true to yourself and your values…and be accountable for actually getting things done. — Alan Mulally, Ford CEO, 2013

OBJECTIVE

Project governance has come into prominence in recent times, though it has always existed informally in various guises. Governance is now correctly viewed as playing a vital role in the successful delivery of a project. Project governance is about helping to ensure that the right projects are done well. Taking the time to put in place good project governance is especially important when dealing with complex or risky projects.

The aim of this chapter is to provide appropriate guidance for establishing and maintaining the structures and forums needed for effective project governance at all stages in the project lifecycle.

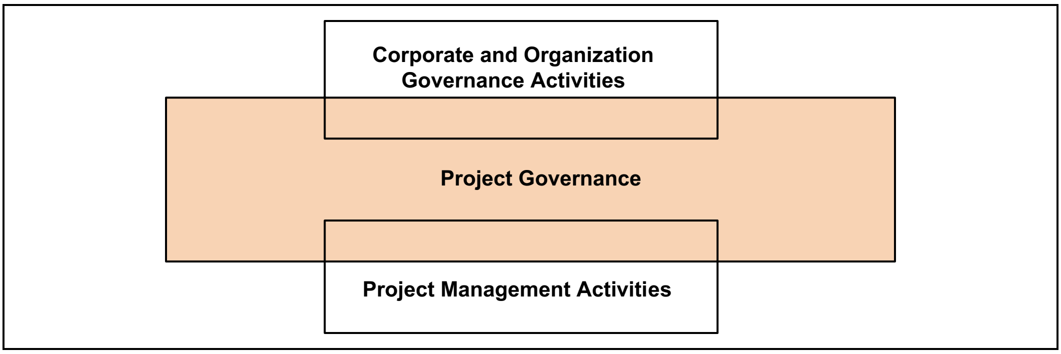
WHAT IS PROJECT GOVERNANCE?

Project governance is the management organization framework within which project decisions are made. Good project governance facilitates efficient decision making, timely and optimum decisions made by the right people, and decisions that meet the needs of the project and its stakeholders.

The U.K. government defines *project governance* as "those aspects of governance related to ensuring the effectiveness of projects" (HM Treasury 2007). While the wording is typically governmental wishy-washiness, the underlying premise is valid.

As shown in Figure 3.1, project governance sits between the owner's corporate governance and the specific project management regime, overlapping both areas. The demarcation between a company's corporate controls and project management activities is frequently ill-defined. Project governance does not seek to more accurately distinguish between the overlap zones; rather it seeks to better define the specific arrangements required within the overlap areas for successful project execution.

While the accountabilities and responsibilities related to a mining company's regular business activities are laid down in its organizational governance arrangements, unless the mining company specifically develops a project governance policy, a framework will not exist to govern the development of its capital investments, that is, its projects.



Source: HM Treasury 2007; *Project Governance,* Crown copyright.

FIGURE 3.1 Project governance

The role of project governance is to provide such a decision-making framework to govern its capital investments. The best framework is logical, robust, and repeatable—a structured approach for conducting project activities.

COMPONENTS OF PROJECT GOVERNANCE

The main activities of project governance relate to the following:

- Program structure and direction
- Project ownership and leadership
- Effectiveness of project management functions
- Reporting and disclosure (including consulting with stakeholders)

These activities are illustrated in Figure 3.2.

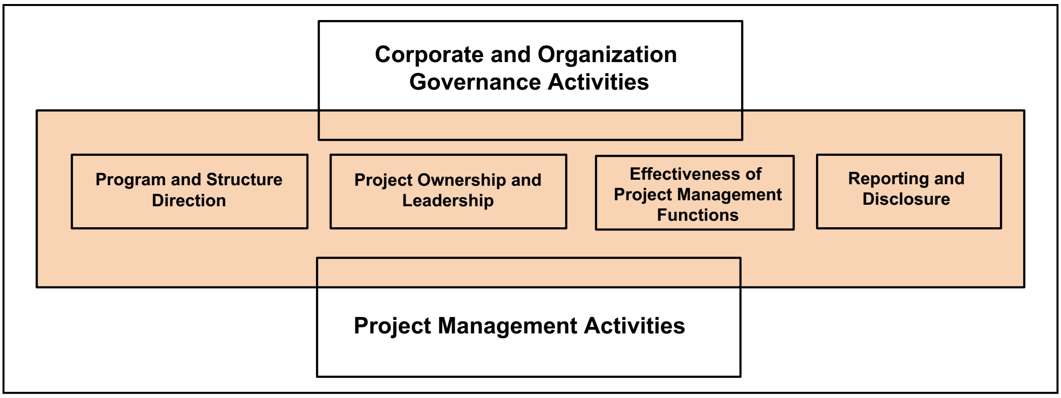
The highest levels of the mining company must act to set the project governance mechanisms in place, have them function correctly, and instill in stakeholders confidence in the arrangements. A project needs a different organizational structure from that of corporate governance and distinct from that of line operational management. It needs to have a minimum of layers, and it needs to be both flexible and cross-functional. A project's governance structure may need to evolve as different project stages transpire, and thus the framework should be revisited from time to time during the life of the project.

THREE PILLARS OF PROJECT GOVERNANCE

The project governance decision-making framework is supported by three pillars:

1. **Structure:** Establishment of an effective governance oversight structure
2. **People:** Appointing the right people to project leadership
3. **Information:** Regular, timely reporting that informs the decision makers

There are several ways of delivering effective project governance. Because some of the structures and mechanisms can sometimes conflict, it is important to identify potential problems at project outset to ensure that the necessary protections are in place.



Source: HM Treasury 2007; *Project Governance,* Crown copyright.

FIGURE 3.2 Governance components

CORE PRINCIPLES OF PROJECT GOVERNANCE

The project governance framework has to be based on certain core principles to be effective (Johnson 2013).

Principle 1: Ensure a Single Point of Accountability for Project Success

A single leadership point of accountability ensures clarity of leadership and timeliness of decision making. A project without a clear understanding of who is accountable for its success essentially has no leadership. This is the most fundamental principle of project accountability.

Without one single person driving the process of dealing with the solutions to the difficult issues that beset all projects, a successful project outcome will be impeded. This is particularly true during the crucial project initiation phase; it needs a point person to make sure that the project starts off on a firm footing.

Principle 2: Assign a Competent Project Manager to Lead the Project

It is not enough to nominate someone to be accountable—the right person, an effective project leader, must be selected to be accountable. There are two aspects to this:

1. The right person with the appropriate skills, either from within or from outside the organization must be selected and then held accountable. If the wrong person is selected, the project will be no better placed than if no one is accountable for its success.
2. The person must be given sufficient authority by the mining company to ensure that they are empowered to make the decisions necessary for the project's success. Besides having the competence, the assigned project manager must be given the authority and the resources to enable appropriate decisions to be made.

It is the project manager's responsibility to ensure that disciplined governance arrangements supported by appropriate methods and controls are applied throughout the project life cycle. The person who assumes accountability for the project's success is the subject of Principle 3.

Principle 3: Make Project Management Independent from Asset Ownership

Often mining companies assign the project management role to the future asset owner (i.e., future mine operations), thinking that this will provide more assurance that the completed project will meet the mine operator's needs (which is indeed one of the critical measures of project success). However, the result of this approach, more often than not, leads to wasteful scope inclusions and frequent failure to achieve the other corporate and stakeholder requirements. Reasons for this shortfall include the following:

- The benefit of doubt for project decisions goes to the stakeholder who is the future mine operator, thus skewing project outcome.
- Project requirements receive less scrutiny, reducing innovation and outcome efficiency.
- Different skill sets surround project management and mine operations management, thus placing sound project decision making and procedure at risk.
- Mine operational needs always prevail when problems require attention, placing the project at risk of being neglected during such times.
- Project contingency or underrun monies are at risk of being allocated to additional scope for mine operational needs.

The one proven mechanism for ensuring that projects meet corporate and stakeholder needs, while optimizing value for money, is to assign project management to a specialist party that otherwise would not be a stakeholder to the project; in other words, make project management independent of asset ownership and all other stakeholder groups. Such assigned project management must be given clear terms from the mining company, outlining project requirements and the organization's obligations to project stakeholders.

To embed the specialist parties needed to manage projects, many major mining companies establish a corporate projects group, independent of the company business operations divisions, that reports directly to the CEO (as was done at Freeport-McMoRan and Cyprus Amax during the authors' tenures, and as was done within the old Placer Dome organization). The mandate of such a projects group is to identify potential projects, appoint project managers as early as possible in the project's life, establish the basis of company and stakeholder engagement, determine the key result areas for the project consistent with company values, and oversee the performance of projects. These parameters are commonly detailed in a project governance plan that remains in place beyond the life of the project (and is distinct from a Project Execution Plan, which is more detailed and only comes into existence during the development of the project).

An alternative to the specialist corporate projects group is establishment of an ad hoc project steering committee for each project, composed of key company decision makers and external project experts. Rio Tinto has used this approach in the past for its mining divisions. (One of the authors served as an external expert on a Rio Tinto committee).

The decision-making effectiveness of a committee versus a specialty projects group has to be considered, however. The effectiveness of a committee can be thought of as being inversely proportional to its size. Large committees often fail to make timely decisions.

Having experienced both approaches, the authors unequivocally favor the corporate projects group over the steering committee approach. To be effective, the group must have the trust of the CEO, it needs to be nimble and small, and it needs to be composed of people with key skills. Projects group results for Freeport-McMoRan and Cyprus Amax (group size varying from one to five persons over the years) were superior to the mining industry average and thus would seem to endorse this approach. (See Figure 34.1.)

Conventional wisdom holds that that the corporate projects group, which relies on its small size and close team relationships to foster transparency, is best suited for lean companies with low-risk projects harboring few complications. Conventional wisdom would also say that steering committees are best suited for larger-size companies with complex projects where information is less transparent and there is high exposure to project budgets exceeding market expectations. Considering that the projects-group approach favored by the authors successfully delivered some of the largest, most complex projects of the past three decades to two of the world's top ten mining organizations, one would have to question the validity of conventional wisdom.

Principle 4: Establish an Enabling Governance Oversight Structure

Good project governance is enabled by a good governance oversight structure. In small-to-midsized, nimble companies, this can be one person—for example, a senior vice president (VP) of projects—as long as it is the "right person." With large organizations, this is more typically accomplished via a project governance board. Whatever the oversight entity size, the entity becomes a resource for project management to draw upon for program direction when needed, as well as to keep informed. If the oversight entity is a board with more than one person, then the governance board will include corporate executive presence, user groups, and perhaps even stakeholder representation.

The oversight entity has overall responsibility for the governance of project management. The roles, responsibilities, and performance criteria for project management are defined by this entity. The oversight entity can decide when independent scrutiny of a project management system is required and can implement such scrutiny accordingly.

The authority of the oversight person or body and how it relates to the projects must be laid down in policy and procedural documentation. In this way, the oversight entity's governance will not duplicate or impede the role of project management and can, if desired, be integrated with the wider company governance arena.

The oversight entity's role is that of an independent review body that oversees and monitors project management, and then relays project information and advice to facilitate decision making at the corporate executive level. The oversight body has no decision-making power of its own.

If the oversight entity is a board, then the effectiveness of the governance board structure is dependent on the people that populate the board. Membership should be determined by the nature of the project. This in turn determines which organizational roles and which, if any, stakeholders should be represented (Figure 3.3).

To be relevant, governance board composition needs to include a senior corporate executive, a senior operations person (to represent and understand the issues of the ultimate user of the project), and a senior projects person (who can represent the deliverer of the project). A three-person board can be sufficient in most organizations; the smaller the number, the more agile the entity.

As board numbers increase, the detailed understanding of project issues by each attendee is reduced. Many attend not to foster project health but as a way of finding out what is happening on the project. There is not enough time for each person to speak, so those with the

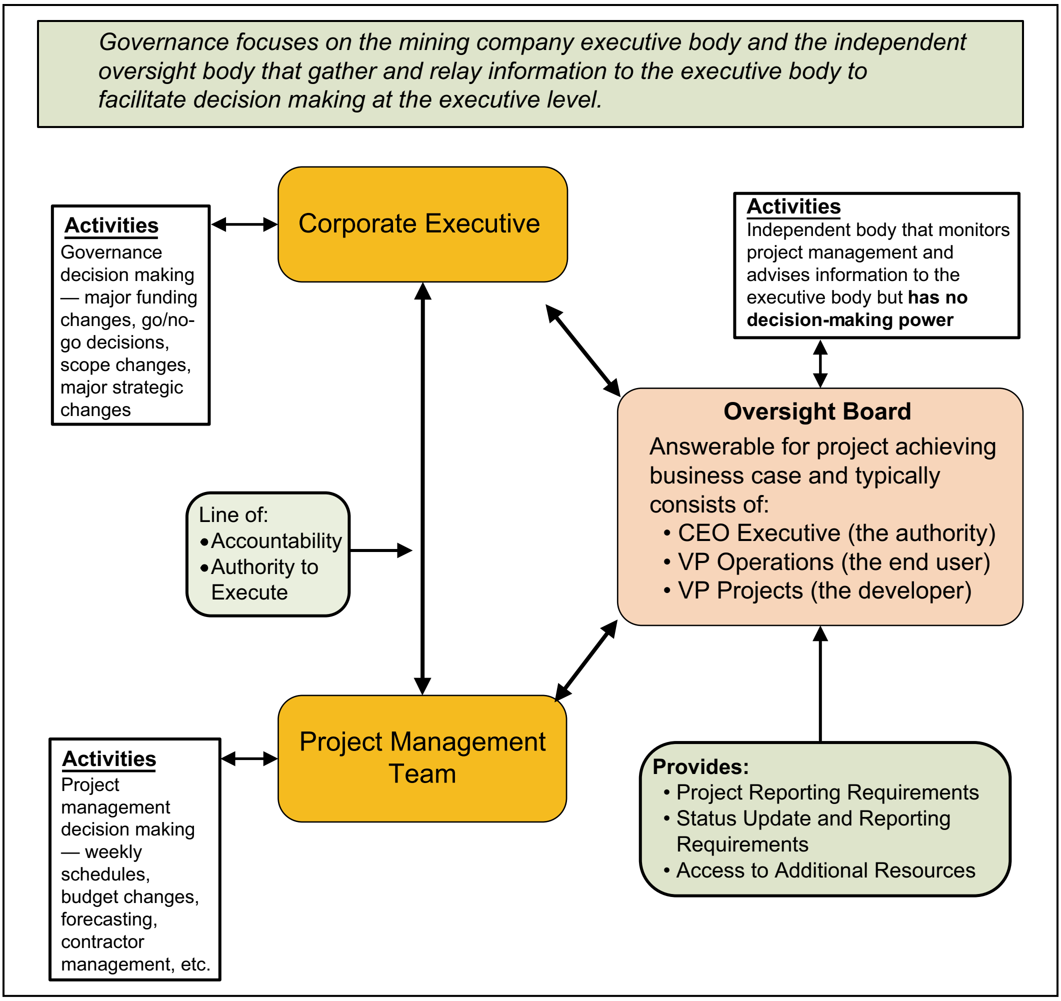


FIGURE 3.3 Project governance interface

most valid input must compete for time and influence with those who have only peripheral involvement. Not all present will have the same level of understanding, so time is wasted bringing everyone up to speed on the particular issue being discussed.

Principle 5: Split Stakeholder Management and Project Decision Making

In reality, projects have to deal with multiple stakeholders. Both project decision making and stakeholder management are essential to the success of the project, but these are two separate activities and they need to be treated as such. Separation prevents decision-making forums from becoming clogged with tangential stakeholder agendas. If a stakeholder committee is formed, membership needs to be restricted to only those select stakeholders absolutely central to project success. Large committees that are more like stakeholder political forums than project decision-making forums become a hindrance to timely decision making (Garland 2009).

Principle 6: Separate Project Governance from Company Governance

Adoption of this principle will reduce the number of decision-making layers and the associated delays and inefficiencies. This separation ensures that a project's decision-making body is empowered to make decisions in a timely manner.

Project governance structures are established precisely because mining company organization structures do not provide the necessary framework to deliver a project. Projects require flexibility and rapid decision making. The hierarchical mechanisms associated with mining company organization charts do not enable this. Project governance structures overcome this by drawing the key project decision makers out of the mining company's conventional organization structure and placing them in a separate forum, thereby avoiding a hierarchical decision-making process. Consequently, the project governance framework established for a project should remain separate from the company organization structure.

Principle 7: Provide Timely Reporting and Disclosure

Every organization has valid requirements in terms of reporting and stakeholder involvement. Dedicated reporting mechanisms established by the project can address the former, and the project governance framework must address the latter. Clearly defined criteria have to be established for reporting project status and raising awareness of risks and issues to the levels required by the owner mining company.

Regular reports on the project status, issues, risks, and the current state-of-the-project business case have to be escalated regularly by the project manager to the key mining company decision makers and stakeholders. The project business case updates must be supported by timely, relevant, and realistic information that provides a reliable basis for making authorization decisions.

ADDITIONAL PRINCIPLES FOR MULTI-OWNED PROJECTS

In a multi-owned project, the owner shares ultimate project control with other parties. The following are additional principles of good governance for such projects, courtesy of the Association for Project Management (APM 2007):

- All the owners should agree upon a formal governance arrangement.
- There should be a single point of decision making for the project (see Principle 1).
- The allocation of authority for representing the project with owners, stakeholders, and third parties should be a clear and unambiguous.
- The project business case should include agreed-upon definitions of the project objectives, the role of each owner, and their incentives, inputs, authority, and responsibility.
- Each owner should make sure that the legal competence, obligations, and internal governance arrangements of all the co-owners are compatible with its own standards.
- The owners should agree on recognition and allocation of rewards and risks, taking into account the ability to influence outcome, thereby creating incentives for cooperative behavior.
- Project leadership should exploit synergies arising from multi-ownership and should actively manage potential sources of conflict or inefficiency.
- A formal agreement should define the process to be invoked, and the consequences, when a material change of ownership is considered.

- A mechanism should be in place for independent review or scrutiny when it is in the legitimate interests of one or more of the project owners.
- A dispute resolution process should be in place that does not endanger the achievement of project objectives.

ATTRIBUTES OF GOOD GOVERNANCE

Governance is not a project management function or activity, nor is it an additional layer of decision making. Good governance is all of the following:

- An explicit organizational structure that enhances accountability
  - The structure encourages adherence to designated authority, check points, and communication lines.
  - Processes are not mere formalities to mark compliance.
- An objective monitoring process that can impartially assess investment readiness
  - Facts and data drive decision making.
  - The project performance is transparent.
- A series of go/no-go executive decisions over the course of the project life cycle
  - The project is not allowed to move around the gate (approval point) processes.
  - Third-party independent reviews eliminate optimism bias.
- An information-sharing process that streamlines and empowers decision making
  - Deliverables are completed collaboratively.
  - The risk of project surprises is reduced, and quality is enhanced.
- Minimization of bureaucracy
  - Templates of required reports are developed; needed content is identified.
- A project team that shares a holistic view of project success
  - The governance oversight entity and the project team are cohesively aligned.
  - There is cross-functional alignment of key business and technical requisites.

Figure 3.4 portrays how the governance function and its go/no-go decision gates relate to the project management function. Stage gates are discussed in detail in Chapter 5.

PROJECT ELEMENTS FOR GOOD GOVERNANCE ATTAINMENT

Important specific project elements that support good project governance include the following (Owen 2013):

- A compelling business case, clearly stating the objectives of the project
- The appointment of a competent project manager
- Sufficient decision-making authority allotted to the project manager
- A clear, unimpeded reporting line from project manager to the executive body
- Identification of all stakeholders with an interest in the project
- A defined method of communication and disseminating data to each stakeholder
- A methodology for stakeholders to have their interests in the project addressed
- Clear assignment of project roles and responsibilities for delivery of the project
- A published project plan that spans all project stages from initiation to operations
- A system of accurate, upward status and progress reporting
- A process for recording and communicating risks identified during the project

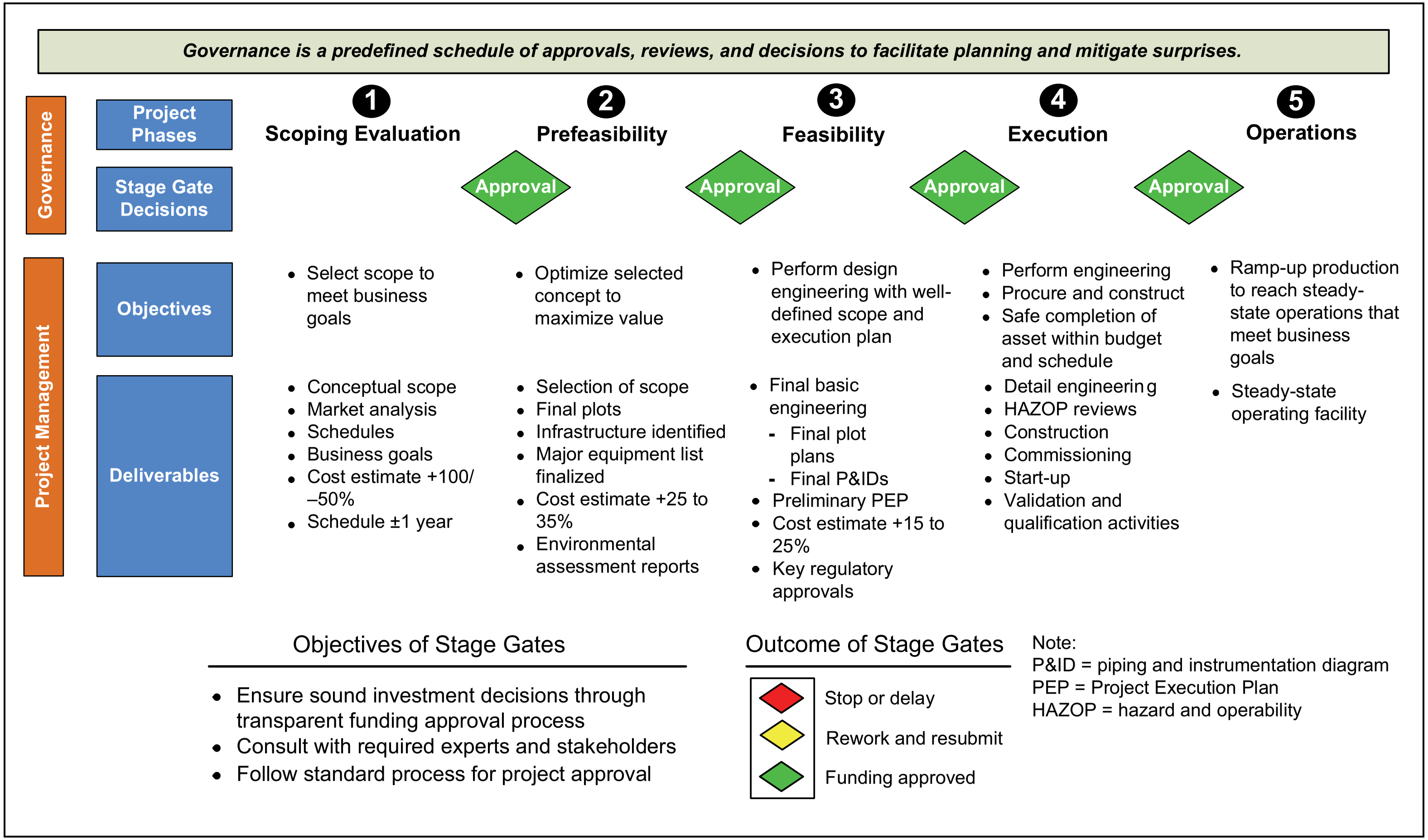


FIGURE 3.4. Governance program

- A mechanism to assess compliance of the completed project to its original objectives
- A forum for issues resolution
- A quality standard for the key governance documents and the project deliverables
- A central document repository and a centrally held glossary for the project

PROJECT GOVERNANCE ROLES

Good project management practice requires the fulfillment of a number of generic, well-defined roles that are defined at project outset. A mining company's organizational chart designates who in the organization is responsible for any particular operational activity that the company conducts; an equivalent chart is needed for project development activity.

Project Oversight Body

The project oversight body is appointed by the mining company's corporate management to provide overall direction to the project. This entity is accountable for the success of the project through the project manager. It has a certain amount of responsibility and authority for the project, set by corporate management, but it has no project decision-making power by itself. The oversight body provides leadership on culture and values, owns the business case, keeps the project aligned with the organization's strategy and portfolio direction, governs project risk, works with other sponsors, focuses on the realization of benefits, ensures continuity, and provides assurance and feedback.

It is the oversight body's duty to ensure that a coherent and supportive relationship exists between the mining company business strategy and the project goals. Typically, members of corporate management make their project investment decision based on the recommendation of this entity, supported by the business case prepared by the project manager. If the oversight body is a board rather than one person, the governance board should meet regularly, one or two times a quarter, to review progress against plan, assess risks, approve any major changes, and ensure that the project remains within specified constraints.

For the project manager, the oversight body provides timely guidance, enables trade-offs, clarifies the decision-making framework, sets business priorities and strategies, communicates business issues, provides resources when requested, engenders trust, manages relationships, supports the project manager's role, and promotes ethical working. The project oversight entity is a support resource for the project manager in engaging stakeholders and, when needed, can be the final arbitrator between conflicting stakeholders.

Project Manager

The project manager has the authority to run the project on a day-to-day basis on behalf of the company and is accountable for delivering a successful project outcome. The project manager's prime responsibility is to ensure that the project produces the required items, to the required standard of quality, and within the specified constraints of time and cost, thus delivering the benefits defined in the business case.

The project manager reports directly to an individual corporate executive within the mining company, for example, a senior VP of projects or the president of the projects group or, in smaller organizations, the CEO. The project manager does *not* report to the governance oversight body, as this would add a layer into the organizational structure and thus be a direct violation of good governance.

Project Management Team

The project management team reports to and supports the project manager by providing the functional business inputs required to manage the project on a day-to-day basis. The project management team meets regularly, either weekly or biweekly, to plan the use of resources, control risks, manage stakeholder engagement, and implement the project communication plan. Meeting highlights are reported to the project governance oversight body.

Project Stakeholders

While Principle 5, separation of project decision making and stakeholder functions, must be adhered to for governance to be effective, stakeholder issues still need attention.

Whatever stakeholder management mechanism is put in place, it will need to capture stakeholder inputs and views and address their concerns to their satisfaction. Stakeholders need to have their opinions sought and be afforded an ability to shape the project. Stakeholders will become disgruntled if the project does not consider their issues, if their concerns are not being championed, and if their needs are not being addressed.

Therefore, project stakeholders need to be engaged at a level that is commensurate with their importance to the organization, though in a manner that fosters trust.

GOVERNANCE ISSUES THAT HAVE CAUSED PROJECT PROBLEMS

1. Failure to give the project manager sufficient authority to execute necessary decisions
2. A bulky governance oversight body that is an impediment to project decision making
3. Shortcutting approval steps (gates) and pushing the project "no matter what"
4. Absence of a clear link between the project and the mining company's priorities
   - No agreed-upon measures of project success
   - Inconsistent application of business and project objectives
5. No senior management project ownership or leadership within the mining company
6. Inadequate resources and skills to deliver the project—lack of pragmatism about owner capabilities
7. Failure to account for external risks and/or overweighting of familiar risks
8. Lack of effective engagement with stakeholders

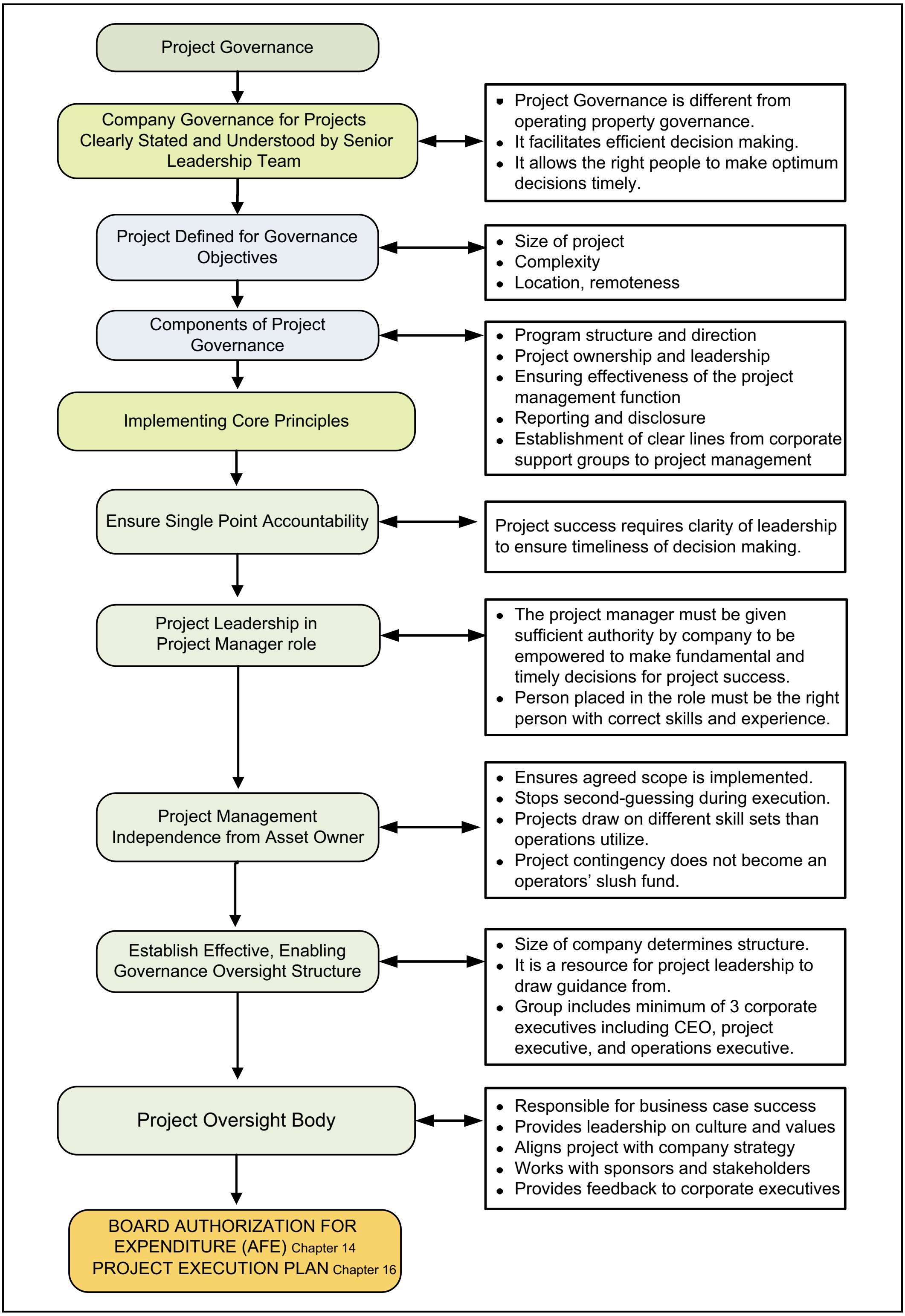
RESULTS OF GOOD GOVERNANCE

Project governance will

- Ensure that the required approvals are obtained at each appropriate stage of the project,
- Enable the project team to deliver the required outcomes,
- Ensure appropriate review of issues encountered within the project,
- Describe the proper flow of information about the project to all stakeholders,
- Provide a framework for project disclosures,
- Outline relationships between internal and external groups involved in the project,
- Foster a culture of frank internal disclosure of project information, and
- Provide access to best practices and independent advice.

CHECKLIST 3.1 GOVERNANCE

No.	Item	Status	Date	Initials
1	Project governance—established			
	A. Governance framework and process understood by owner's senior leadership team			
	B. Governance framework and process understood by the project leader			
2	Project—clearly defined			
	A. Project success measures agreed to			
3	Project governance components—developed			
	A. Project organization framework in place			
	B. Project management leadership appointed			
	C. Project ownership established			
	D. Unimpeded reporting line from project manager to executive body			
4	One point of accountability for project success—in place			
5	Levels of authority—established			
	A. Clear assignment of project roles and responsibilities			
	B. Relationships and responsibilities for support groups set			
6	Governance oversight body structure—established			
	A. Responsibility of oversight body clearly stated			
	B. Impartial monitoring process in place			
7	Project management independence from asset ownership—OK			
8	Project governance separate from owner's company governance—OK			
9	Stakeholder management separated from project decision making—OK			
	A. Process in place for stakeholder issues to be addressed			
10	Timely reporting and disclosure lines—set			
	A. An information-sharing mechanism established			
	B. Report templates developed; required content identified			
	C. An upward status and progress reporting system settled			



- Project Governance is different from operating property governance.
- It facilitates efficient decision making.
- It allows the right people to make optimum decisions timely.

- Size of project
- Complexity
- Location, remoteness

- Program structure and direction
- Project ownership and leadership
- Ensuring effectiveness of the project management function
- Reporting and disclosure
- Establishment of clear lines from corporate support groups to project management

Project success requires clarity of leadership to ensure timeliness of decision making.

- The project manager must be given sufficient authority by company to be empowered to make fundamental and timely decisions for project success.
- Person placed in the role must be the right person with correct skills and experience.

- Ensures agreed scope is implemented.
- Stops second-guessing during execution.
- Projects draw on different skill sets than operations utilize.
- Project contingency does not become an operators' slush fund.

- Size of company determines structure.
- It is a resource for project leadership to draw guidance from.
- Group includes minimum of 3 corporate executives including CEO, project executive, and operations executive.

- Responsible for business case success
- Provides leadership on culture and values
- Aligns project with company strategy
- Works with sponsors and stakeholders
- Provides feedback to corporate executives

FLOWCHART 3.1 Governance

CHAPTER 4

Scoping Evaluation

Ideas are like rabbits. You get a couple and you learn how to handle them,
and pretty soon you have a dozen. —John Steinbeck, 1902–1968

OBJECTIVE

This chapter identifies the steps that follow the identification of a potentially viable idea, and then the development of that idea into an opportunity capable of being presented to senior management within a scoping evaluation document. (This document is also known as a *scoping study* or a *conceptual study*). A scoping evaluation is a preliminary exercise or research that is meant to define the scope of a project.

The prime goal of the scoping evaluation is to make sure that the assessment includes all the major facets of the idea, as it is now a potential project, and that the format presented to management allows for either rejection or further pursuit.

THE IDEA

"Idea people" are the beginning life blood of a project; they are the true project originators. Projects stem from ideas—ideas that lead to ventures that can advance corporate goals by, for example, increasing revenue, decreasing expenditures, expanding output, enhancing company image, or improving public relations.

Ideas for potential projects to enhance a mining company's operations, either foreign or domestic, typically originate from one or more of the following:

- An exploration department
- The mining company's operations divisions
- Corporate business development personnel
- The company's executive leadership team
- The board of directors

These entities identify and nurture concepts that augment corporate goals and objectives. Mining ideas generally fall into the following categories:

- New grassroots mineral discovery
- New property, mine, deposit, or purchase acquisition

    - Projects arising from a potential sale, tender, privatization, or joint venture of a resource opportunity. In these instances, the mineral resource has generally already been largely delineated by drilling.
- Existing mine reserve addition and/or development
- Expansion, rehabilitation, or modernization of existing property
    - Includes new process systems. Typically, no new reserves are involved.
- Cost reduction or efficiency-oriented improvements
    - Includes purchase of major equipment
- Compliance mandates to satisfy new or changing regulations
- Philanthropic pursuits to enhance social acceptance and/or sustainability

The activities necessary to develop these ideas are generally controlled by the initiating entity; that is, idea nurturing typically originates from outside the project management system.

Ideas for potential projects originating from the corporate business development staff are typically new mine or new deposit acquisitions. Business opportunity development personnel would work closely with exploration and the appropriate operations division through the negotiation stages of the acquisition, but seldom would corporate business opportunity development staff play any major role after the acquisition is final.

To gain credibility, the idea has to be expanded into a formal, reviewable document. Over the years, the mining industry has found that a phased approach to determining viability, rather than a one-step evaluation process, works best. The one-step approach, with no predecessor studies, is risky from a technical and economic viewpoint. It invariably results in a suboptimal operation.

OPPORTUNITY

The opportunity stage expands the idea into a formal scoping evaluation through the collection of sufficient data, followed by analysis of such data to generate a preliminary economic evaluation. A project team is appointed to develop the Management Review Submission documents that can provide management with the tools for a decision to either proceed to the next stage or to reject and terminate any further expenditure.

It is within this opportunity stage that the potential project first becomes subject to the guidelines and constraints of the project management system. Steps to be taken during the opportunity stage include the following:

- Appointment of a team leader and selection of an appropriate support team (Typically, the likely ultimate owner of the opportunity [e.g., the pertinent operations division management], assigns the team leader.)
- Definition of the scope of work, along with the project objectives, all in writing
- Personnel assignments
- Data collection, the nature of which depends on the opportunity being assessed
- Data analysis
- Concepts development, that is, how the opportunity is to be exploited and executed
- Environmental, permitting, social, and sustainability review
- Schedule development, including a forecast of project duration and a completion date
- Capital cost estimate
- Operating cost estimate

- Personnel estimate
- Marketing analysis
- Risk evaluation
- Preliminary economic evaluation

The chain-of-activity events and their different instigators, from the idea through the opportunity stage, is illustrated in Figure 4.1.

The successful completion of the opportunity stage leads to the preparation of a Management Review Submission report and recommendation as outlined in Chapter 5. This submission would accompany an Authorization for Expenditure (AFE) form prepared in accordance with company guidelines (see Chapter 14 for details).

SCOPING EVALUATION

The scoping evaluation is the first full look at the idea and whether it makes sense. The project team initiates validation of the opportunity. Most activity relates to the collection and analysis of existing data (with the main exception being any exploration effort—where generally new data are created). Wherever data do not exist, a judgment call must be made. Thus, the caliber and experience of the personnel undertaking the scoping evaluation have to be superior.

The scoping evaluation is the first step in the project management process. It is the first critical financial analysis of the opportunity by in-house staff who will determine whether the opportunity is potentially economically viable. This initial evaluation may alternatively be called first pass, preliminary, Level 1, Stage 1, conceptual, order-of-magnitude, rough, back-of-envelope, initial guesstimate, or ballpark estimate. The evaluation results in a formal report and, if favorable, a follow-up submittal with a recommendation to senior management for further expenditure.

The level of drilling and sampling is usually sufficient to define some type of resource; however, the production, process flow diagram development, and cost estimating are based on minimal test work and engineering design, at most. Therefore, this level of study is useful for defining subsequent engineering inputs and further required studies, but it is not appropriate for project execution decision making.

The project manager or team leader has to ensure that all aspects of the opportunity are addressed before it is put before the reviewing management entity. The project manager or team leader also has to make sure that the pursuit of the opportunity does not violate any company policies or guidelines.

An extensive, intertwined list of activity functions needs to be addressed and considered when evaluating any potential opportunity. The degree and depth of evaluation for each area will depend on the nature of the opportunity being evaluated.

Purpose of Scoping Evaluation Document

The purpose of the scoping evaluation is to justify and support the rejection or pursuit of a project idea that initially appears to satisfy corporate objectives. The estimate's economic evaluation accuracy is suitable for further pursuit of the opportunity, or for project rejection, but will not be sufficiently detailed for a corporate go-ahead of construction. The estimate must include an expected final project cost even though this cost figure will be limited by the quality of the information available at the time.

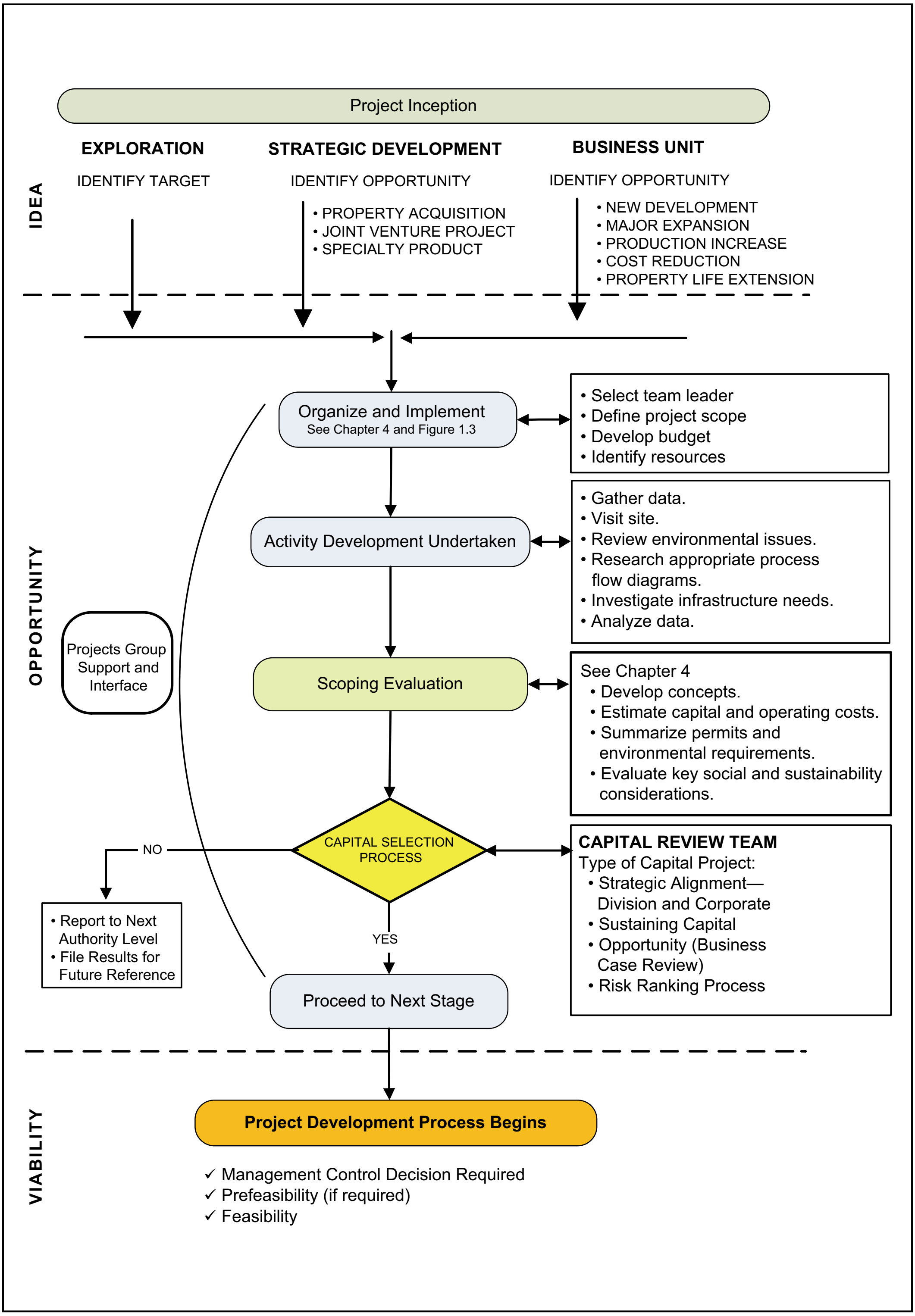


FIGURE 4.1 Opportunity activities

ACTIVITIES REQUIRED

The following sections provide an outline of the activities that need to be undertaken during the scoping evaluation to arrive at a recommendation, mostly using the example of a new grassroots metal mine to convey the context to the reader.

The typical details of a scoping evaluation's needs are listed later in Column 1 of Figure 13.1. Likely, not all of these data would need to be collected and evaluated for a smaller, brownfield project (e.g., a new water treatment plant or an underground crusher expansion).

While the terminology within this book tends to mostly use metal or coal mine examples, the procedures laid out are applicable to any mining project.

Staffing and Responsibility

The responsibility for the development of this stage of the project will normally remain with the originating company entity, for example, the owner's operations business division or the owner's corporate department. This entity selects the project team and the team leader.

The project must be led and conducted by a person with an understanding of this particular mineral industry and who possesses sufficient experience in project management. The leader assumes full responsibility and accountability for the project. Team members will be drawn from the operating units and from exploration, supplemented as needed by outsource specialists and corporate staff.

Data Collection

Data collection involves the gathering of whatever information is germane and available to the opportunity envisaged. For a plant expansion this would involve all data pertaining to the currently operating facility along with any data that can be gleaned from other similar properties. That is, the data analysis effort for a plant expansion in large part depends on benchmarking, and as such, the data collection effort should generally include at least one project site visit. This validates that the benchmarking examples chosen are appropriate.

In the case of a grassroots opportunity, a site visit by the geological staff is requisite. The visitors could also include corporate business opportunity development staff. During the site visit, the geology staff would undertake a review of existing data, maps, and any available assay data. Preliminary geological field work would likely include gathering some new data and samples to enhance assessment of the project (e.g., a preliminary coal quality analysis, spot confirmation assays, and maybe even a few widely spaced drill holes).

Other data collected during site visits include property ownership status, existing metallurgical work (if any), and information on the established infrastructure and support facilities such as water, power, and labor.

Environmental and permitting information is collected through readily available sources, for example, country reports, library search, site visit reconnaissance, and review of existing data. Typically, no field data collection is done at this stage. Social and sustainability issues require a site visit and time listening to local opinions.

A review of the existing logistics support systems and an identification of any significant obstacles to materials flow are important at this early juncture. A preliminary assessment is then made of the data gathered, and any further work necessary is identified and documented. The evaluation made at this scoping stage is essentially based on the best available data that can be obtained in the limited time available. Whenever a piece of data is not available, a judgment call must be made.

Data Analysis

The data gathered are analyzed, and a conceptual portrayal of the project is derived. The potential resource or reserve size is calculated to an inferred or indicated quality, typically using assumed physical limits for the model. Based on these assumptions, the size and quality (i.e., possible grade of the resource) can be postulated, typically via an ordinary kriging or a manual polygonal estimate. A preliminary mine plan can then be prepared and the development period estimated. Because inferred mineralization is almost always included within the resource at this stage of analysis, the resultant evaluation cannot qualify for anything more than a Preliminary Economic Assessment, within the nomenclature of Canadian National Instrument classification NI 43-101.

This mine plan will include an assumption of the cutoff grade, costs, and recoveries, and a generic choice of surface or underground mining method. If open pit, the plan will include a simple block outline of the final excavation with assumed pit slopes (typically 40° to 45°), waste dumps, and coal refuse impoundment locations. If underground, a simple general outline of the mine development is prepared. A plan for an underground metal mine would make an assumption as to stoping system, and that for a coal mine would make an assumption between longwall and room and pillar. Potential mine dewatering issues would then be identified and characterized.

Preliminary metallurgical testing to determine coal washability, sink–float parameters or order-of-magnitude recovery, or process data are occasionally undertaken at this stage, but not always. Mostly, recoveries are derived solely from the existing pertinent metallurgical information.

Concept Development

Based on the derived mine plan, a first cut at the potential plant capacity and estimated plant products is arrived at, using mostly assumed values from which a potentially viable process flow diagram can be developed and a paper production plan established, showing mine life production levels for the mine and the process plant. Normally, only known, benchmarkable processes are considered. A simple block diagram without equipment selection is made, and a site location map is drawn, giving the approximate geographic location of facilities. Any necessary support facilities are identified and their sizes estimated.

Engineering Effort for Requisite Capital Cost Accuracy

The authors' research and experience show that, today, between 1% and 5% of the total engineering and study hours are commonly undertaken within a mining project scoping study, but in general, any level of engineering effort much greater than 2% is a waste of the owner's money for the capital cost accuracy being sought at this stage.

Personnel Estimate

An estimate of the personnel required to operate, maintain, and manage the facility is made using historic factors and generic estimates. Workforce costs are based on the local labor availability combined with the mining company's own experience and knowledge.

Environmental, Permits, Social Acceptance, and Sustainability Review

The project setting is evaluated (local, regional, and country) and the data gathered (on- and off-site) are reviewed for potentially significant environmental, permit, and/or local community social acceptability constraints. The scoping evaluation is compared with the published corporate sustainable development statements to ensure that the project scope and budget are within corporate sustainability guidelines (assuming that such guidelines exist within the mining company).

The project leader should seek counsel from the environmental, permit, or community affairs experts located at the associated operating location (if such exists) and from the corporate environmental and social responsibility departments. An overview of the major environmental, permit, and social considerations, including a characterization of the potential risks, is then rendered. A conceptual plan for handling any identified environmental red-flag issues is derived. Refer to Chapter 8 for in-depth details.

Schedule Development

The project team creates a preliminary Executive Summary (Level 1) Schedule to complete the facility and produce a salable product. Typically, a simple one-page Gantt chart of the major work elements showing project start and end, broken down by calendar months, is sufficient. Refer to Chapter 10 for details of what is required, and see also the schedule example in Figure 10.1.

Capital Cost Estimate

Once the preliminary design concepts have been developed, a capital cost estimate to develop the facility into a fully operating property, including necessary infrastructure support, can be produced. This estimate will be an order-of-magnitude, top-down estimate of the project capital expenditure using throughput capacity and/or shelter volume, experience, historic factors, estimating manuals, and, of course, unit costs wherever known. Refer to Chapter 11 for a more detailed description.

Typical components of the capital estimate include direct and indirect costs for:

- General plant buildings
- On-site infrastructure and improvements
- Off-site infrastructure
- Utilities
- Equipment and furnishings
- Freight
- Spare parts and initial fills
- Unusual or special systems
- Technical support needs (surveys, geotechnical and soil investigations, hydrological studies)
- Testing costs (metallurgical, quality assurance or quality control, and construction related)
- Engineering, procurement, and construction management fees
- Specialist consultants
- Taxes and insurance

- Owner costs
- An estimate of owner preproduction expense and working capital

Contingency

A percentage contingency is typically applied. A contingency figure of 40% would not be unreasonable for a greenfield development at this early project stage, and, on occasion, 70% might even be applied for a new or remote locale, depending on the overall risk assessment. See Chapter 12 for the proper calculation and application of contingency. Escalation is usually excluded at this project stage.

Capital Cost Estimate Accuracy

Accuracy of capital cost at the scoping stage will be around ±40% (at best), but it can legitimately vary across a wider range of −50% to +100%.

Operating Cost Estimate

The team makes an order-of-magnitude estimate of the operating costs and personnel requirements using generic factors and experience, that is, top-down costs. Typically, regional power costs are used. From this, annual expenditures and costs per unit of production are derived.

Marketing Analysis

Marketability of the products needs to be discussed, though at a very high level.

Risk Assessment

A preliminary risk analysis should be performed for each of the key areas.

Typically, corporate in-house staff makes a general overview of the resource risk, country and political risks, business climate, and the engineering, environmental, personnel safety, and financeability risks. Refer to Chapter 9 for details.

Project elements that are *not* captured by the scoping evaluation must be identified and highlighted. A very preliminary fatal-flaw analysis may be prepared at this time, but at this juncture, such an analysis would not be common.

Economic Evaluation

At this point, the team must review the estimate and attempt to forecast the total project cost to the mining company through project life including the full initial capital cost under the premise that it may ultimately be given full approval for construction. An economic evaluation is prepared to broadly demonstrate viability (or lack thereof) using the owner's treasury department guidelines. This final evaluation includes an assessment of the principal economic parameters, a simple spot cash flow analysis, a preliminary pretax and post-tax internal rate of return (IRR), and a net present value (NPV), utilizing pertinent mineral prices. (Mineral prices from the latest published annual company budget will generally suffice.) Special focus must be given to the costs of the possible next stage, that is, the cost of either a prefeasibility study or a feasibility study.

Document Preparation

Generally, in-house staff produces the evaluation document, but occasionally an outside consultant does this. The document can take anywhere from 500 to 10,000 hours to produce, and costs can run from as little as $50,000 to as much as $2 million.

The document will be in the form of a report highlighting assumptions made and reasons for the recommendations presented. The basis of the estimate should be clearly stated. Firm recommendations for the next step, along with an estimate of the costs and time frame, must be given. The report must include an overall schedule showing the key milestones necessary to bring the plant into full production.

CONCLUSIONS FOR PROJECT CONTINUATION

From the information gathered and the analysis made, the team will draw a number of conclusions, which, if positive, are summarized from the scoping evaluation into a Management Review Submission report as outlined in Chapter 5. The Management Review Submission report supports the AFE form (see Chapter 14) and identifies the recommended responsible parties to control and execute the next phase of the project.

This final report and its supporting documentation, including the required AFE form, is then submitted to the appropriate management level for review, and a decision of yes (go forward) or no (rejection) is made. It is the responsibility of the approving management to notify and inform the next level of senior management about the potential future cost impacts of the decision made.

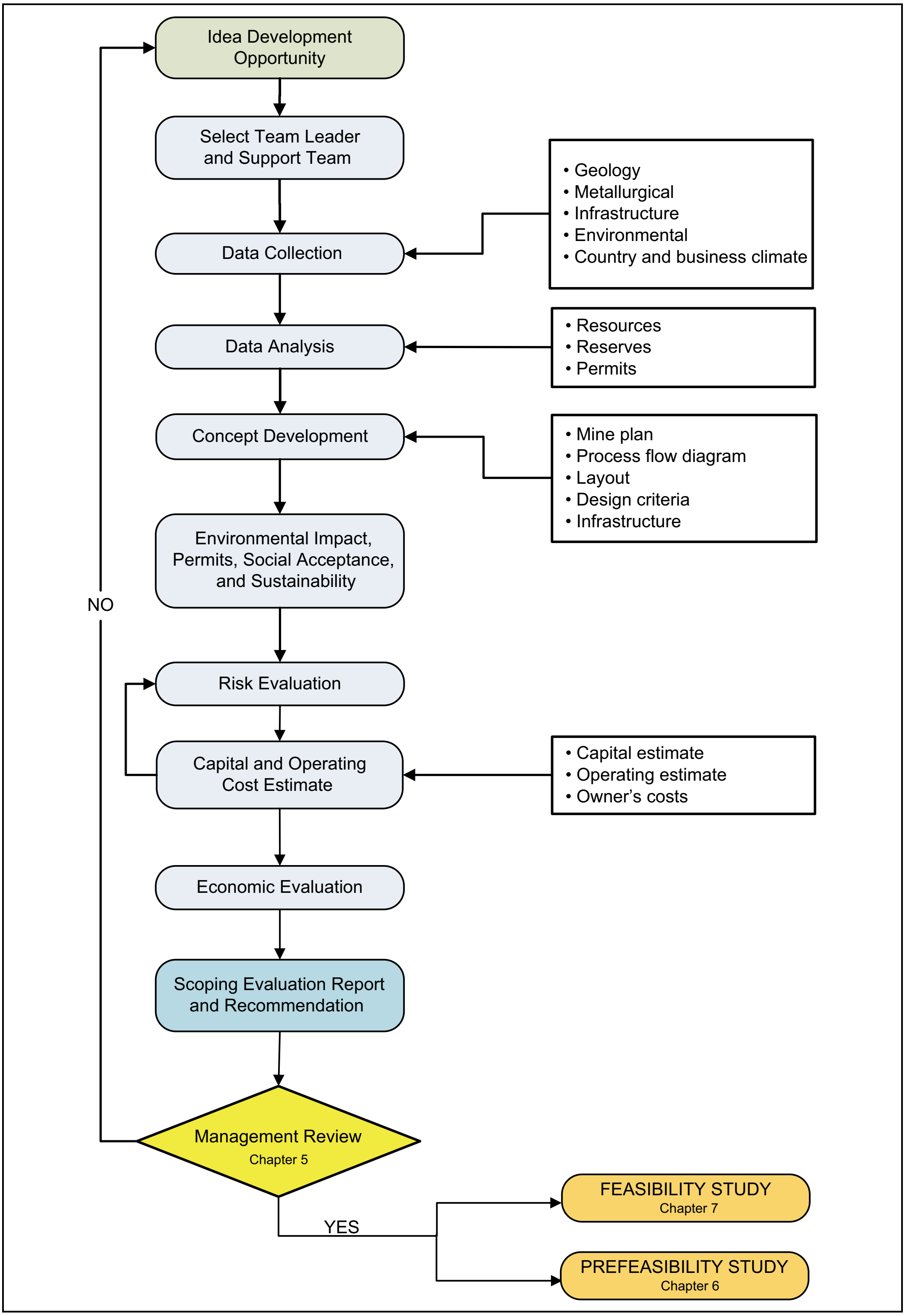
CHECKLIST 4.1 SCOPING EVALUATION

No.	Item	Status	Date	Initials
1	Value-enhancing idea—identified			
2	Idea formally characterized as an opportunity			
3	Owner consensus approval to pursue opportunity			
4	Project scope agreed upon with owner's senior management:			
	A. Critical elements of work to be completed—identified			
	B. Scoping evaluation deliverables and end result—defined			
5	Project leader—named			
6	Project team (in-house and/or outsource consultants)—identified			
7	Cost of evaluation—estimated			
8	Project property or mineral rights ownership status—determined			
9	Engineering support contractor—selected, if applicable			
10	Site visits by:			
	A. Project leader			
	B. Owner's business opportunity development person			
	C. Technical specialists, e.g., mining or metallurgical			
11	Site constraints (location, climate, topography, access, etc.)—reviewed			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
12	Exploration geology program:			
	A. Full site visit by owner's geologist—conducted			
	B. Geologic assessment and sampling—undertaken			
	C. Verification of existing data (drill holes and assays)—done			
	D. Drilling—optional, as appropriate			
	E. Geological resource—estimated			
13	Mining program:			
	A. Preliminary reserve (tons and grade)—estimated			
	B. Mining method—assigned			
	C. Production schedule for mine life—estimated			
14	Metallurgical examination—undertaken:			
	A. Existing metallurgical date—collected and analyzed			
	B. Metallurgical lab tests on collected samples—optional			
15	Engineering design:			
	A. Conceptual engineering—undertaken			
	B. Process flow diagram—derived			
	C. Design concept—outlined			
	D. Site location map—issued			
	E. Major equipment list—produced			
	F. General process description—completed			
16	Infrastructure, support services, and utilities—described			
17	Hydrology—discussion			
18	Power availability—overview			
19	Materials supply and logistics—investigated			
20	Workforce requirements and availability review—undertaken			
21	Environmental studies:			
	A. Environmental specialist—site visit made			
	B. Major environmental risks overview—conducted			
22	Permitting needs and permitting constraints—identified			
23	Social acceptance and sustainability issues—gathered			
24	Project master schedule (to a Level 1 quality)—completed			
	A. Gantt chart of major work element durations—produced			
25	Capital cost estimate (accuracy of –50% to +100%)—completed			
26	Overall operating cost estimate, by unit cost—produced			
27	Economic evaluation: estimated IRR (pretax) and NPV—produced			
28	Project risk characterization—overview			
29	Project conclusions (cf. upfront desired end result)—issued			
30	Scoping evaluation document—complete			



FLOWCHART 4.1 Scoping evaluation

CHAPTER 5

Management Review

> *A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty. — Winston Churchill, 1874–1965*

OBJECTIVE

This chapter provides guidance for project managers in bringing an opportunity to senior management for an early review and assessment as a possible potential project. The submission documents will typically be senior management's first review of the project. The primary objective of the Management Review Submission (explained in detail later in this chapter) is to formally apprise management of the project potential and to request approval for further expenditure on either a prefeasibility or feasibility study level.

The review process contemplated here is much more than a routine request for approval of an Authorization for Expenditure (AFE) for the next work stage. The review must be sufficiently comprehensive to ensure buy-in by all major stakeholders. To make the appropriate decision at this stage, presentation of the ultimate project economics, not just the cost of the next stage, is thus a requisite component of the submission documents.

STAGE GATE

The review process that takes place at this juncture (commonly known as a "stage gate") is the first of a series of approval steps that the project will have to pass through if it is to become a viable project. At each gate, the continuation of the project is decided by a senior company authority. The decision to go forward, or not, is based on the information available at the time, including the business case, risk analysis, and availability of the requisite resources (e.g., money and people with the correct competencies). This initial management review is a part of project governance, as described in Chapter 3.

The scoping evaluation outlined in Chapter 4 summarizes the results of the opportunity stage. This evaluation, along with the package of documents supporting the AFE form, provide the project information and analyses needed for the management review. The AFE requests approval for further expenditures for either a prefeasibility study (see Chapter 6) or a feasibility study (see Chapter 7). Approval or rejection of the AFE for the next logical stage of development of the project opportunity—the yes or no decision—takes place at this management review stage.

While the accuracy of the scoping evaluation is sufficient for the management authority to reject further work on the project, it is seldom enough for full acceptance of the project.

The scoping evaluation merely indicates whether further study is warranted. Thus, a positive management review decision emanating from this stage becomes, in essence, the start of the Project Execution Plan.

DOCUMENTATION

Although the project information and analyses within the scoping evaluation are only at a scoping level, the AFE and its supporting analyses for the next stage of development must still meet the requirements of all pertinent company policies. Simply filling in the AFE form should suffice to summarize the key elements of the requisite analysis expected by management. The suite of materials supporting the AFE—referred to as the Management Review Submission—augment and provide backup documentation to the AFE. At a minimum, the Management Review Submission must include the following:

- A concise summary description of the project: its location, type, size, process flow diagram, and plant capacity
- An outline of the project scope for the work going forward, along with its key objectives, and the project's potential contribution to company goals
- A preliminary schedule with milestones, showing start-up and full production dates
- Forecast production output (e.g., tons of coal per year)
- Estimated capital and unit operating costs
- The team's best professional judgment as to the project's ultimate scale and economic return, that is, a broad economic analysis giving a capital cost estimate for the total project, internal rate of return (IRR), net present value (NPV), payback, and other key performance indicators
- Reconciliation of the project's returns with corporate objectives
- Project benefits
- Conclusions of the scoping evaluation results
- List of key assumptions made in arriving at the scoping evaluation conclusions, including engineering, geological, development, marketing, scheduling, environmental, permitting, and sustainability assumptions, highlighting their overall accuracy
- Recommendations and cost of any further investigation
- Recommendation as to whether the next step should be a prefeasibility or feasibility study
- Definitive cost of the next stage and an outline of how it will be conducted (Note: Often when a prefeasibility study is warranted, the monies for both prefeasibility and feasibility studies are requested at this same time.)
- Identification of the responsible project management entity for the next stage
- Recommendation as to who the project leader should be to conduct the next study
- Suggestions for purchase terms or bid strategies (if the project is an acquisition target)
- A discussion of potentially significant risk factors associated with the project

REVIEW AND APPROVAL PROCESS

Figure 5.1 summarizes a typical mining company management review and approval process. A similar process is applicable to all subsequent management review stages during the project development.

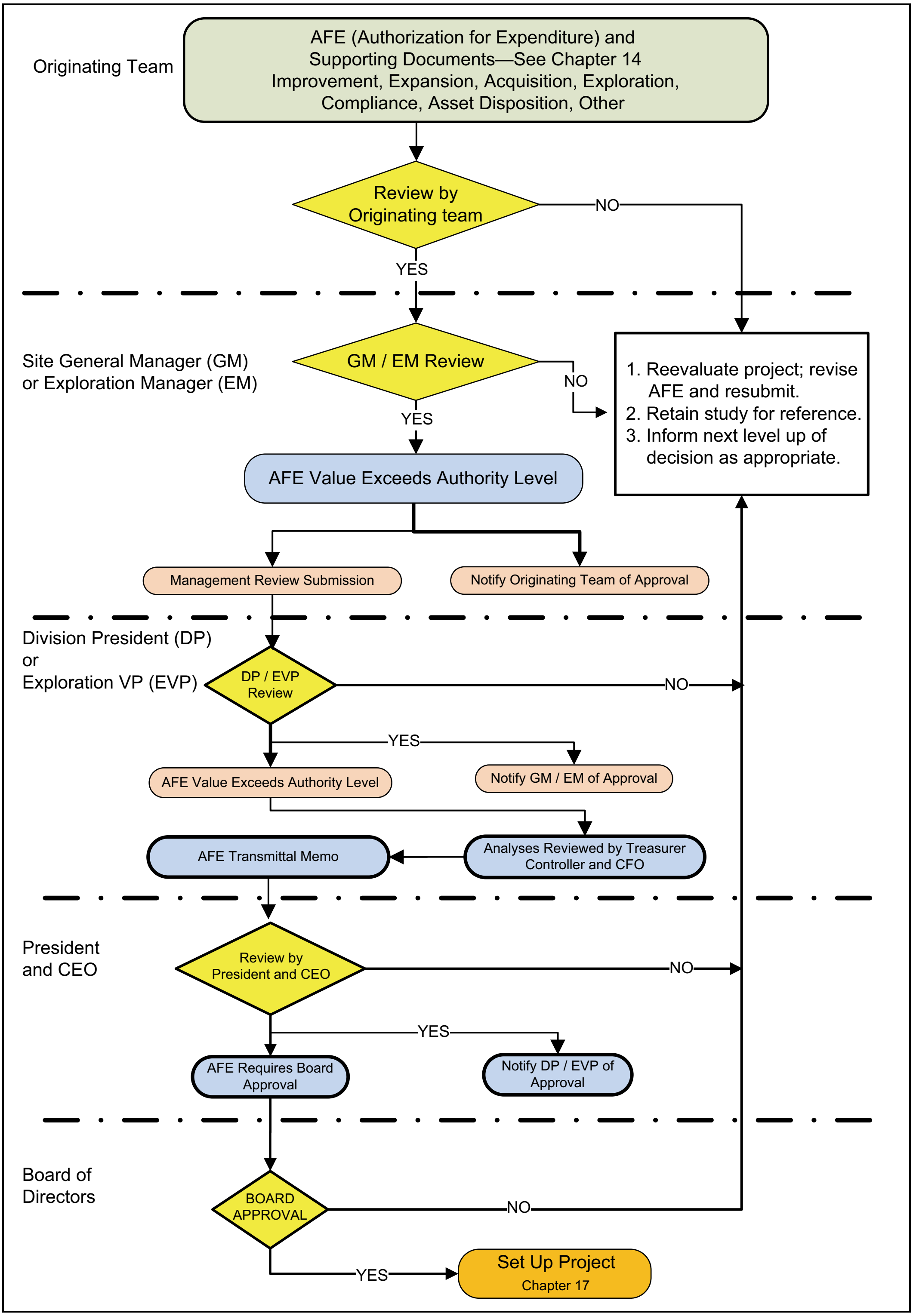


FIGURE 5.1 Project approval process

Note: This "typical" mining company AFE policy guideline would be applicable at any stage of a project's expenditures. It is included here in Chapter 5 since normally the first AFE in a project's life will be prepared at this initial management review stage.

An AFE is required for all of the following:

No.	ITEM
1	**Capital Expenditures:** Items of property, plant, or equipment that cost more than $10,000, and with a useful life of three or more years. In meeting the $10,000 requirement, a group of items should be considered one asset if it takes all items of the group to meet the required function.
2	**Intercompany Fixed Asset Transfers:** Receipt of equipment with a fair market value exceeding $10,000.
3	**Major Mine Development Programs** where expenditures are greater than $500,000.
4	**Operational Expenditures or Major Repairs** that are unusual or nonrecurring in excess of $250,000. Examples requiring an AFE are plugging and abandoning wells, drilling gob vent holes, subsidence, moving gas lines, etc.
5	**Exploration Expenditures:** Search for geologic reserves, evaluation, and the predevelopment phases for such deposits over $150,000.
6	**Environmental Expenditures:** Reclamation and remediation expenditures in excess of $150,000.

Supplemental AFEs are required if an overrun of 10% is expected, or when a significant change in scope from the original approval is made. The supplemental AFE should be approved in writing before further work commences.

The AFE submission requires an assessment of alternatives and risk and an economic analysis for all decisions with financial consequences in excess of $150,000. For expenditures under $150,000, no economic analysis is required but an assessment of risk is still required.

All analyses for projects exceeding the authority of Operations division management are to be reviewed by the Treasurer, Controller, and CFO. The project value, which determines the appropriate review and approval level, is determined by the purchase or sale price, including any assumed debt, plus working capital investment (or the total value of expenses for a contract.)

FIGURE 5.2 Typical mining company AFE preparation guidelines

The project manager has to be familiar with company policies and guidelines pertaining to AFE capital expenditure preparation and analysis and must ensure that all requirements are met. Normally, AFE documents are issued (and monitored) by the mining company's corporate treasury department.

The guideline procedure that outlines the types of expenditures requiring AFEs and lays out the requisite level of management of approval for a particular expenditure level is typically issued by the mining company controller department (see Figure 5.2). The company controller's guidance should be sought to ensure process conformance. The treasury department should be called on for assistance with any economic analysis questions and to provide input regarding economic assumptions and business issues.

While the AFE amount requested at this stage may be relatively small, reflecting only the costs of a prefeasibility or feasibility study, management's review of the AFE must be done with an understanding of the potential project's ultimate scope and economics. It is the responsibility of the executive approving the AFE to advise or to seek higher-level senior counsel for those projects where the AFE indicates that further development is likely to involve expenditures that will require higher level and/or board approval.

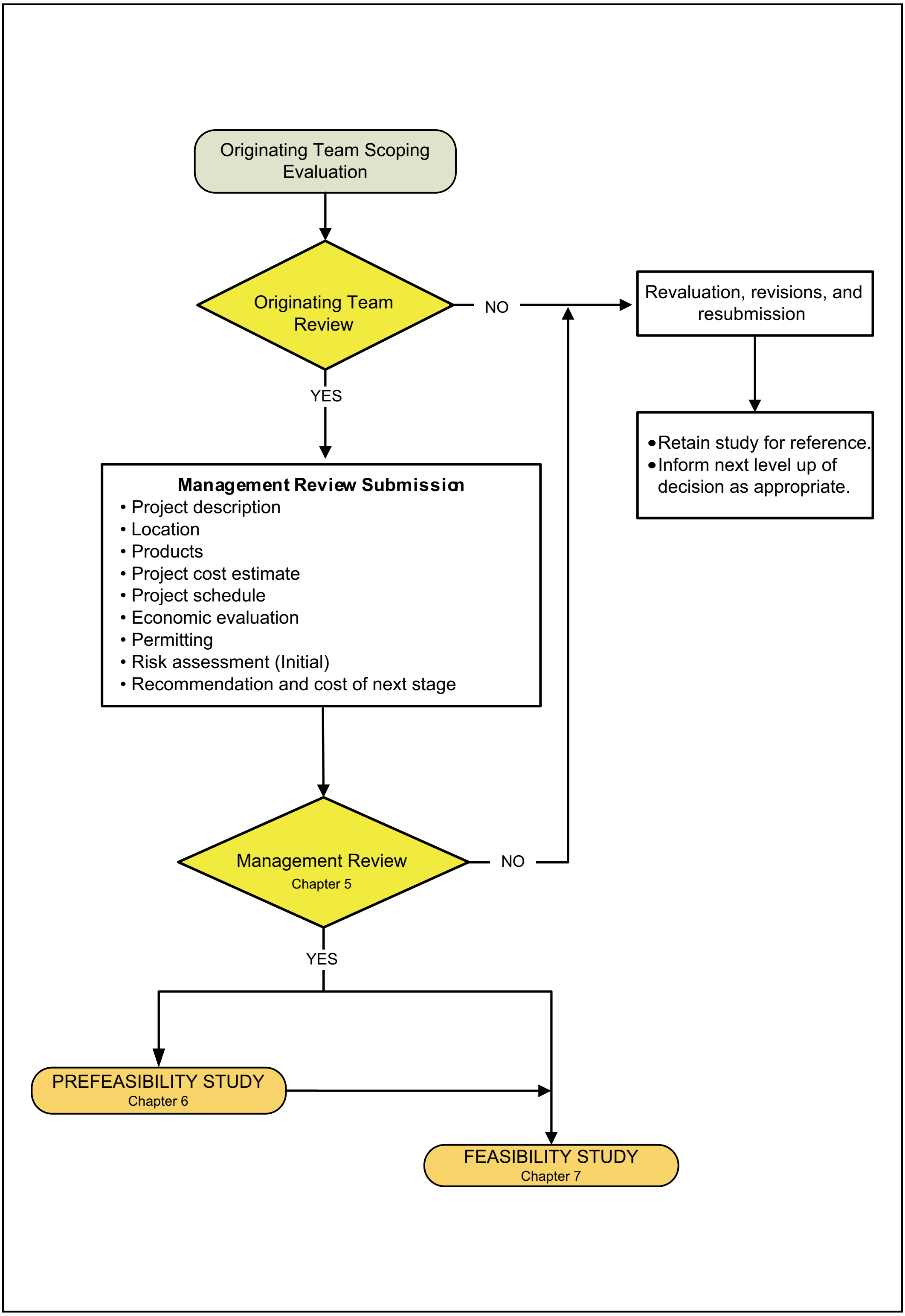
RESULT OF REVIEW

The outcome of the management review would be one or more of the following:

- Approval of the AFE for the study recommended by the originating team
- Approval of the AFE with limiting conditions
- Deferral of AFE pending additional information or analyses
- Rejection of any further evaluation or expenditure

CHECKLIST 5.1 MANAGEMENT REVIEW

No.	Item	Status	Date	Initials
1	Scoping evaluation analysis—complete			
2	Owner's organization review level—determined			
3	Owner's Management Review Submission—prepared			
	A. Concise project description—completed			
	B. Project scope of work, going forward—outlined			
	C. Development schedule—estimated			
	D. Project capital cost—estimated			
	E. Project economics (pretax IRR and NPV)—derived			
	F. Future operations production and unit costs—estimated			
	G. Key assumptions—documented			
	H. Significant risks—identified			
	I. Scoping study conclusions—summarized			
	J. Reconciliation of project benefits and deliverables with owner's corporate objectives—produced			
4	Recommendation for prefeasibility or feasibility study—determined			
5	Recommendation for project management of next stage—resolved			
6	AFE for prefeasibility or feasibility study—prepared			
	A. AFE guidelines review—undertaken			
	B. AFE form—prepared and signed			



FLOWCHART 5.1 Management review

Viability Stage

CHAPTER 6

Prefeasibility Study

The value of an idea lies in the using of it. — *Thomas Edison, 1847–1931*

OBJECTIVE

The primary objective of the prefeasibility study is to broadly quantify, for the first time within a formal structure, the proposed project's real contribution to the corporate goals. The project team undertakes a prefeasibility study to evaluate the project such that a determination can be made as to whether there is justification to go to a full feasibility study.

The prefeasibility study should further ensure that the proposed project is the best alternative for the opportunity being considered, and if a brownfield project, that it can be practically integrated into existing operations. Thus, one of the main functions of this study is to undertake all possible value engineering trade-offs regarding the different options that can be sensibly postulated for achieving project ends. The goal is that by the time the project embarks on the feasibility stage, one "best" path to project success has been established.

SCOPE

The prefeasibility study is the first truly comprehensive evaluation of the project, and it is undertaken whenever too much uncertainty remains from the opportunity stage evaluation to justify going immediately to a full feasibility study. This stage is thus optional, a step on the way to a feasibility study. To embark on a prefeasibility study, however, there has to be a belief that the project has a chance of fulfilling corporate objectives.

The prefeasibility study expands on the conceptual installation derived during the scoping evaluation. This second-stage evaluation may alternatively be called a Level 2, Stage 2, intermediate, or indicative estimate.

All areas of the project are identified within the prefeasibility study. Sufficient backup data are gathered, including specific costs, to enable a comprehensive risk evaluation to be made.

Generally, a prefeasibility study requires using some specialist outside consultants working under and/or with an outsource engineering company or an engineering, procurement, and construction management (EPCM) company.

Because of the lower accuracy of its capital cost estimate (as compared to a feasibility study), the prefeasibility study will not have "bankable" quality results.

Purpose of Prefeasibility Study Document

The prefeasibility study describes a conceptual installation that could be realistically built. The study demonstrates probable economic viability and provides the framework to allow a follow-up, definitive feasibility study to be put together.

One of the key purposes of the prefeasibility study is to avoid getting to the feasibility stage with a nonoptimized design. Once the project is in the feasibility phase and a 100-person engineering group has been mobilized, most aspects of the project direction have been set, and the project disciplines are all moving at a similar pace with very little opportunity to stop and examine the interrelated operating variables. Any attempt to make last-minute optimizations within the feasibility study is generally done with less than adequate engineering and below par estimation accuracies, all of which lead to errors and negative ripple effects to schedule, permit acquisition, and cost. (Late facility design changes and postpermit document submittals generally require permit amendments, which inevitably stretches out the permitting process.)

The way to avoid such feasibility maladies is to perform all the optimization work within the lighter-staffed prefeasibility phase, so that these possibilities disappear by the time to prepare the feasibility study. The prefeasibility phase is the time to find the best path among alternatives and discern (and eliminate) fatal flaws.

ACTIVITIES REQUIRED

The activities undertaken during the prefeasibility study are similar to those executed during the scoping evaluation. However, a broader degree of detail is studied, more definition of the project and its associated costs are made, more specialist people are involved, and greater use is made of the accumulated experience of the Owner's internal expertise and technical knowledge within its existing working operations. The project elements not addressed (or those that were finessed) in the scoping evaluation study are examined within the prefeasibility study.

In executing the prefeasibility activities, the appointed project manager or leader and the team typically use the experiences of both the Owner's staff *and* an outsourced EPCM contractor.

Project Management

The appointed project management leadership must have the estimating skills and relevant minerals industry knowledge to fully comprehend all the issues that can arise within a particular project. The team leader should be someone from inside the mining company or, if from the outside, then placed on the mining company's payroll, as this leader must be fully conversant with corporate objectives. The team leader must be versatile enough to determine which work should be performed in-house and which by outsourced contractors.

Links to operations personnel are maintained throughout the prefeasibility study to ensure that their viewpoints are represented and that operations buy-in is secured for critical concepts.

Data Collection

For a grassroots project, data collection will include two or three site visits by company technical and business team specialists. Site visits by outsourced experts are typically part of the activities at this stage. During these site visits, the project team undertakes a preliminary review of the country, the prevailing business climate, environmental issues, and permitting requirements.

The geological team will locate to the site to review existing data and maps, initiate creation of its own geologic maps and cross sections, set out test pits, and undertake geophysical and geotechnical sampling. The geological team will set up drill-hole grid patterns on moderate spacings for open-pit projects and start infill drilling of any existing widely spaced drilling. For underground operations, drilling is generally optional (and typically only conducted if access preexists).

The geological team performs check assays of existing cores and verifies existing drill-hole data (via the use of twin holes, surveys, etc.). Preliminary mineralogical sampling and analysis are performed, metallurgical mapping begun, and a preliminary mineralogical study commenced. Coal quality analyses and coal washability tests are initiated.

Other data collected during the site visit include information related to any existing metallurgical work and details on the established infrastructure and support facilities such as water, power, and labor. Environmental conditions are derived from a review of existing data, library search, and on-site evaluations.

Data Analysis

The project team then analyze the data gathered. The indicated geologic resource is established and should now have been delineated sufficiently to reasonably estimate the tonnage and grade, though not necessarily to a full U.S. Securities and Exchange Commission form 10-K filing report proven and probable level or to a Canadian National Instrument classification NI 43-101 requirement quality. Physical limits are established from the geological data and/or variograms. A block model of the resource is produced by the project team (or more typically by a specialist hired by the team). Based on the depth, size, and grade of the resource, a decision between surface and underground is made, and a preliminary mining plan developed.

The mine plan will include a calculation of cutoff grade from preliminary, assigned floating cone parameters. This plan will also include incremental pit pushbacks, along with detailed outlines of the final pit, waste dumps, and coal refuse impoundments if a surface facility or a basic outline of the mine development if underground.

For a surface mine operation, software such as Gemcom Whittle can take the geologic block model—in conjunction with economic, metallurgical, surface topography, and geotechnical criteria—to create a series of economic pit shells that will provide the basis for design and production scheduling. Preliminary pit slopes would be set by geotechnical information and/or rock type, but haul roads would be factored rather than designed at this stage.

For underground metal mines, a specific stoping system would be laid out. For underground coal, a decision between longwall and room-and-pillar mining would be made, and basic designs for ventilation, roof control, and secondary mining would be created.

Concept Development

Bench-scale metallurgical and coal-washability laboratory testing on representative mineral samples are sanctioned by the project team (usually at an outsource specialist facility) in order to yield estimates on plant capacity and plant products. The test work is taken to an advanced stage to prove the chemistry and provide preliminary recoveries and processing parameters from which a process flow diagram can be developed. Product output is established for the mine life (e.g., concentrate, coal tons, metal sales).

Annual ore and waste tonnages, grade, production, and strip ratios are then derived, and a mine-life production schedule is produced from these resource and reserve figures.

Preliminary engineering is initiated by the project team's engineer (usually an outsourced EPCM company). The major drawings for preliminary definition of scope are created, the general design basis is outlined, and design criteria are formulated for the facility to be constructed. Technology choices are evaluated. All major value engineering trade-off studies are completed at this stage.

Main elements of the mass balance, the approximate heat and material balances, along with a list of the major equipment and the major instruments and valves are prepared and shown on the key process flow diagrams. Design criteria use known measured site climatic conditions.

Waste dumps and coal refuse impoundments are designed to match the mine life production tonnage.

Preliminary topographical maps are produced, typically 1:10,000 scale with 10-m contour intervals. A site location map and simple general arrangement drawings of the major equipment are completed. Some location optimization may be done.

The property ownership position and land status issues are determined. Any pertinent mineral rights, access easements, and property encumbrances are identified.

A preliminary hydrological study is undertaken, identifying likely water sources and estimating mine dewatering needs, if any.

A preliminary geotechnical and soils study is initiated (typically by outsourced specialists), providing potential pit slopes, anticipated soil conditions, and foundation types. From these studies and reports, preliminary quantities and typical drawings are produced for the civil works.

A brief description of the main plant items and the preliminary equipment sizing is prepared. Piping and instrumentation diagrams and electrical one-line drawings are prepared.

The main infrastructure facilities necessary to support the project are identified, listed, and sized. Studies are initiated for their design, location, and cost (e.g., the logistics system, warehousing, roads, rail, water, power, camp, communications).

Value Engineering Trade-Off Studies

During the prefeasibility stages of engineering, process and design concepts are constantly examined and dissected. Multiple-value engineering trade-off studies are used to eliminate as many of the major alternatives as possible within the project scope. The objective is to identify the optimal, cost-effective path for achieving the desired project outcome. Examples of major value engineering studies conducted at the prefeasibility stage could include the following:

- Throughput of 5,000 tons per day versus 10,000 tons per day
- Block cave versus sublevel cave mining methods
- Semi-autogenous grinding (SAG) mills versus roll crushers
- Tailings dam location 1 versus tailings dam location 2
- Pipeline concentrates transport versus truck transport versus rail transport
- Site-generated power versus grid-supplied power

The project manager must guide the prefeasibility work effort to ensure that only truly viable engineering solutions are investigated. Examining unrealistic alternatives serves no purpose.

Theoretically, all of the realistic key alternatives are scrutinized in the prefeasibility stage, and then the one best path is studied in detail in the feasibility stage. In practice, a few alternatives generally emerge during the feasibility study, but the goal is for these options to be only lesser consequence optimizations (e.g., vent shaft locale 1 vs. vent shaft locale 2, or two 36-ft-diameter SAG mills vs. one 40-ft-diameter mill).

Engineering Effort for Requisite Capital Cost Accuracy

Between 5% and 12% of the engineering and study hours are typically completed within the prefeasibility study; 7% is a good target. Any level of engineering effort greater than 10% is mostly a waste of the Owner's money for the overall accuracy being sought at this stage.

Personnel Estimate

A preliminary estimate of the personnel required to construct the facility is produced. Similarly, an estimate of the personnel required to operate, maintain, and manage the operating plant is made for each department. The potential sources of labor are identified.

Workforce costs are derived from known construction labor rates in the region and from nearby, similarly sized operating facilities.

An organization chart for the necessary project management team is derived.

Environmental and Permits Assessment

The general nature, scope, and schedule of environmental and/or other potential permitting requirements are evaluated. Available environmental data related to the project are obtained from existing sources, country reports, and site visits. The scope and level of environmental work undertaken at this stage are equivalent to what is conventionally referred to as a Phase I, Environmental Due Diligence, for equity acquisitions.

"Red flag" environmental or permitting issues are investigated and preliminarily evaluated. For example, is the project located in or near areas of environmental concern such as national parks, preserves, designated scenic areas, sensitive rivers, or lakes? Are biologically sensitive species present on-site?

Major project design and infrastructure considerations that may be influenced by environmental or permitting constraints are identified. For example, will tailings sites need to use unconventional liners? Is the waste rock or tailings acid generating?

Baseline ecological field studies and permitting processes with long lead times are started wherever development timing is critical, and where resolution of environmental issues is vital to eventual project success. Conceptual reclamation plans, sediment and erosion control plans, and geotechnical stability reviews are drafted.

A preliminary environmental management plan is prepared. This plan encompasses all of the ecological issues and has the framework for an environmental monitoring program. A preliminary evaluation of the project's impact on the environment is compiled, along with a realistic assessment of the political and public issues. The plan includes preliminary ideas for the management of the identified red-flag issues, as well as a generic listing of the environmental and other necessary permits, supported by a broad summary characterization of the project's environmental and permitting risks. A permit acquisition timetable is developed. If applicable, a draft environmental assessment, environmental impact statement, or environmental and social impact assessment, as appropriate for the jurisdiction, would be initiated at this stage.

The project manager should obtain environmental support and counsel from the environmental or permitting expertise located at the associated operating location (if such exists), supplemented by wisdom from within the mining company's corporate environmental affairs department. This will help to ensure that engineering designs stay compatible with permit requirements.

Through these in-house consultation steps, resources can be made available to the prefeasibility team for the purpose of managing consultants and/or outside counsel in developing the appropriate level of prefeasibility effort for the environmental or permitting evaluations. (Refer to Chapter 8 for a more detailed description.)

Social Acceptance and Sustainability Review

The local community perceptions as well as the broader stakeholder opinions of the legitimacy and credibility of the proposed project are evaluated, along with an assessment of the presence or absence of trust regarding the mining company.

Available data related to the project community and any indigenous cultures are obtained from existing sources and from site visits. At the prefeasibility stage this typically includes the following:

- Literature reviews
- Focus group interviews
- Cultural heritage research
- Stakeholder impact analysis

An overview social impact assessment for the predicted life cycle of the project is produced, listing the likely direct and indirect impacts (positive and negative) to the community. The social impacts could be real (increased demands on local schools) or perceived (elimination of a local wildlife species). The major social risks—that is, potential impacts on the community or, conversely, on the project by the community—are also identified.

Red-flag social issues are investigated and preliminarily evaluated. For example, will an existing village have to be relocated? Will an in-situ leach pose a risk to groundwater presently being used by local ranchers and towns?

The main project design and infrastructure considerations that will need to be influenced by social or sustainability constraints are identified. For example, will there be a large influx of temporary construction workers imposing strains on existing community resources? Will a block cave underground mine project create surface subsidence?

A preliminary social management plan is derived. This plan summarizes the findings of the preliminary impact assessment and outlines the measures that will likely enhance positive impacts and avoid, mitigate, or offset the negative impacts. An estimate of the timing, frequency, and duration of the management measures is a key component of this plan, including, in particular, the preliminary strategy for management of the identified red-flag issues.

The prefeasibility study is reviewed from a sustainability viewpoint to ensure that the project will be undertaken in such a way that project activities and the products produced together can demonstrate a net positive contribution to human and ecosystem well-being.

The project leader should obtain support and counsel from any community outreach expertise located at the associated operating location (if such exists) and/or located within the mining company's corporate social responsibility departments. This helps make certain that preliminary engineering designs stay compatible with social acceptance requirements.

The Owner's corporate departments will likely be a good source for locating the specialist consultants and/or outside counsel resources to develop the quality and accuracy necessary in the prefeasibility level social management plan.

Schedule Development

A master schedule is prepared for the project (Level 2, Management Summary), including an outline of the engineering tasks and a Gantt bar chart of the overall major component time frames (permitting, construction, start-up, etc.). This Level 2 schedule, showing just the key milestones and the major activities, suffices for a prefeasibility study. (Refer to Chapter 10 for a more detailed description of a Level 2 schedule.)

Capital Cost Estimate

Once the design concepts have been developed, a capital cost estimate of the facility must be produced. The estimate is in some part top-down, for example, prepared by probable unit cost or spread, including installation. However, the estimate needs to be more refined than the scoping evaluation. Hence the key cost elements are derived from the bottom up and are task based, and a minimum of one letter quote is required for all major equipment. (Refer to Chapter 11 for a more detailed description.) Sustaining capital is similarly estimated.

The Owner's cost is estimated from both factoring similar projects and some bottom-up estimating for the key items. A site visit by the Owner's estimator typically needs to be made to ensure that appropriate benchmarks are chosen for the top-down portions. The Owner's cost is the most frequent source of project cost underestimation, generally due to complete omission of many requisite items. Thus the project manager needs to pay special attention to ensuring that *all* of the elements of the Owner's cost are included within the study.

Civil, structural, piping, and mechanical costs use partial takeoffs from the drawings that are available, but the remaining costs in these disciplines are factored. Electrical and instrumentation costs are mostly factored following the instrumentation philosophy outlined in the design criteria. The key major items should use takeoffs, however.

Material pricing uses mostly the engineer's internal pricing data bank, but key items come from new supplier quotes. All items with long lead times are identified. Material volumes and amounts are mostly factored, with takeoffs only on major items. Bulk commodities are estimated from the general arrangement drawings. Labor rates and productivity are taken from available pertinent data.

Environmental compliance costs and working capital are estimated using experience factors from similar operations or projects. Construction indirect costs, contractor overhead, profit, and the like, are factored. Future feasibility study costs and future engineering are quantified by a firm quote.

Contingency

A broad evaluation of the contingency is made in the prefeasibility phase. For the level of effort expended and the degree of risk remaining, contingency, while still heavy, should now be within a range from 15% to 30%, generally around 22%. Remember, many items are still stochastic estimates. (See Chapter 12 for a more detailed discussion on applying contingency.)

Escalation, if included, is usually applied as a percentage per year to midpoint using the latest internal company budget forecast amount from the Owner.

Capital Cost Estimate Accuracy

An overall capital cost accuracy of ±25% is expected from a prefeasibility study, though anywhere in a range from −30% to +40% would be acceptable.

Operating Cost Estimate

Operating quantities for the project are estimated, and operating costs are arrived at by using one or more of the following sources:

- Approximate labor, fuel, power, reagent, and liner costs
- Local or past experience
- Benchmarking of similar projects
- Factoring from estimating manuals

These are a mix of bottom-up and top-down procedures.

Maintenance costs are estimated as a percentage, for example, on initial cost of machinery or from handbooks and tables. Annual expenditures are broken down by work area and shown in total dollars and unit costs, that is, per ore ton or per unit of material produced.

Marketing Analysis

The market size is studied and the likely demand for the project's product output estimated.

Risk Assessment

A reasonable risk analysis can now be prepared of each of the areas, using the actual data collected and the assumptions made. This risk analysis contemplates what can go wrong if the project does or does not go ahead. The list of risk elements requiring evaluation for the Authorization for Expenditure is the starting point for the risk assessment. A typical list would likely include the following among other items:

- Constructability
- Installation cost
- Future operational constraints
- Deposit geology and/or resource estimation
- Engineering and technology
- Environmental, permitting, social, and sustainability requirements
- Market
- Political, country, or business climate
- Financeability, taxes, and foreign currency

The analysis of the resource and engineering risk is made based on the work performed and the data available. A preliminary fatal-flaw analysis is occasionally included in the engineering component of the prefeasibility study.

Overviews of the country and local political risks, including the business climate; technology, construction, and future operations; legal, permitting, and environmental requirements;

and taxes and financeability are made using in-house judgment and/or outside expertise. A list of the areas to review for a country risk analysis is shown later in Figure 9.2.

The risk assessed to each line item of the project forms the basis of the contingency assigned to the project cost, which in turn is a reflection of the overall risk to the project. (Refer to Chapter 9 for a more detailed discussion of project risk.)

Economic Evaluation

At this point, the team must review the estimate and forecast the total return from the project on the premise that it could ultimately be approved for construction. This is why it is so important for the prefeasibility study to be accurate enough to yield reasonably reliable results.

An economic evaluation is prepared by the project manager and the Owner's financial specialists working together, using guidelines typically provided by the Owner's treasury department. The evaluation encompasses an assessment of the principal economic parameters, including reserves, mining and processing rates, metal recoveries, development period, mine life, infrastructure needs, and capital and operating cost estimates.

Mineral prices are obtained from the Owner's latest forecast, and a preliminary currency risk assessment is made. The Owner's treasury department is normally the source for estimates of the likely financing fees, insurance, and interest payments that will be incurred during construction. These all need to be added into the overall project capital figure.

A cash flow analysis is then prepared by financial specialists. Unit cash costs and full costs are developed. A pretax internal rate of return (IRR) and net present value (NPV) at the appropriate Owner discount (hurdle) rate are derived, plus some selected sensitivity analyses are produced.

A comprehensive list of the assumptions made must be provided with the analyses. The prefeasibility study will contain substantial contingencies and still describes a conceptual plant that *may* be built rather than one that *will* definitely be built. It is illustrative only and seldom provides sufficient information for final design. Special focus must be given to the costs of the possible next stage, that is, the cost of a feasibility study.

Document Preparation

An outside EPCM firm commonly coordinates and puts together the prefeasibility study document. The EPCM is generally selected via a formal request for proposal and interview process (as described in Chapter 19). A best practice for choosing an EPCM firm is by using a special bidder-selection form (shown later in Figure 19.3). The prefeasibility document will be in the form of a report highlighting the assumptions made and the reasons for the recommendations presented.

The components of a typical prefeasibility study are essentially similar to that of a feasibility study, just in less detail. Thus Figure 7.1 can be used as a reference for what data need to be included within the prefeasibility study.

Clear recommendations for the next step, along with an estimate of the costs and time frame, must be given. The basis of the estimate has to be clearly stated. An outline framework of the project execution process and its accompanying quality management and project control programs should be included. The report must have an overall schedule showing the key milestones necessary to bring the plant into full production. This should be a Management Summary (Level 2) Schedule.

Depending hugely on scope, the prefeasibility study will require from 5,000 to 120,000 labor hours to produce and can cost between $400,000 and $20 million to complete.

CONCLUSION FOR PROJECT CONTINUATION

From the information gathered in the final prefeasibility study report and its supporting documentation, the project team produces a conclusion regarding the project's continuing viability. If the conclusion is positive, the team will summarize it into a Management Review Submission report, similar to that submitted for the scoping evaluation.

The Management Review Submission report allows an AFE form reconciling the project's returns with corporate objectives and supporting documentation to be submitted to the appropriate management level for review. A decision of yes (go forward) or no (do not go forward—not feasible at this time) is then made by the pertinent level of the Owner's senior management.

The supporting documentation to the prefeasibility study is an expansion of the Management Review Submission described in Chapter 5. It contains more detail now that more information is available, but the basic headings remain the same.

If the potential project is deemed to show adequate promise, the prefeasibility study submission will motivate further investigation, that is, a feasibility study. It is the responsibility of the approving management to notify and inform the next level of senior management about the possible future cost impacts of the decision on whether to continue or not.

An additional consideration at this prefeasibility stage is an accompanying recommendation to commence long lead-time environmental field studies and permitting processes wherever development timing is critical, and/or if early resolution of environmental issues is deemed important to project success.

LEVEL OF EFFORT FOR PREFEASIBILITY STUDY

For reference and guidance, a detailed listing of the typical degree of effort required for the prefeasibility study is shown later in Column 2 of Figure 13.1.

While a project prefeasibility study for a mining company is commonly conducted by an outsourced consulting engineering firm, for example, an EPCM firm, it could be undertaken in-house with outside specialist assistance where appropriate. Either way, it needs to contain the same details as an outsourced report would have.

CHECKLIST 6.1 PREFEASIBILITY STUDY

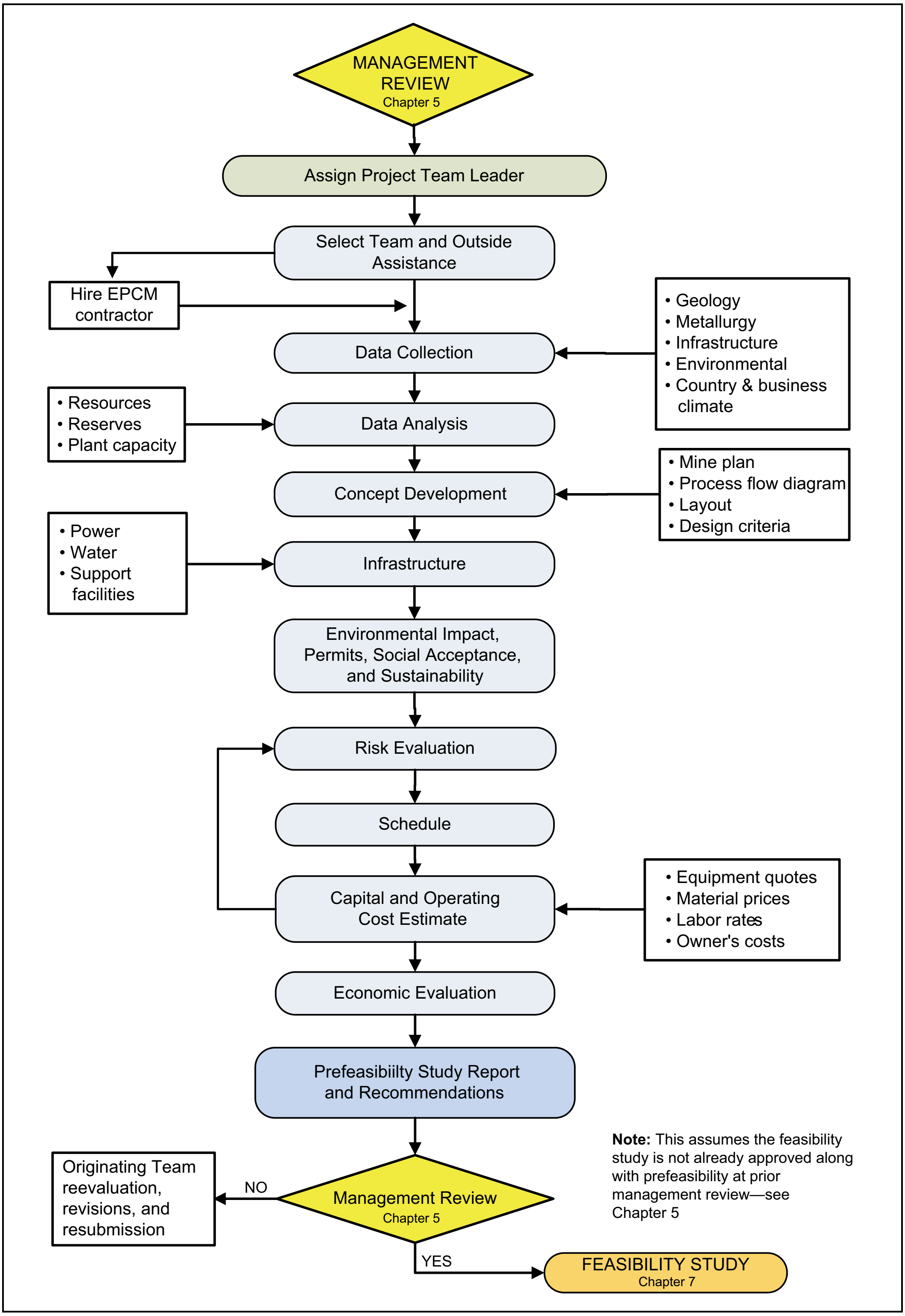
No.	Item	Status	Date	Initials
1	Completed scoping evaluation from opportunity stage—in hand			
2	Management approval to proceed (per Chapter 5)—authorized			
3	Scope of work for prefeasibility—set and agreed upon with Owner			
4	Project manager named and project team identified			
5	Mineral rights—secured			
6	Engineering/EPCM contractor support to project team—selected			
7	Site visits by:			
	A. Project leader or engineering/EPCM contractor			
	B. Owner's business development, purchasing, HR, and operations leadership			
	C. Key technical specialists—for example, geotechnical and hydrology			
8	Site constraints (location, climate, topography, access etc.)—identified			
9	Exploration geology program:			
	A. Mapping and sampling by on-site geologist—undertaken			
	B. Reliability of existing data (drill-hole coordinates, etc.)—OK			
	C. Check assays of existing core—complete			
	D. Confirmatory select drilling—undertaken			
	E. Mineralogical examination—conducted			
10	Geological resource (indicated or better)—calculated			
11	Preliminary reserve estimate (tons/grade) to NI 43-101 PEA quality			
12	Mining program:			
	A. Geotechnical interpretation—undertaken			
	B. Mining method—selected			
	C. Preliminary mine plan—prepared			
	D. Production schedule (annual and mine life)—prepared			
13	Metallurgical examination—undertaken:			
	A. Ore characterization tests (hardness, abrasion, etc.)			
	B. Bench-scale lab tests on collected samples or new core			
	C. Float, grind, bottle, and/or column tests as appropriate			
14	Probable mineral process flow diagram—developed			
15	Engineering design:			
	A. Preliminary soils and geotechnical investigation—complete			
	B. Basic engineering—initiated			
	C. Value engineering trade-offs—mostly complete			
	D. Overall engineering >5% complete			
	E. Design criteria—outlined			
	F. Site location map, plot plan, and simple general arrangement drawings—produced			
	G. Major equipment sizes and specifications—listed			
	H. Process description—narrative developed			
16	Infrastructure, support services, and/or utilities—needs identified			
17	Hydrology study—undertaken			
	A. Water supply—located			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
18	Communications—investigation completed			
19	Power availability—review undertaken			
20	Access and transport (roads, rail, port, air)—review undertaken			
21	Materials management:			
	A. Sourcing, logistics, and warehouse options—reviewed			
	B. Key long lead-time items—identified			
22	Workforce requirements—estimated			
23	Environmental studies:			
	A. Environmental specialist—site visit made			
	B. Baseline data gathering—initiated			
	C. Red-flag issues—identified			
	D. Long lead-time baseline monitoring program—initiated			
	E. Conceptual reclamation, sediment and erosion control, tailings, and dump stability plans—prepared			
	F. Acid rock drainage—evaluation undertaken			
	G. Characterization of environmental risks—undertaken			
	H. Report of major environmental issues—produced			
24	Permit list—prepared			
25	Social impact assessment—broad overview produced			
26	Management Summary Master (Level 2) Schedule—completed			
27	Capital cost estimate (±25% at 90% confidence)—completed			
28	Operating cost estimate by work area—produced			
29	Economic evaluation: IRR (pretax) and NPV—prepared			
30	Governance oversight meetings—initiated			
31	Project risk and opportunities assessment—issued			
32	Prefeasibility study document—complete			

Note: HR = human resources; PEA = Preliminary Economic Assessment.



FLOWCHART 6.1 Prefeasibility study

CHAPTER 7

Feasibility Study

> *The Feasibility Study scope of work must be "is it feasible" and not*
> *"make it feasible." Sometimes the answer is "no."*
> *— Peter McCarthy, AusIMM President, February 2013*

OBJECTIVE

The objective of the feasibility study is to quantify within a universally acceptable structure the proposed project's real contribution to corporate objectives. The study provides solid evidence of the project's feasibility (or lack thereof). It compiles the data necessary for making a yes or no recommendation to the appropriate levels of management for proceeding or not proceeding into the detailed engineering and construction stages that compose project execution. An accompanying objective is to reach the yes/no judgment as early as possible, with no more money spent than necessary to reach an informed decision.

SCOPE

A feasibility study examines all phases of an investment proposal in as much detail as necessary to justify whether to continue into the next stage of project development. The feasibility study encompasses a sufficiently comprehensive set of activities such that the information gathered from those activities can be integrated into a project plan and then analyzed to determine the project's economic viability (Dyas 2002).

If project feasibility is established, then the study can be considered a "bankable document," but only insofar as the feasibility study document has sufficient detail, the engineering and construction criteria are sufficiently identified, the completeness of the project is sufficiently ascertained, and the accuracy is sufficiently tight. While the word *bankable* has fallen into disuse in recent years, and the more favored term today is *definitive* feasibility study, the bankable yardstick still has merit. The feasibility study needs to determine whether the project is sufficiently viable to merit infusion of external funds from an independent financial institution. If a mining project is not sufficiently viable for funding, then it is not economically viable, which means it is not feasible. Although the term *technical feasibility* exists in the nonprofit, governmental world, it thankfully has no place in the mining world.

This third project viability study (following the initial scoping evaluation and the intermediary prefeasibility study) is also referred to as a Level 3, Stage 3, detailed, or final feasibility study in certain jurisdictions. This book will ignore all this nomenclature clutter and stay with the traditional term, *feasibility study*.

Purpose of Feasibility Study Document

The feasibility study addresses all the same issues as the prefeasibility study, but in greater depth. Considerably more test work has to be undertaken. The components of a typical feasibility study are shown in Figure 7.1.

The feasibility study describes the complete project and the installation that will be built. It provides solid evidence of the project's feasibility to meet corporate goals. Sufficient scope is defined to not only facilitate project budgeting and management approval, but also to allow full and proper control during project execution.

The estimate accuracy has to be suitable for nonrecourse external financing of a major portion of the project capital. The capital cost estimate within the feasibility study will become the base estimate for control of the project should it receive approval.

ACTIVITIES REQUIRED

The activities undertaken during the feasibility study are similar to those executed during the prefeasibility study, but the feasibility study delves into much more detail, resulting in a definitive characterization of the project and its full cost. Specifically, the following must be included in the study:

- Determination of the mineral resource and a mine reserve
- Establishment of a mining method based on the measured and indicated reserve
- Confirmation of a suitable mineral process flow diagram
- Performance of a market analysis
- Determination of infrastructure needs and utilities' support requirements
- Quantification of the environmental and social impacts and their mitigation
- Assessment of sustainability and mine closure requirements
- Estimation of the costs of delivering the project in an operational mode
- An economic analysis to determine if the project meets the Owner's objectives

The feasibility study provides a definitive technical, environmental, and commercial basis for an investment decision. The project deliverables must be precisely defined within the feasibility study. Iterative processes are used to optimize all critical elements within the project. Production capacity, technology, investment and production costs, sales revenue, and investment return are all identified.

In executing the feasibility study activities, the project leader will typically draw on the experience of an engineering, procurement, and construction management (EPCM) contractor, involve numerous specialists, and make substantial use of the accumulated experience of the mining company's own staff and existing operations.

Project Management

Unlike 50 years ago when studies were mostly produced in-house, now the feasibility study is generally executed by an outside engineering company selected by a formal request for proposal (RFP) process, but monitored and assisted by in-house company staff. If the project has a high probability of success, then the company selected should preferentially be an EPCM firm. This increases the chance that the same contractor will be the project deliverer and possibly even the project constructor.

The following outline lists the minimum recommended topics to cover.

1. Introduction
2. Executive Summary
3. Project Description
4. Project Background and History
5. Property/Land Ownership
6. Geology
7. Resources and Ore Reserves
8. Mining
9. Hydrology
10. Metallurgy
11. Process
12. Infrastructure and Utilities
13. Tailings Storage Facility
14. Environmental and Permitting Requirements
15. Sustainability and Social Acceptance Programs
16. Health, Safety, and Training
17. Security
18. Operations Plan
19. Transport and Logisitics
20. Project Schedule and Execution Plan
21. Capital Cost Estimate
22. Operating Cost Estimate
23. Risk Assessment and Opportunities
24. Financial Analysis
25. Marketing
26. Appendices
    a. Value Engineering Trade-off Studies
    b. Consultant and/or Owner Specialist Reports
       (e.g., geotechnical, pilot tests, underground ventilation)

FIGURE 7.1 Feasibility study contents

If an EPCM firm is expected to be the project deliverer, then the earlier the EPCM is involved in the project, the greater value it can add to the way the project is planned, designed, procured, and built. There is considerable benefit to the EPCM being brought in during the early study stages. It allows the EPCM to more fully understand the Owner's needs and expectations, and thereby more likely leads to solutions that are technically fit for purpose within the Owner's time frame and budget.

The formal selection process for the feasibility study provider is similar to that outlined in detail in Chapter 19. This process requires a written RFP and a separate interview, as with the prefeasibility study. In addition, a site visit by the bidding organizations is mandatory. The collective bid responses, interview feedbacks, and site visit information are synthesized into an objective ranking of the bidders using a Project Bidder Selection, Evaluation, and Ranking form, similar to that illustrated later in Figure 19.3.

The team leader, that is, the project director or manager, should preferably be an engineer skilled in design and engineering management as well as project management. The project leader, the project team, and any specialist support staff need to have solid, in-depth practical experience and an understanding of the mineral types and the project technologies being used. Typically, the majority of the team, particularly the design engineers and the cost estimators, come from the EPCM company. However, to maintain Owner buy-in to the design and other critical concepts, the mining company's operations personnel need to be frequently consulted or, better still, included as key members of the design team.

Data Collection

For a grassroots project, data collection requires multiple site visits by mining company technical and operations specialists, plus focused input from external experts.

Site data: During site visits, the project team members undertake a specific review of the host country and the prevailing business climate. They gather historical data on existing operations and/or old workings that will enhance their understanding of issues going forward.

Climatic data (sufficient for surface facilities design) and ambient temperature data (sufficient for refrigeration and/or heating equipment designs) in underground developments are collected.

Geology: The geological team members establish themselves on-site to produce detailed geological maps, including cross sections, long sections, and level plans clearly defining the deposit in three dimensions. They gather basic data on the lithology, formations, and structures hosting the deposit, along with the petrology and mineralogy aspects of the mineral body and the country rock. The team members make a detailed geological assessment of the structure, rock zones, and core lithology; they dig test pits and take geophysical and geotechnical sampling.

Mineralogy and metallurgy: Detailed mineralogical assaying takes place. A mineralogical support study is produced (usually by an outside expert.) Metallurgical mapping and mineral characterization for processing purposes would also be undertaken at this same time. Comprehensive coal washability and sink–float tests are conducted. Data collected should include information related to existing metallurgical test work, if any.

Drill data: Existing drill-hole data are verified by the mining engineers on the project team, and downhole spot-check surveys are undertaken. Check assays of existing drill-hole samples are made using the project team's prime laboratory, along with confirmation assays using a different laboratory. (Confirmation assays are typically undertaken in the second laboratory at a minimum ratio of 1:20 to the prime laboratory's assays).

For an open pit, closely spaced drilling on a firm grid pattern is conducted, sufficient to confirm continuity of mineralization. A minimum of five twin core holes is required.

If an underground operation is indicated, initial access must be established, and confirmation of surface results from underground drill-hole patterns have to be made. Whenever the project is an underground mine, this innocuous statement has huge economic consequences. For example, for the $970 million Nickel Rim South Mine project of Xstrata completed in 2009 in Sudbury, Ontario, the Xstrata board had to approve in 2004 a $598 million budget to sink two shafts of 1,785 m and 1,675 m depth, respectively, along with 22,000 m of development drift and 135,000 m of underground drilling just to obtain enough data to complete its feasibility study to the corporation's mandated 90% confidence limits; that is, more than 60% of the project's capital was incurred to determine if the project was feasible (Collins 2009).

Sampling procedures: Checks are made to confirm that core, drill cuttings, and channel samples were obtained by acceptable industry practices. Assaying techniques similarly need confirmation of proper protocols and absence of bias. Reviews should include the following:

- Accuracy verifications on the logging of drill cores and cuttings
- Confirmation of proper splitting techniques, generation of pulps, and treatment of rejects
- Audits of assay lab procedures and repeatability
- Checks on methodology and adequacy of specific gravity calculations

Geomechanical and hydrology: Real geotechnical data have to be collected on-site by qualified personnel. (Estimates of rock and ground strength used in prior scoping and prefeasibility studies no longer suffice.) These personnel gather the rock mechanics and hydrological input data to develop mine design, estimate open-pit stability and underground support requirements, and allow the selection of an appropriate mining method.

Operations and infrastructure: Other data collected during the site visits will include relevant details on the established infrastructure and support facilities, such as water, power, and labor. These provide the information necessary for cost estimating and plant design. A list of questions and data requests should be prepared prior to visits to any brownfield or operating site.

Environmental: During the site visits, the project team has to undertake specific reviews of the environmental issues and permit requirements. They will complete a comprehensive evaluation of the baseline environmental conditions and issue a focused characterization of the project's potential impacts on the environment.

Data Analysis

The data gathered are analyzed by the appropriate experts within the project team. Doubts concerning tonnage, grade, strip ratio, and minability of the ore are removed such that all reserves are now proven and probable, that is, they meet the quality standards of the Securities and Exchange Commission (SEC) Form 10-K, Canadian National Instrument classification NI 43-101, Joint Ore Reserves Committee Code (JORC Code; JORC 2012), or South African Mineral Resources Committee Code (SAMREC Code; SAMREC 2007).

Resource or reserve modeling: Reserve calculations are prepared by the project team's mining engineers. Two separate derivations should be produced with at least one by an outside recognized specialist. The prime calculation needs to be geostatistical, and the other check calculation can be nongeostatistical (e.g., polygon, cross sectional, and preferably manually derived).

Physical limits are set by variogram statistical analysis combined with a manual establishment of geologic boundary. Inferences and interpretations of the collected data along with any areas of uncertainty that exist are documented by the project team. Specific areas that need to be addressed for accuracy and adherence to standard practices include the following:

- Compositing and plotting of the raw data
- Handling of bulk sample data versus adjacent drill-hole data and block model output
- The appropriateness of search radii, particularly with the geostatistical data
- Grade caps of high-grade assays
- Treatment of outliers

Mine design parameters: A concise description of the strategy for the mine development—that is, how the project's priorities and resources will be managed to meet the project objectives—should be outlined by the project manager. The factors that control the selection or timing of the development methods and plan need to be set.

1. Tonnage factors are derived from the geologic data collected.
2. Cutoff grades are calculated based on the operating cash cost, general administrative expense, resource taxes and royalties, metallurgical recoveries, smelter and refinery treatment cost and payment factors, and the capital cost.
3. Dilution is established from the mining method. If this is an underground project, then dilution needs to include overbreak dilution, internal dilution (from below cutoff grade inclusions), fill dilution (if any type of filling is used), and production dilution (humans sending ore and/or waste to the wrong place).

Given the information on the size and grade of the resource, a detailed mine plan can be developed by the project team's mining engineers that respects the geologic, geotechnical, and climatic environment.

Pit slopes for surface mines are established by sector from cell mapping and oriented core holes. Bench width and heights are set along with haul-road configurations and final pit limits.

Underground projects detail their development design. Metal mine projects lay out a specific stoping or caving system with commensurate opening dimensions, equipment clearances, ground control, ventilation requirements, hoisting capacity, escape routes, and so forth. Coal mine projects (longwall or room-and-pillar) produce specific ventilation, roof control, conveyance, haulage, utility placements, and secondary mining plans.

If the mining method and mine plan are configured by an outside party, it bolsters the bankable credibility. Factors that limit the choice of mining method or mine plan alternatives are documented, along with the factors that led to the selected option. The advantages and disadvantages comparison of alternatives to justify the logic behind the final design selection decision is a necessary discipline for arriving at the best mining scenario.

The mine plan will be a detailed, optimized phase design, including haul-road progressions for pits, development layouts, stope spacing, and sectional advance sequences for underground. The project team calculates the yearly and final site locations, outlines, and heights for the pit, waste dumps, and coal refuse impoundments. Stripping schedules and cutoff grades are optimized and set for each year in the life of the mine.

Environmental: Governmental permitting actions sufficient to produce an environmental impact statement (EIS) or environmental and social impact assessment (ESIA) would generally be initiated at this time.

Concept Development

Property: All property ownership, lease tenure, and/or land status issues are either resolved or their paths to resolution are solidly set. Property title and mineral rights are secured; access easements and property encumbrances are identified.

Mining methods: The project team sets the pit layout and stope design envelopes. The usages and/or avoidance of old workings are addressed. The elevation, orientation, and selection of the mine starting point are made to enhance the efficiency of layout for extracting the resource. The goal throughout is to optimize the resource's tonnage and grade.

Based on the reserve data established, the yearly and mine life ore and waste tonnages, grade, production, and strip ratios are calculated, and a production schedule is produced using pushbacks for open pits and development advance sequences for underground.

The progression of steps to develop and produce ore; the extraction efficiency, dilution rates, equipment and personnel required, ground support or slope stability requirements, and any special services have to be derived and documented. Collateral issues that may arise must be addressed, such as acid mine drainage, surface subsidence, and water management.

The iterative process that creates the feasibility study deliverables for an underground mine plan is illustrated in Figure 7.2. This figure, adapted from unpublished work of George R. Stephan (2007a) portrays the level of effort required, not just for the mine plan but for all the other elements of the feasibility study, for example, materials handling, process plant, and infrastructure.

Materials handling: The team derives and describes the methods, machinery, and pathways for transporting ore and waste from the pit benches, stopes, and development headings to the process plant or waste disposal points. Expensive key facilities, such as the major accesses (shafts, declines, adits, and roads), hoists, crushers, conveyors, and mobile equipment, are specified and engineered to the degree required for the study's accuracy. Any necessity for ore blending must be addressed at this point as well.

Process selection: Metallurgical tests are advanced enough to identify all likely issues and to provide process design parameters. A specific, detailed process flow diagram is determined from extensive test work, and a follow-up comprehensive confirmatory pilot plant is run.

The team's chosen laboratory completes the test work necessary to estimate the optimal liberation size, metallurgical recovery, and concentrate grade. Mineralogical "bad actors" are identified, and a viable process to nullify is determined.

A pilot-scale plant is used to determine the effect of ore variability, along with a determination of retention times; grinding and classification efficiency; and power, grinding ball, reagent and water consumptions.

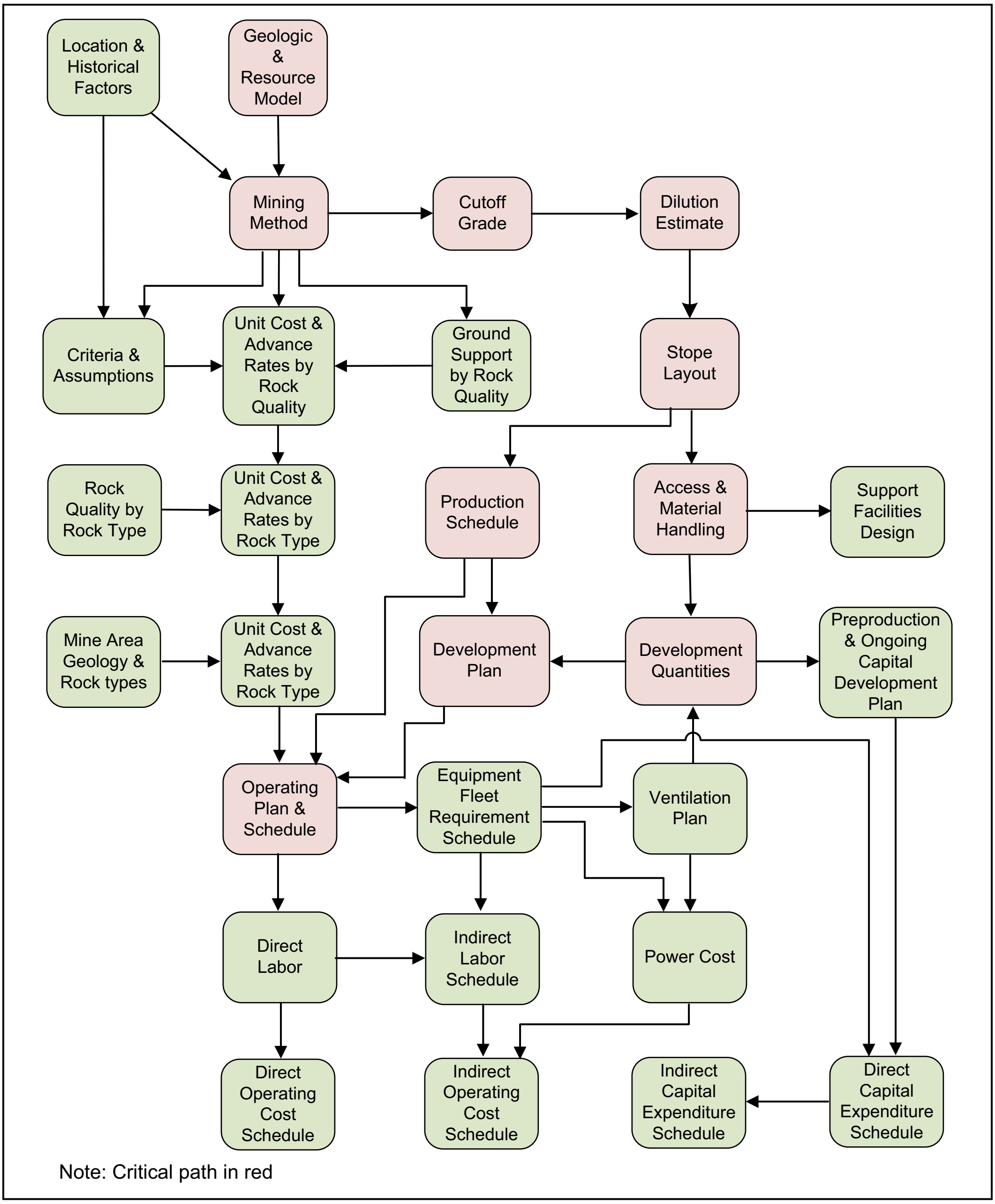
Plant capacity and plant products are established. Comprehensive metallurgical and coal washability laboratory work sufficient to derive defensible recoveries are completed, and a detailed process description is drafted. Annual product output is established for the mine life (e.g., concentrate, coal tons, or metal), and ramp-up to full design by month is set.

Mine fragmentation analysis, ore hardness classification, work index determinations, crushing and grindability indexing, abrasion tests, screen analyses, flotation trials, thickening and filtration characterizations, concentrate and tailings dewater results, process stream mass balance, heat and material balance, along with the detailed equipment list and process flow diagrams, dust generation, and capture studies are completed and, for the most part, optimized. Line sizes, instrument types, and valves can now be shown.

Equipment selection: The team prepares a complete equipment list with detailed sizings for all major equipment priced FOB (free on board) job site for the mine, process plant, and support facilities. Major item horsepower ratings are given, and instrument philosophy is stated.

The selection criteria that led to inclusion in the equipment list are documented for fixed and mobile equipment. The adequacy of quantity, size, design, productivity, availability, and utilization is justified. The sufficiency of support equipment is confirmed. The purchase timing of delivery, setup, and spares is set, as are the replacement and/or rebuild schedules. The method to receive, store, and distribute supplies and spare parts is established.

Personnel transport: The method is stipulated for accomplishing the safe and rapid transport of personnel to minimize time lost during shift changes and to facilitate operational flexibility. This is particularly important for underground projects.



Source: Adapted from Stephan 2007a.

FIGURE 7.2 Mine plan and cost estimation preparation path

Engineering support: Semicomplete soil tests and reports are produced with actual soils conditions and the type of foundation specified, along with detailed quantities and detail drawings for civil works. Semidetailed topography maps are produced, typically at a 1:2,000 scale with 2-m contour intervals. A detailed hydrology study is completed confirming water availability, its source, any necessary mine dewatering strategy, and the effects on local groundwater users.

All major trade-off studies are now complete. The entire design basis is established; the general specifications and the basic design engineering are essentially complete. Design drawings allowing a full definition of scope are produced. The design criteria account for all known site climatic conditions; thus these criteria can be the basis for final design during the detail engineering stage. Definitive quantities can be derived for estimating purposes.

Mine services: The power demand is derived, along with the delivery system description, equipment specifications, maintenance needs, and management control.

Water management criteria are calculated: expected inflows; process requirements; equipment and dust suppression needs; and methods for capture, transport, and disposal or reuse. Pumping and clarifying requirements are determined. Emergency plans are set.

Compressed air demand, oxygen demand, and ventilation requirements for underground are all derived. System design descriptions are developed and documented.

Facility locations: Exact, optimized geographic locations of facilities are established on the site location maps, respecting pertinent topography and regulations. Detailed general arrangement drawings, supported by linked piping, instrumentation, and one-line electrical drawings, are complete.

Infrastructure: The infrastructure facilities necessary to support the project are fully identified and characterized, such as the logistics system, roads, rail, water, sewage, power, fire protection, emergency escape routes, refuge chambers, fencing, explosives storage, air strips, offices, medical facilities, laboratories, warehouses, laydown yards, maintenance and repair facilities, workshops, lamphouse, fuel farms, training facilities, change houses, lunch rooms, dining hall, camp, housing, communications, computers, and dispatch systems.

While long lead-time items are identified within the feasibility study, no procurement or construction is initiated until management approval for the project is obtained. Pressure to fast-track the project and order equipment, as well as mobilize the earthwork contractor, will come from various quarters, but this should be rejected. Fast tracking is an excuse for moving forward and undertaking activities out of sequence, without all requisite facts and decision tools in hand.

Engineering Effort for Requisite Capital Cost Accuracy

The authors' research and experience show that the total engineering effort incurred (including study hours) by the end of a feasibility study with typical mining projects can range from an inadequate low of around 7% to as high as 35% to 40%.

To achieve the recommended ±15% capital cost accuracy necessary for a bankable feasibility study, a minimum engineering effort of at least 20% is requisite. The authors advocate 25% to 30%, a percentage that is in line with the findings of Bullock (2011a, 2013). This recommendation is double what is typically found in most project feasibility studies. Admittedly, the cost of such an initial engineering effort is considerable; therefore, before the reader rejects such a recommendation, two points need to be considered:

1. The biggest reason for project overrun is undefined scope at project execution kick-off, and the biggest reason for lack of scope definition is insufficient engineering definition. Money spent on adequate initial engineering is key to delivering the project within budget. The extra engineering dollars spent up-front will turn out to be far less than the average 26% cost overrun incurred by the majority (85%) of mining projects (McCarthy 2013).

2. The recommended engineering effort is the figure for *all* of engineering, including geotechnical, mine design, hydrology, and tailings facility, not just the EPCM firm's component. If total engineering is at 25% to 30%, typically an EPCM component would be two-thirds to three-quarters of that percentage, at around 20% (±3%).

Workforce Estimate

The project team makes an estimate of the workforce size and the skills required to operate, maintain, and manage the operating plant by breaking down the labor complement for each department. The likely source of labor is identified, and the labor buildup schedule derived. The training requirements for operations start-up are documented.

Costs of the estimated personnel are produced from zero-based budgets with details by job function and by year. Supervisory and hourly rosters for operations and maintenance are derived with appropriate wage rates, burdens, and benefits annually for the life of the mine.

Regulatory requirements for personnel training and/or certification, such as Mine Safety and Health Administration, explosives handling, hoist person certification, environmental monitoring, emergency response, hazardous material and toxic waste handling, and the like, have to be identified and then properly included within the labor cost component.

The project team produces an organizational chart for execution of the project, showing reporting relationships and the Owner's project management team roles. A commitment to a team partnering alignment philosophy is appropriate at this juncture.

Environmental and Permitting Impact Appraisal

The team conducts a full review of the potential impact of the proposed project on the environment and a detailed review of the nature, scope, and schedule for obtaining environmental and/or other governmental permits. For large projects with significant environmental permitting requirements, this evaluation is commonly completed in the form of a legal constraints study by outside counsel, under the direction of the mining company's corporate law department.

Based on the amount of engineering effort completed, environmental and other selected governmental permitting actions would generally be initiated during this stage; that is, the major permit applications would be submitted. At a minimum, long lead-time environmental studies and permitting processes would certainly have all been started by this time.

Red-flag issues are fully investigated and evaluated. For example, is the project located in or near areas of environmental concerns such as national or state parks, wildlife preserves, designated scenic areas, world heritage sites, sensitive rivers, or lakes? Are biologically sensitive species, such as the Andean flamingos of northern Chile, present on-site? In some instances, environmental permitting issues that are considered high risk for project development may need to be addressed before development approval can be obtained from management, or before any on-site project construction disturbance is allowed.

All the necessary environmental data related to the project from existing sources and databases are obtained, and site-specific environmental sampling and analyses are completed. This is not an inconsequential task; collecting the necessary baseline data typically takes a minimum of 24 to 27 months, if none exist on-site prior to the project undertaking. For any greenfield project, completion of this comprehensive evaluation of the site's baseline environmental conditions is mandatory.

A comprehensive environmental management plan that covers all the environmental issues and includes a finalized environmental monitoring program is produced as a component of the feasibility study (typically as an appendix). This work component is accomplished as part of an EIS or Environmental Assessment (EA) in the United States, or as part of a broader environmental evaluation that is often required by a project's foreign location or by the project's lending institutions (e.g., an ESIA as currently mandated by the World Bank, the European Bank for Reconstruction and Development, and the Overseas Private Investment Corporation). The scope and level of environmental work undertaken at this stage is equivalent to what is conventionally referred to as a Phase II, Environmental Due Diligence, for an equity acquisition.

All major project design considerations that may be influenced by environmental permitting constraints are identified. For example, will tailings sites need to be constructed with nonconventional liners? Will the waste rock be acid generating, and if so, how will it be treated?

A comprehensive summary is produced of the environmental and permitting requirements, including a focused characterization of the project's potential impacts on the environment. A realistic assessment of the political and public issues that will likely ensue from these impacts is then made to enable a detailed characterization of the environmental and permitting risk to be drawn. Reclamation plans, sediment and erosion control plans, and geotechnical stability analyses are all undertaken. Legal constraints, including scope, timing, and cost analyses of pursuing environmental or other necessary permits, are highlighted.

The team identifies environmental mitigation measures likely to be necessary for permitting or other approvals. The quality assurance or quality control parties responsible for environmental compliance are identified. However, the team must be careful not to inadvertently commit on paper to environmental mitigations that are not legally or environmentally necessary just to curry favor with special interest groups. Where it is believed to be necessary to go beyond legal requirements to obtain local social acceptance, then the additional cost of so doing should be highlighted.

To obtain the full spectrum of environmental input and support, the originating team leader or project manager should seek the counsel of environmental or permit expertise located at the Owner's associated operating locations or within the corporate environmental affairs department. Through these consultations, environmental and permitting resources can be made available to the project team for the purpose of managing the hired environmental or permitting consultants who will develop the feasibility-level evaluations.

Social Acceptance Assessment

A comprehensive social impact assessment for the predicted life cycle of the project (including postclosure) is produced for the feasibility study, listing the likely direct and indirect impacts (positive and negative). The social impacts could be real (increased demands on local schools) or perceived (elimination of a local wildlife species). The major social risks (i.e., potential impacts of the project on the community, or conversely on the project by the community) are identified.

Available data related to the project community and any indigenous cultures are obtained from existing sources and on-site work. At the feasibility stage this typically includes the following:

- Literature reviews
- Site meetings with community affairs personnel from existing company operations

- In-depth face-to-face interviews of individuals, community groups, and focus groups
- Questionnaire surveys, targeted on those affected by the project
- Cultural heritage research and mapping
- Social baseline study appraisal of the communities that will be affected by the project
- Stakeholder impact analysis

A full social profiling analysis of the community and stakeholder perceptions (real and perceived) regarding the legitimacy and credibility of the proposed project is conducted, along with an assessment of the presence or absence of trust regarding the mining company. The purpose of this profiling is to gain an understanding of those communities and stakeholders impacted (or with a belief that they will be impacted) by the project from a social and an economic viewpoint.

The obvious red-flag social issues are compiled and evaluated, and mitigation plans are developed. Examples include using World Bank guidelines to relocate an existing village, designing a pumping drawdown barrier to remove an in-situ leach risk to a rancher's groundwater supply, or relocating a pipeline route to avoid the sacred site of an indigenous group.

The project design features that will need to address the more subtle social or sustainability constraints are also identified, and mitigation plans are put forward. For example, a fully equipped stand-alone construction camp could be provided to accommodate the large influx of temporary construction workers, thus removing potential strains on existing community resources. Delivery of hazardous chemicals could also be scheduled in daylight hours with security escort vehicles to reduce community fears regarding potential spillage.

Social Management Plan

The social management plan is an action plan based on the findings of the social impact assessment. The management plan outlines the measures that will be taken to enhance positive impacts and to avoid, mitigate, offset, or compensate any negative ones. The plan would include an estimate of the timing, frequency, duration, and cost of the management measures, in particular, the strategy for handling the identified red-flag issues. Equally important, the plan establishes monitoring and reporting procedures.

To produce the social impact assessment and the resultant social management plan, the project leader should obtain support and counsel from any community outreach expertise located at the associated operating location and/or within the Owner's corporate social responsibility departments. This will help ensure that the project's engineering designs stay compatible with social acceptance requirements.

These in-company resources are the best sources for locating the specialist consultants and/or outside counsel experts that will almost certainly be needed to develop the quality and accuracy necessary in any feasibility-level social management plan.

Most mine-related social management plans are developed in partnership with the regulatory agencies and the community (see Chapter 8 for definition of *community*). Such codeveloped plans provide an opportunity to link activities with local and regional planning processes, as well as to other company operations. Thus, these plans address cumulative impacts and facilitate coordination of project activities with the services and infrastructure of government.

Sustainability Review

The feasibility study is reviewed from a sustainability viewpoint to ensure that the project will be undertaken in such a way that project activities and the products produced together can demonstrate a net positive contribution to human and ecosystem well-being over the long term:

- The permitting and fiscal regimes under which the project takes place must be efficient, noncorrupt, and result in security of tenure for the project facility.
- The project outcome must demonstrate an equitable sharing of costs, benefits, risks, and responsibilities between the host government and/or community and the mining company.

Schedule Development

A comprehensive, integrated master schedule for the project, including major milestone dates and a Gantt time-scaled diagram showing all key project deliverables (engineering, procurement, construction, start-up, etc.), is produced. This Project Coordination (Level 3) Schedule outline goes from feasibility study, through engineering, construction, commissioning, and initial metal production all the way to full design commercial production. See Figure 10.3 for an example of a Level 3 schedule.

Including a one-page key milestone schedule in the feasibility study is an excellent pictorial complement to the more complex Level 3 schedule for the executive reader. Figure 7.3 shows an example of such a schedule, extracted from a feasibility study for an Asian gold mine project.

This initial integrated project schedule has to be logic driven and resource loaded. It must use critical path methodology to properly show all major element interfaces involved in the construction execution. In other words, the detail must meet a Level 3 schedule threshold. This initial critical path schedule is generally best set up highlighting all the activities that have less than 30 days of total float, or slack.

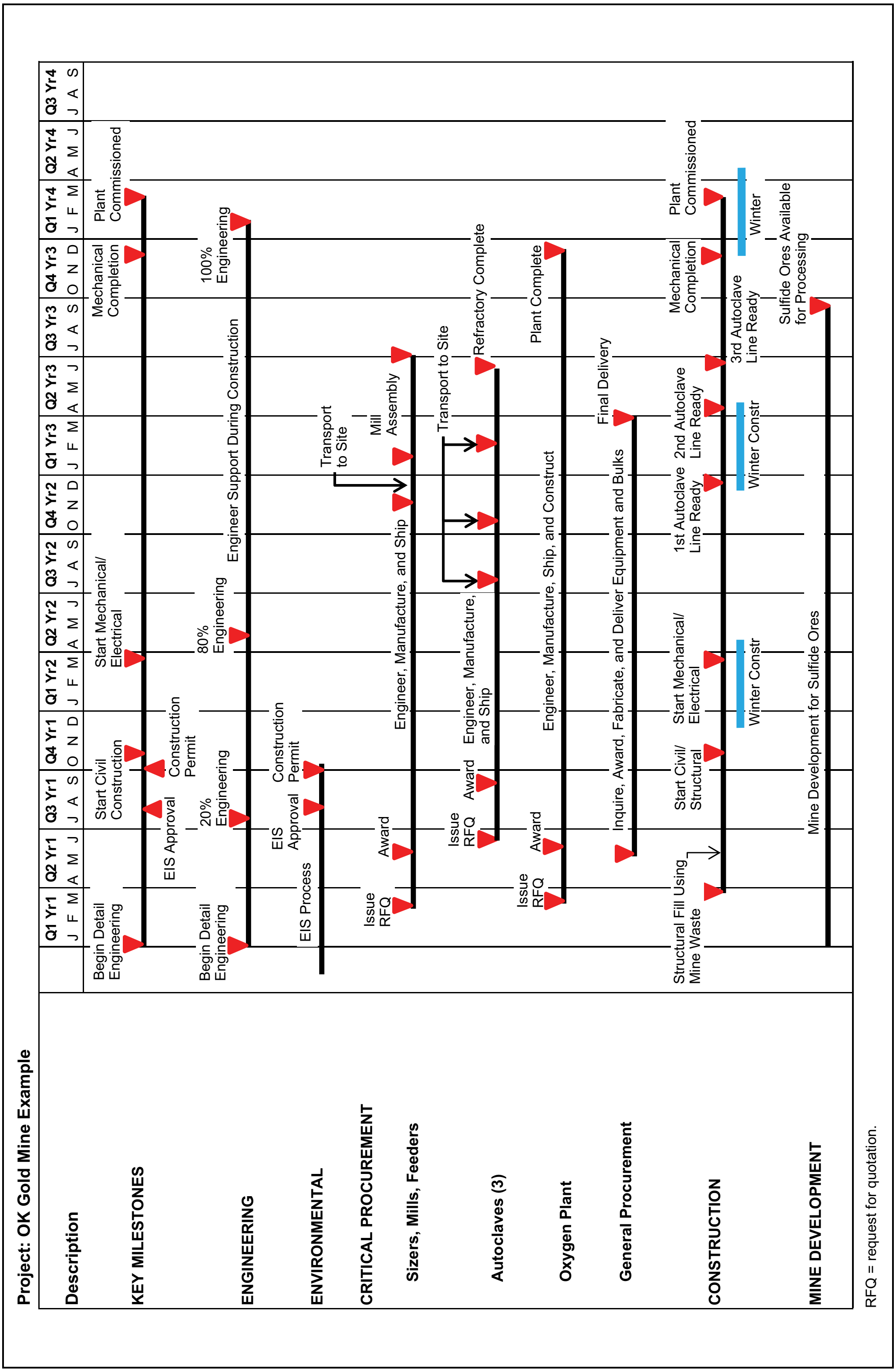
A probabilistic evaluation of the overall project schedule duration (including a sensitivity chart with a P10/P90 S curve—see Figure 12.5) should be included to help highlight the potential schedule risk within the project.

Capital Cost Estimate

Once the design concepts have been developed, a capital cost estimate of the facility must be produced. This estimate covers initial cost and sustaining capital over the life of the mine.

A tabulation is made of the project's development and construction tasks; their estimated cost and timing; the quantity and cost of equipment acquisition; and all other anticipated project costs such as EPCM, power, rentals, leases, fees, insurances, royalties, sustaining capital, closure, shutdown, salvage, and reclamation. The cost categories are defined, the structure of the calculation system is described, and the assumptions made in the estimation process are identified and justified. (It is useful to define and explain capital versus operating costs within the feasibility document.)

Sustaining capital to maintain production as the mine advances, including additions for the mine fleet and equipment rebuild and/or replacement, is shown yearly for at least the first



RFQ = request for quotation.

FIGURE 7.3 Milestone schedule

5 years of operation (i.e., postcompletion of the project). This helps to clarify that no project capital is being inappropriately slipped into sustaining capital.

The estimate is prepared by spread, including installation. Initial fills and spares are part of the project capital. Site visits by the estimator and the major equipment suppliers are made. The estimate has to be more accurate than the figure produced for the prefeasibility study. Consequently, the majority of the cost elements are task based and bottom-up. Only minor gap issues are filled top-down. A minimum of two letter quotes for all major equipment is needed.

The estimates for civil, structural, piping, mechanical, instrumentation, HVAC, electrical, and architectural costs are predominately made from partial takeoffs of quantities from completed drawings. Some drawings (e.g., structural and mechanical) will be almost fully developed, but others (e.g., electrical) will likely be very preliminary.

Material pricing is mostly taken from supplier proposals. Material volumes and amounts are partly takeoff, partly factored. Bulk commodities are quantified from plot plans and design drawings.

Construction costs (direct, indirect, overhead, profit, etc.) are from formal contractor and subcontractor proposals for this particular project, including the major infrastructure facilities. Construction labor rates are actual rates plus tangible burdens for the geographic area. Probable labor productivity is evaluated, and an appropriate productivity rate is selected and documented. The assigned productivity for each construction discipline is normally stated as a multiplier of U.S. Gulf Coast labor productivity norms.

The Owner's cost and preproduction expense are estimated from a zero-based budget. The Owner's cost is frequently underestimated and is, in fact, one of the most prevalent areas of error in the budget. It is vital that *all* of the Owner's cost elements be properly included in the feasibility study.

Environmental compliance costs are detailed from the design engineering for the specific permit requirements. Accuracy of environmental costs should now be better than ±20%.

Working capital is prepared from a zero-based budget by the EPCM firm and mining company accounting personnel together, using similar or actual local area experience. EPCM costs are typically based on submitted quotes. Feasibility study component costs need to be more than percentages of direct costs (though the percentages in Column 3 of Figure 13.1 should be used to confirm validity).

Constraints or limits placed on the cost-estimating process must be documented, such as the number of quotes; any Owner-specified wages, salaries, and burdens; all mandated purchasing methods; and equipment or labor productivity rates. Exclusions are kept to a minimum, but whatever exclusions exist, each *must* be specifically highlighted along with the battery limits to the project scope.

The feasibility study is the decision tool for the project. Should the project be given full approval for construction, the capital estimate will underpin the control budget.

Contingency

Contingency is allocated by assessing the accuracy of the takeoffs and costs. Overall, contingency is always a positive number. While it should be down in the 12% to 18% range (usually around 15%), it will rarely go below 10%, as there simply is not enough detailed engineering and/or removal of unknowns in a feasibility study to get below this level. (See Chapter 12 for guidance on how to calculate and apply contingency.) Escalation could now be assigned to each project area along with risk, but more likely will still be applied as a single figure using the latest company budget forecast, similar to the approach used in the prefeasibility study.

Capital Cost Estimate Accuracy

The level of accuracy is determined by the level of effort, that is, the level of detail in the information input to the capital cost estimate and the level of work performed in the design, engineering, procurement, and estimating steps. As such, the feasibility study must include explicit statements as to the level of detail in the engineering undertaken to date, the methodology of the cost estimate, and the amount of contingency allowance.

The goal for the capital estimation process and contingency assignment is that, at the end of the risk assessment exercise, the confidence level is 90% that the derived project total capital cost will be sufficient; in other words, there is less than a 10% chance of a budget overrun (Hickson 2000c).

To achieve this 90% confidence level in the capital cost estimate amount, a capital cost accuracy of better than ±15% is needed. To achieve this level of accuracy requires the undertaking of a considerable amount of engineering work, far more than the less-than-10% engineering work effort that is typically undertaken in most projects (which is why most projects underestimate their capital cost). See Chapter 11 and Figure 11.4 for an understanding of the role of estimate accuracy when deriving a capital cost amount.

To further emphasize this point, for a 90% confidence level, the following guidelines from Frohling et al. (1975) should be kept in mind:

- To achieve ±15% accuracy in capital expenditures (CAPEX) requires 25% of engineering to be complete.
- To achieve ±10% accuracy in CAPEX requires 50% of engineering to be complete.
- To achieve ±5% accuracy in CAPEX requires 100% of engineering to be complete.

These guidelines are as true today as they were 50 years ago. To get an accurate project cost up-front, you have to undertake the necessary engineering.

What will this cost? Typically, a detailed, bankable feasibility study will cost about 4% of the total project cost (3% to 5%). Thus, to achieve a 90% confidence level for a $1 billion project, the Owner should plan on spending about $40 million for the feasibility study. This cost includes the resource assays, reserve modeling, metallurgical tests, geotechnical investigations, tailings storage facility design, environmental permitting baseline support work, and so forth. Actual cost of the study document itself from the EPCM will likely be roughly one-third of this, at around $15 million (1.5% of the project cost).

Operating Cost Estimate

The costs for labor, operating equipment, materials, supplies, and all other charges to perform the routine operating tasks are estimated. The periodic totals of those costs to achieve and maintain the production schedule are then tabulated and summarized, resulting in unit costs for the record. The structure of the calculation system is described, cost categories are defined, and the assumptions made in the estimation process are identified and justified.

If a contract mining company is to be employed, then firm contractual costs per ton and/or per ton mile need to be in hand along with any distance over- or under charges, mobilization or demobilization charges, overheads, and any staff or support equipment charge-outs.

Operating quantities are detailed, and costs are derived from a bottom-up, zero-based budget with minimal use of factoring. Annual expenditures are calculated in total dollars per ore ton and per unit mineral produced, broken down by area (department) and by element. Letter quotes are obtained for most operating supplies, including fuel. Written quotes for power are obtained from the local public utilities based on the estimated demand. The quantities for each of the major operating consumables are detailed and their prices obtained via formal quotes.

Maintenance costs are mostly percentage estimates of, for example, the initial cost of machinery for replacement parts, but experience factors from similar operations are used where appropriate and available. General and administrative costs, including access, security, inventory and warehouse controls, management systems, enterprise resource planning systems, and safety programs, are derived from zero-based estimates, almost always by the Owner. Operating costs should classically have an accuracy of +15% to –5%.

Marketing Analysis

A marketing plan is produced, usually by outside parties, identifying the potential buyers for the full mine output. The financial health of the market for the project's products is assessed, and pricing and stress scenarios are investigated.

Risk Assessment

A formal risk analysis incorporating Monte Carlo statistical simulation for the totality of the project risks is undertaken. The risk issues at this stage are now largely understood with no significant unknowns remaining. Refer to Chapter 9 for a more detailed coverage of risk.

A detailed analysis of the geological and engineering risk is made based on the work performed and the data collected.

A specific review of the country and political risks, and the business climate risk is made. A checklist of the areas to review in a country risk analysis is shown later in Figure 9.2. Additionally, the technological, environmental, operations, construction, safety, legal, permit, market, tax, and financial risks are all separately and together evaluated by recognized outsourced specialists wherever possible. The assessment of each identified risk within the project forms the basis of the contingency that is assigned to the feasibility study cost estimate. Refer to Chapter 12 for details.

Generally, it is appropriate to conduct an informal fatal-flaw analysis during the feasibility study stage. This is a precursor to the formal fatal-flaw analysis conducted during the detailed engineering stage. See Chapter 27.

Economic Evaluation

At this point, the team must review the estimate and accurately forecast the ultimate value of the project. The potential for a project to generate sufficient revenue to be economically feasible has to be determined, considering construction cost, debt service, operating cost, and other expenses. Market analyses may need to be conducted to evaluate the expected revenue and/or the real need for the minerals from the proposed facilities.

The ability of an Owner to receive funding assistance may influence the feasibility of the proposed project. If this is so, the potential of funding from the probable governmental and private agencies or programs will need to be evaluated. This in turn will likely lead to the consideration of criteria such as the purpose of the proposed project; the effects on the income levels of local residents; the likelihood of employment creation; and any environmental, societal, or sustainability enhancement.

The economic evaluation is prepared based on cash flow calculations for the life of the stated reserve using guidelines provided by the Owner's corporate treasury department. The evaluation includes a full assessment of the project's key economic parameters, including reserves, mining and processing rates, metal recoveries, development period, mine life, infrastructure needs, capital, and operating cost estimates. Mineral prices are set by the Owner. Thus the gross value of the ore can be estimated for the study, and a sophisticated cash flow analysis can be derived by financial specialists.

A full investigation of the tax regime (local and national), and any central bank or export/import issues for international projects along with royalty and tax considerations are detailed. All such applicable costs are included within the economic evaluation.

A currency risk exposure, to the nearest $5 million for each currency on an annual basis, is prepared by the project team for the Owner's corporate treasury department. The treasury department is normally the entity that has the knowledge to provide the estimate of likely financing fees, insurance, and interest payments during construction. These items are needed by the project team for insertion into the project capital cost total.

A post-tax internal rate of return (IRR) and net present value (NPV) at the appropriate Owner discount (hurdle) rate plus multiple sensitivity analyses are then derived from the evaluation spreadsheets. These sensitivities typically reflect differing commodity prices and variations to the derived operating and capital costs. A comprehensive list of the assumptions made must accompany the economic analysis, along with the sources of data and an explanation of taxes and royalties assessed.

As Richard Bullock (2011b) points out, one of the most important elements in performing a project evaluation is that each one should be done exactly like every other evaluation within that mining company. The company's evaluation process must require that different evaluators follow exactly the same procedures on each project. This way, the decision from the corporate leadership will be based on comparable economics.

FEASIBILITY STUDY DOCUMENT

The feasibility study document is a report highlighting the assumptions made and the reasons for the recommendations. The basis of the estimate should be clearly stated. Any benchmarking that has been undertaken of similar projects should be highlighted (such benchmarking is *always* recommended). Predecessor studies are listed with explanations about any shortcomings, data gaps, accuracy limitations, changes, and so on, that led to the current study.

Not only should the project design basis be agreed to by all parties by this time, but also the work breakdown structure (WBS—see Chapter 11) should be outlined, along with a tying company code of accounts. The accompanying project procedures manual and the controls system should be drafted, the project reporting needs should be defined and initiated, and the audit philosophy established (the latter all normally within a separate Project Execution Plan, or PEP).

The study document is in essence the final record of the quantity and quality of the feasibility study—the evidence of value derived from the project monies expended (Stephan 2007b). Clear recommendations must be provided about how the project should be managed and controlled going forward, along with an estimate of the costs and time frame. The feasibility study report must include an overall schedule showing the milestones necessary to bring the plant into full production.

Feasibility Study Document Preparation

For most major projects, the feasibility study document is produced by an external EPCM firm selected through the formal RFP process outlined in Chapter 19. This raises a cautionary flag. A growing number of small engineering consulting firms that are not construction or procurement groups are soliciting major project feasibility study work, mostly on the basis of lower cost. The problem here is that many of these firms do not have the depth of in-house backup cost data or field experience of the larger EPCMs that have served the mining industry for decades. Unfortunately, many of these new, smaller firms are claiming accuracies that simply are not true and, when properly examined, cannot be statistically supported. Studies are being produced that are called *feasibility*, but are nothing more than *prefeasibility* at best. The authors have even seen so-called feasibility studies that would struggle to meet a scoping evaluation standard.

The reality is that anyone can put a name on a document, call it a feasibility study, attach a low 10% contingency to make the Owner feel good, and claim a ±15% accuracy range. With feasibility studies, as in life, you essentially get what you pay for. If you use a small, unqualified company to produce a cheap study, the project will get approved with insufficient preparation work, thereby pushing the real feasibility work into basic engineering, which will in turn result in increased cost and schedule extensions, and, ultimately, dismay on the Owner's part when the true project cost appears in the engineering phase. The answer here is to pay the necessary money for a proper feasibility study done by a competent company with the background and data to support it.

Depending on scope, a feasibility study will require between 20,000 work hours for a small, simple project and 375,000 work hours for a multisite, multibillion dollar project and can cost from $1.5 million to $60 million, respectively, to complete.

Document Ownership

A feasibility study is *not* a public document, nor is a scoping study or a prefeasibility study. Even if produced by an outside firm, the feasibility study is always the property of the mining company, with distribution and external publication controlled by that organization.

Disclaimer

The final version of the feasibility study from an external source such as an EPCM firm will always include a disclaimer similar to the following:

> *The EPCM shall have no liability whatsoever for any defect, deficiency, error, or omission in any statement contained in or in any way related to the study or any related documents. The EPCM makes no warranty, express or implied, nor assumes any liability with respect to use or reliance on any information, technology, engineering, or methods disclosed in the*

> *study. Any forecasts, estimates, projections, opinions, or conclusions reached in the study are dependent on numerous technical and economic conditions over which the EPCM has no control, and/or which may not occur. Reliance on such opinions or conclusions is at the sole risk of the person relying thereon.*
>
> *The data, information, and assumptions used to develop the study were derived from documents or information furnished by others. The EPCM did not independently verify or confirm such information and does not assume responsibility for its accuracy or completeness. Any forecasts, costs, or pricing estimates in the study are considered forward-looking statements and represent the EPCM's current opinion and expectation of likely outcome. These statements do not anticipate military action, embargoes, production cutbacks, regional conflicts, changes in governmental policies, or other events or factors that could cause the forecast or estimates to differ materially from what is contained in our forward-looking statements. The study is dated as of the date completed. The EPCM has no obligation to update the study or to revise any opinions, forecasts, or assumptions because of events, circumstances, or transactions occurring after this date.*

The preceding disclaimer does not mean that the Owner should not rely on data within the study or that the EPCM does not want any future work; it simply means that the EPCM's legal department is attempting to manage its liability risk. The EPCM can insert all the caveats it wants into its disclaimer, but this will not protect it from the "reasonable person" test; that is, that clients can expect their EPCM to possess the expertise to not use data that are unreasonable, for example, 100% recoveries from a zinc flotation mill, or a 1,000-m drill-hole search radii for a measured kriged porphyry copper reserve.

STUDY PERIOD DURATION

The time duration between identification of an opportunity (e.g., a mineral discovery) and completion of the feasibility study can vary significantly. Extremely high-grade and/or smaller deposits take less time to identify and prove economically feasible to mine than do large, marginal resources that need optimization of every aspect to prove viability. While one author has gone from discovery to full production in less than 30 months duration twice in his career, this is not typical and is unlikely to be repeated in today's ever-changing regulatory climate.

Overall, today, it will take from 2 to more than 7 years to take a project from inception to a completed feasibility study. Figure 7.4 lists the typical durations for project studies taken from the authors' personal sources, but they fit within the publications of Bullock (2011b), Noort and Adams (2006), and Hickson and Owen (1997), among others. The durations illustrate the study effort (and engineering work) needed to attain the requisite accuracies for each study phase. These times will change significantly depending on the size, grade, location, ownership, and financing requirements of the project, as well as the process type and complexity.

CONCLUSIONS FOR PROJECT CONTINUATION

The feasibility study contains defined contingencies and describes the actual plant to be built; in other words, the facility is no longer the conceptual design plant outlined in the prefeasibility study.

Study Phase	Average Time Duration	Time Range
Scoping Evaluation	8 months	4 to 15 months
Prefeasibility	18 months	8 to 36 months
Feasibility	27 months	12 to 39 months
Total	4 years 5 months	2 to 7.5 years

FIGURE 7.4 Project study durations

From the information gathered, the team again reaches a conclusion regarding the project's continuing viability, which, if positive, is summarized into an Authorization for Expenditure (AFE) submission.

The AFE submission consists of the feasibility study, supporting documentation, the preliminary PEP, and the AFE form reconciling the project's returns with corporate objectives. The AFE submission is submitted to management for review and for a decision of yes (go forward) or no (rejection). If the project is deemed to show adequate return, the submission will motivate approval of project execution.

It is the responsibility of the approving management to notify and inform the next level of senior management of the possible future cost impacts of the decision made. To successfully move the project further along, the team must ensure that all formal documentation submitted to senior management is prepared in accordance with company AFE guidelines and protocol.

The supporting documentation necessary for the AFE submission is essentially a further expansion of the Management Review Submission outlined in Chapter 5 for the scoping evaluation (Chapter 4) and added to during the prefeasibility study (Chapter 6). Details of these necessary supporting documents are given in Chapter 14.

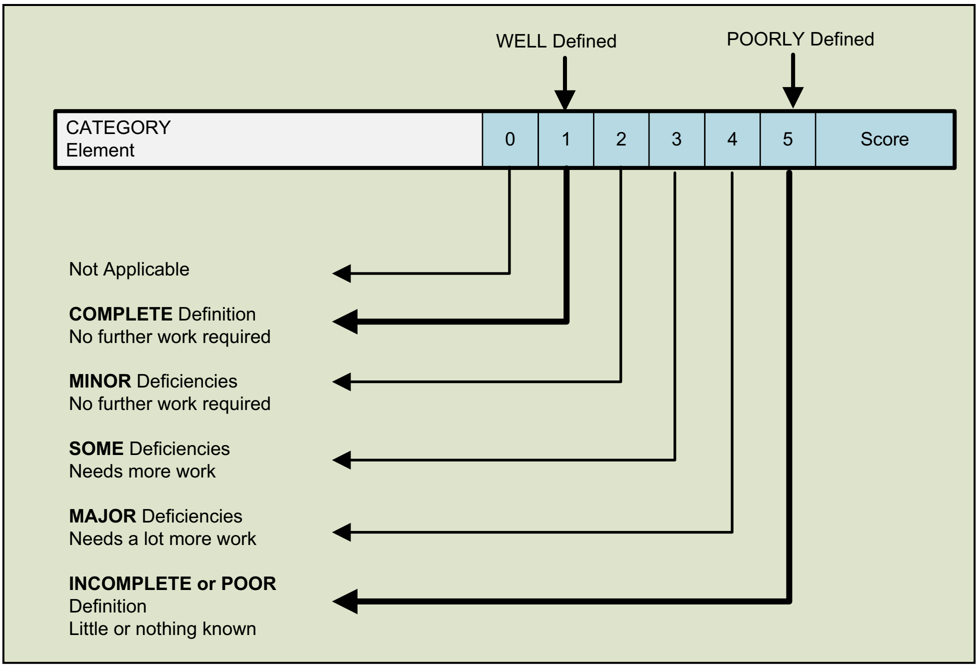
PROJECT DEFINITION RATING INDEX

A recommended tool for deciding if the project is ready to proceed forward to the execution stage is the Project Definition Rating Index (PDRI). The PDRI was introduced by the Construction Industry Institute (CII) in 1996 as a front-end project planning aid to measure a project's completeness with regard to concept, feasibility, and scope definition (CII 2013).

The PDRI was originally intended to identify any gaps and evaluate the completeness of project definition prior to detailed design and construction. But since its inception, the PDRI has been refined, and it is now a fairly easy-to-use, logical method for evaluating a project's readiness to move forward, not just at feasibility completion but at any stage of the project.

The PDRI uses a comprehensive checklist of 70 critical scope definition elements, each element being scored, then weighted on its relative importance to the other elements. The PDRI identifies and precisely describes each element within the scope definition package, so that the project team can assign completeness factor scores (0 to 5) as a measure of that element's impact on project risk. See Figure 7.5. Since the PDRI score relates to risk, the areas that need further work are quickly identified. The PDRI consists of three main sections:

1. Basis of project decision
2. Basis of design
3. Execution approach



Source: Adapted from CII 2013.

FIGURE 7.5 PDRI definition levels

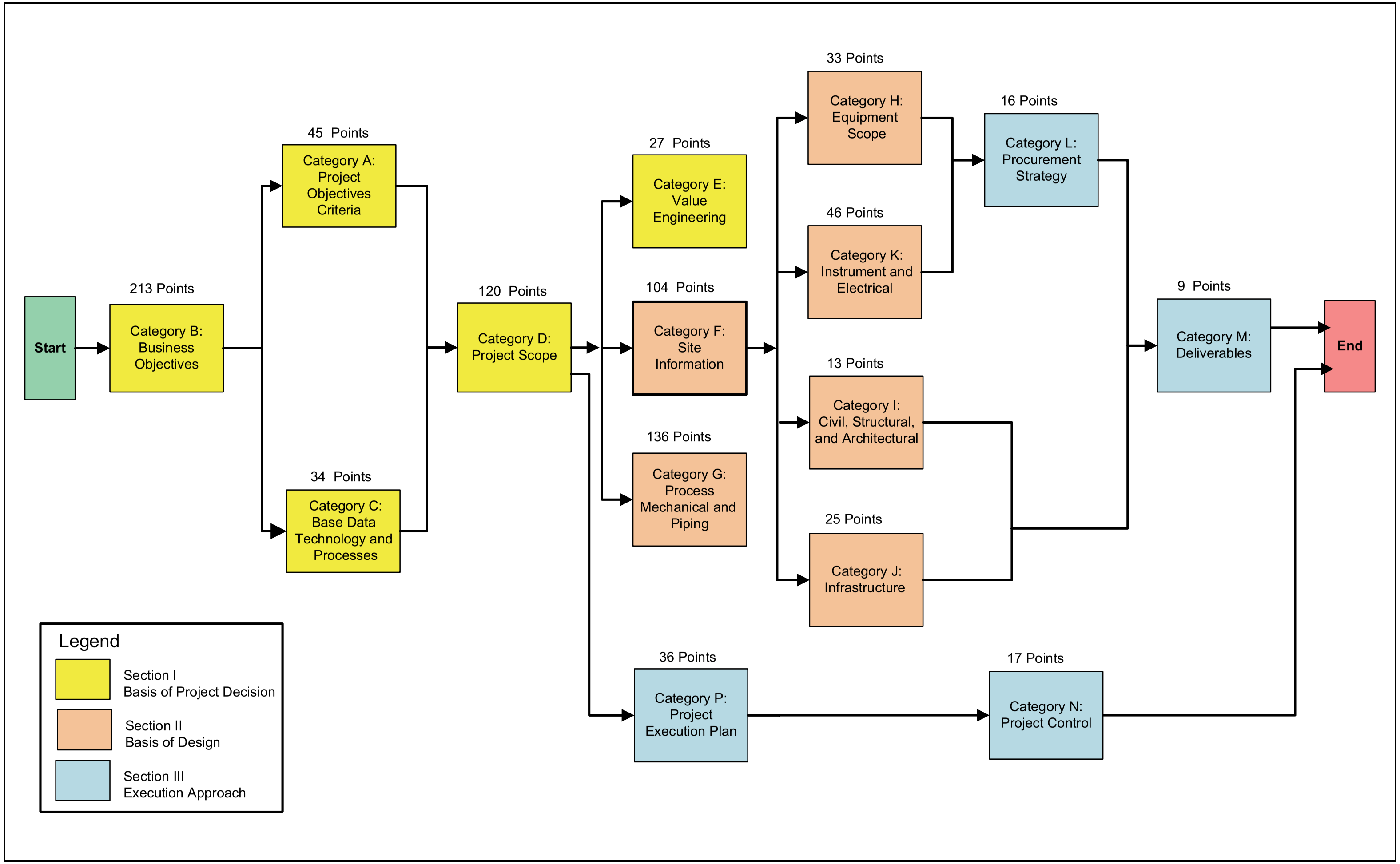
These three sections are then further subdivided into a weighted logic matrix of 15 categories (containing the 70 scope definition scoring elements), as shown in Figure 7.6. A PDRI score of 200 or less has proven to lead to an increase in the probability of project success.

If the project team elects to use the PDRI, (and it should), then Edition IR 113-2 for industrial projects is the version to use. The CII has two other versions (for buildings and for infrastructure), but both of these are less applicable to mining.

KEY FEASIBILITY STUDY DELIVERABLES

The following are the deliverables that an Owner should expect to have at completion of the feasibility study:

1. Reserves published with National Instrument classification NI 43-101, JORC Code, or SAMREC Code quality
2. Project scope firmly set—no major trade-offs, alternatives, or gaps remaining
3. Geotechnical (pit slope and building foundations) study complete
4. Hydrology study complete
5. Mine plan complete—annually for first 5 years, along with mine life output
6. Process plant process flow diagrams and mass balances established
7. Key piping and instrumentation diagrams (P&IDs) prepared; initial plot plans and general arrangement drawings complete
8. Design standards selected
9. Project criteria and basic data established
10. Requisite infrastructure and project utilities fully identified



Source: Adapted from CII 2013.

FIGURE 7.6 PDRI logic flow diagram

11. Design (basic) engineering essentially complete (>85%)
12. Total engineering more than 20% complete (recommend 25% to 30%)
13. Major equipment and long lead-time items listed
14. Project labor source and productivities known
15. Project Coordination (Level 3) Schedule prepared—logic-driven, resource-loaded
16. Class 3 capital estimate made—with ±15% accuracy at 90% confidence level (i.e., sufficient for a project execution control budget)
17. Project WBS established
18. Quality plan established (for quality maintenance within the project)
19. Risk assessment undertaken and mitigation plans agreed to
20. Economic analysis demonstrating that project deliverables satisfy corporate goals
21. List of all requisite permits, regulatory approvals, and licenses documented
22. Environmental submission prepared (EA, EIS, or ESIA) in a separate document
23. Engineering contractor selected (or a short list of viable EPCM contractors in hand)
24. Procurement plan outlined (sourcing, logistics, and materials management)
25. Straw man organization chart for project execution complete
26. Project delivery method proposed
27. Contractor work packages proposed
28. Preliminary Project Execution Plan prepared (in a separate document)

TYPICAL EXAMPLE OF A FEASIBILITY STUDY

For reference and guidance, the typical degree of detail required for completion of the feasibility study is provided in Column 3 of Figure 13.1.

CHECKLIST 7.1 FEASIBILITY STUDY

No.	Item	Status	Date	Initials
1	Completed scoping evaluation or prefeasibility study—in hand			
2	Management approval to proceed (per Chapter 5)—authorized			
3	Scope of work for feasibility study set and agreed upon with Owner			
4	Project team identified and project manager named			
	A. EPCM contractor support to project team—selected			
5	Property and site description			
	A. Data collection—undertaken			
	B. Background report—complete			
6	Mineral rights secured; land ownership / property lease—in place			
7	Field visits undertaken by:			
	A. Project leader			
	B. Core leadership group within project team			
	C. Key EPCM discipline heads			
	D. Owner's team (operations, business, and HR)			
	E. All project specialists (geotechnical, hydrology, etc.)			
	F. Power expert			
	G. Logistics and materials management			
8	Site constraints (location, climate, topography, access, etc.)—defined			
9	Geology program:			
	A. On-site mapping and sampling by geology team—done			
	B. Verification of existing data (including core assay checks)—OK			
	C. Confirmatory development and drilling—complete			
	D. Bulk sampling for metallurgical program—complete			
	E. Mineralogical study—undertaken			
	F. Geologic model—created			
10	Mineral resource determined			
11	Mine reserve produced to NI 43-101 / SEC Form 10-K quality (2 derivations)			
	A. Cutoff grade defined			
12	Mining program:			
	A. Initial access to deposit—established			
	B. Geotechnical study—undertaken			
	C. Pit slope determination and stability study—complete			
	D. Pit prestrip and pioneering requirements—determined			
	E. Mining method—selected			
	F. Detailed mine plan—designed (including scope and criteria)			
	G. Mine equipment—selected			
	H. Mine services—detailed			
	I. Production schedule (annual and mine life)—complete			

(Continues)

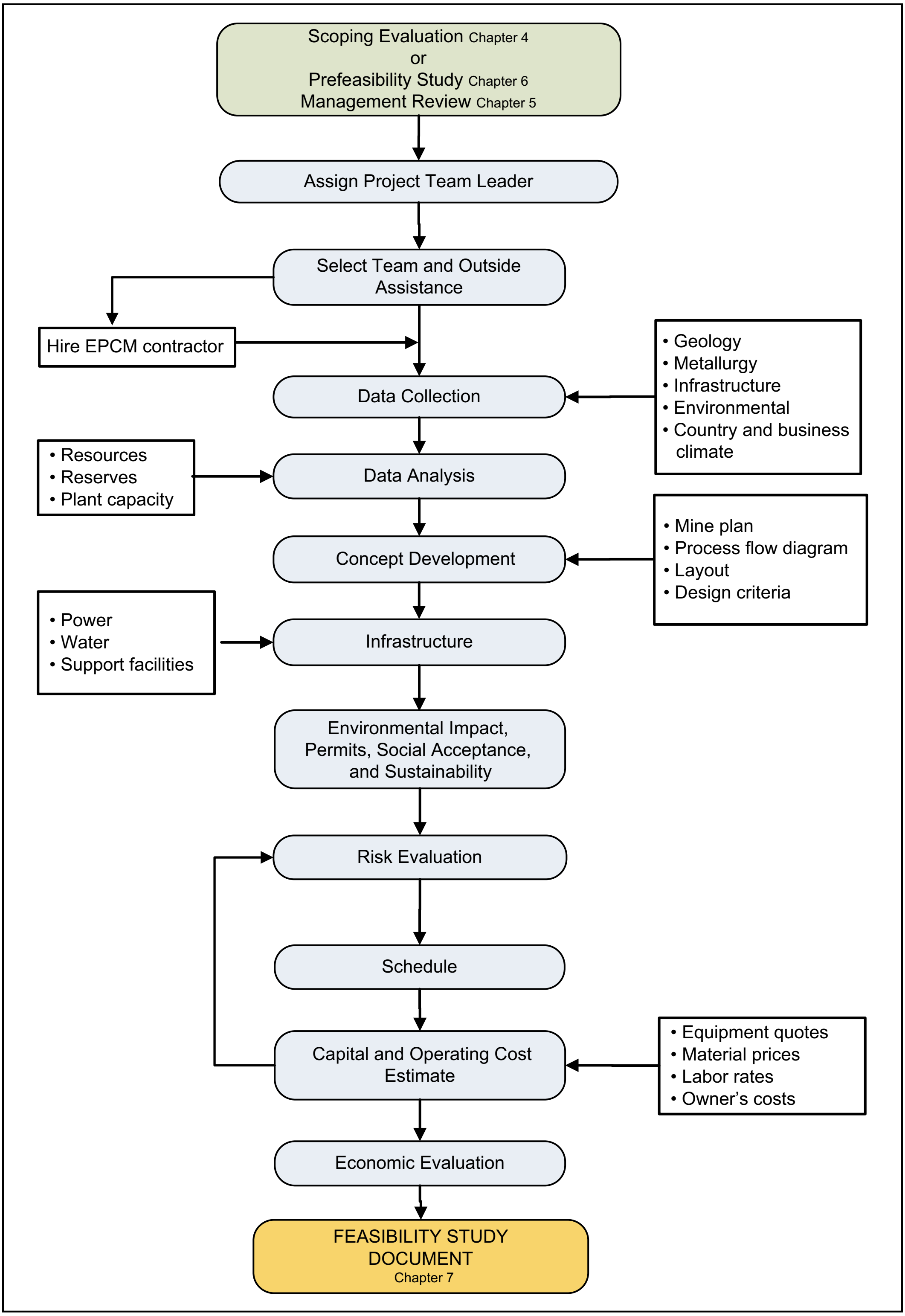
(Continued)

No.	Item	Status	Date	Initials
13	Metallurgical program—all requisite elements undertaken:			
	A. Metallurgical map of deposit			
	B. Ore characterization tests (hardness, abrasion, etc.)			
	C. Bench-scale lab tests on collected samples and/or new core			
	D. Process tests (float, grind, column, etc.)			
	E. Bulk (module) heap or leach tests—as appropriate			
	F. Pilot-plant test			
	G. Reagent selection tests			
	H. Salable product determination (composition and transport)			
14	Mineral process flow diagram—suitability confirmed			
15	Engineering design:			
	A. Soil and geotechnical reports—complete			
	B. Topographic maps (1:2,000 at 2-m contours)—in hand			
	C. Basic engineering—more than 85% complete			
	D. Value engineering trade-offs—complete			
	E. Overall engineering—more than 20% complete			
	F. Process flow diagram—determined			
	G. Mass and water balances—calculated			
	H. Design standards, criteria, and specifications—developed			
	I. Site facilities location layout map—established			
	J. Detailed general arrangement drawings—produced			
	K. Equipment sizes and specifications—detail list complete			
	L. Process description—detailed narrative produced			
16	Infrastructure, support services, and utilities—needs identified and sized			
17	Hydrology—initial study completed			
	A. Dewatering strategy—in place			
	B. Water supply (process and potable)—determined			
18	Communications—system designed			
19	Power availability—initial study completed			
20	Access and transport (roads, rail, port, air)—initial study undertaken			
21	Project security—requirements documented			
22	Materials management:			
	A. Procurement plan—prepared			
	B. All long lead-time items—identified			
	C. Preliminary transport and logistics plan—undertaken			
	D. Warehousing and laydown sites—identified			
23	Workforce requirements—listed by job function and pay rate			
	A. Health and safety requirements—documented			
24	Training program needs—outlined			
25	Environmental and social impacts appraisal and quantification—done			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
26	Environmental studies:			
	A. Environmental specialist—on-site			
	B. Baseline data gathering—undertaken			
	C. Red-flag issues—identified and evaluated			
	D. Environmental monitoring and control program—initiated			
	E. Sediment and erosion plan—prepared			
	F. Reclamation plan—complete			
	G. Acid rock drainage study—complete			
	H. Geotechnical analysis for tailings and dumps—undertaken			
	I. Chemical reagents handling plan—produced			
	J. Characterization of environmental risks—undertaken			
	K. Environmental impacts and mitigation report—complete			
	L. ESIA / EIS / EA (or equivalent)—submitted			
27	Permits:			
	A. Existing and proposed regulations—fully determined			
	B. Approval schedule list—complete			
	C. Permit application submittals—initiated			
28	Social acceptance baseline study and impact analysis—complete			
	A. Social management plan—developed			
29	Sustainability and mine closure requirements assessment—produced			
30	Level 3 Project Coordination Schedule (Gantt chart with work elements)—complete			
	A. Major milestones list—produced			
31	Work breakdown structure (WBS)—produced			
32	Project execution framework—outlined			
	A. Project controls system—outlined			
	B. Project reporting needs—defined			
	C. Quality management program—outlined			
33	Capital estimate (±15% accuracy at 90% confidence)—complete			
34	Operating cost estimate—complete, by area and by element			
35	Economic evaluation: IRR (pre- and post-tax) and NPV—finalized			
36	Market analysis—performed			
37	Currency exposure—defined			
38	Risk assessment (including country risk, if international)—complete			
39	Project opportunities analysis—complete			
40	Statement of project's competitive advantage—prepared			
41	Determination of whether project meets Owner objectives—done			
42	Project Definition Rating Index (PDRI) on project readiness—undertaken			
43	List of potential partners—prepared, if appropriate			
44	Financing options—identified, if required			
45	Feasibility study document—complete			



FLOWCHART 7.1 Feasibility study

CHAPTER 8

Environmental Impact, Permits, Social Acceptance, and Sustainability

Just because you have a mineral anomaly that can make you money, it doesn't give you the right to dig a hole in the ground. Society has to be OK with it.
— Robin J. Hickson, March 1986

Nature provides a free lunch, but only if we control our appetites.
— William Ruckelshaus, June 1990

OBJECTIVE

This chapter lays out the steps that need to be undertaken for the project to earn acceptance and approval from external controlling entities. The efforts required to gain the necessary approvals at each study stage are summarized and contrasted with each other in this chapter. Effort levels increase as the project progresses from scoping, through prefeasibility, then feasibility, and on to execution. The objective here is to ensure that the project is cognizant of and addresses the environmental, societal, and sustainability factors that shape mining projects today.

SCOPE REALITY

The two quotes at the lead-in to this chapter pertain not only to free, capitalistic market economies, but they are equally valid for centrally planned Marxist economies such as the old Soviet Union or the quasi-dictatorships found in several corners of today's evolving world. The reality for any mining project is that there is always some crucial element of society, not controlled by the mining company, with a completely different agenda and set of values that needs to believe it is not being materially harmed if the venture goes forward. This does not mean that they it has be converted into a supporter of the venture, or that the project cannot go forward if dissenters exist. It just means that the issues and concerns of these key segments of society have to be defused.

Telling these societal elements that "jobs will be created," or "the world needs these minerals for you all to drive around in your Priuses," or that "mines occupy less space than interstate interchanges" does not help. These retorts are your issues, not theirs. To enable the mining project to go forward, it is *their* concerns that need to be focused on and ultimately placated, or better still, removed completely.

UNDERSTANDING EXTERNAL STAKEHOLDERS

Mining projects inevitably impact neighboring stakeholders. There are environmental impacts such as water resource diminution, air, noise and water pollution, dust intrusions, biodiversity loss, and visual landscape changes. There can also be social impacts, such as physical and economic displacement, and changes in the quality and way of life.

Properly understanding the external stakeholders' mind-set regarding these impacts has become critical to a project's success. If stakeholder acceptance for the handling of these impacts is not obtained, then project risks such as delay, access denial to resources, and net present value erosion, along with loss of shareholder trust, are exacerbated.

The scale of value erosion from stakeholder angst over project impacts (real or perceived) can be substantial, sometimes even breaking the project. It is generally borne out in project delays, most of which stem from nontechnical rather than technical or commercial issues.

In a review of 67 mining projects from 2008 to 2012 (all costing more than $500 million), Jonathan Molyneux (2013) of ERM discerned that only 30% of the projects were delivered on schedule, and 81% of the delay causes were nontechnical. The nontechnical causes of delay consisted of the following:

- Lack of social acceptance (e.g., protests by local communities and nongovernmental organizations [NGOs])—42%
- Environmental concerns—35%
- Permit Issues—23%
- Land Access—6%
- Health and safety—6%
- Extreme weather—3%

Even more interesting is that technical challenges did not make the top six in the Molyneux list. Technical causes made up only 3% of the delays. (The remaining delay causes were mostly commercial: revenue-sharing issues with governments, changes in input prices, commodity prices, etc.)

Projects suffering from nontechnical problems also had longer delays (two-thirds delayed by more than a year) than projects with just technical and commercially caused delays (50% delayed beyond 1 year).

DOCUMENTATION

In the United States the environmental work effort and permit approvals are generally accomplished as core components of either an environmental impact statement (EIS) or an environmental assessment (EA). However, most project lending institutions (e.g., the World Bank, European Bank for Reconstruction and Development [EBRD], and Overseas Private Investment Corporation [OPIC]), and many foreign governments (e.g., Turkey) require a much broader document, an environmental and social impact assessment (ESIA), which is in essence a combined EIS, social impact analysis, and sustainability review document all in one.

For simplicity, this book's premise is that the environmental and permit documents needed to execute a project are different from those required for a social acceptance or sustainability review, regardless of whether the ultimate document has these elements combined or separate.

Environmental and Permit Tasks in the Project Viability Stage

The work effort to obtain the permits necessary to construct and operate a mine needs to be initiated as soon as the project is perceived to have any kind of viability. The work then continues throughout the prefeasibility study (mostly through baseline data gathering), through feasibility with presentation of the environmental documents to the regulatory agencies, and into the execution phase, with the goal of arriving at operational approval prior to the project being handed over to operations. Figure 8.1, taken from a 2014 project in British Columbia, illustrates the length of time that permitting can take and highlights the parallel activities that support the permit process.

Fairly early in the timeline, it makes sense for the mining company's environmental department to assign a dedicated environmental liaison to the project. This will help to ensure that the project's environmental issues are handled properly and timely.

Scoping Evaluation Activities

Environmental and permitting information is collected from readily available sources. The project setting is then evaluated for significant environmental or permitting constraints. (See Chapter 4.) Potential risks are summarized and a conceptual plan for handling the risks is derived.

Prefeasibility Study Activities

Project-related environmental data are obtained from existing sources *and* site visits, then a scope and schedule are produced for meeting the environmental and permit requirements. (See Chapter 6.)

- Red-flag environmental and/or permit issues are preliminarily investigated.
- Design factors influenced by environmental or permit constraints are identified.
- Long lead-time baseline environmental field studies and permitting processes start.
- Conceptual plans for reclamation and sediment control are drafted.

A preliminary environmental management plan encompassing all issues is prepared. The level of work undertaken is equivalent to a Phase I, Environmental Due Diligence, and entails the following elements:

- A preliminary evaluation of the project's impact on the environment
- A realistic assessment of the political and public issues
- A broad summary characterization of the project's environmental and permit risk
- Preliminary plans for management of identified red-flag issues
- The framework for an environmental monitoring program
- A generic listing of the environmental and other necessary permits
- Development of a permit acquisition timetable

If deemed critical to project success, a draft EIS or EA would be initiated at this stage.

Feasibility Study Activities

The project team conducts a comprehensive review of the project's impact on the environment and a detailed assessment of the scope and schedule for obtaining the permits. (See Chapter 7.) All project-related environmental data are obtained from existing sources and databases.

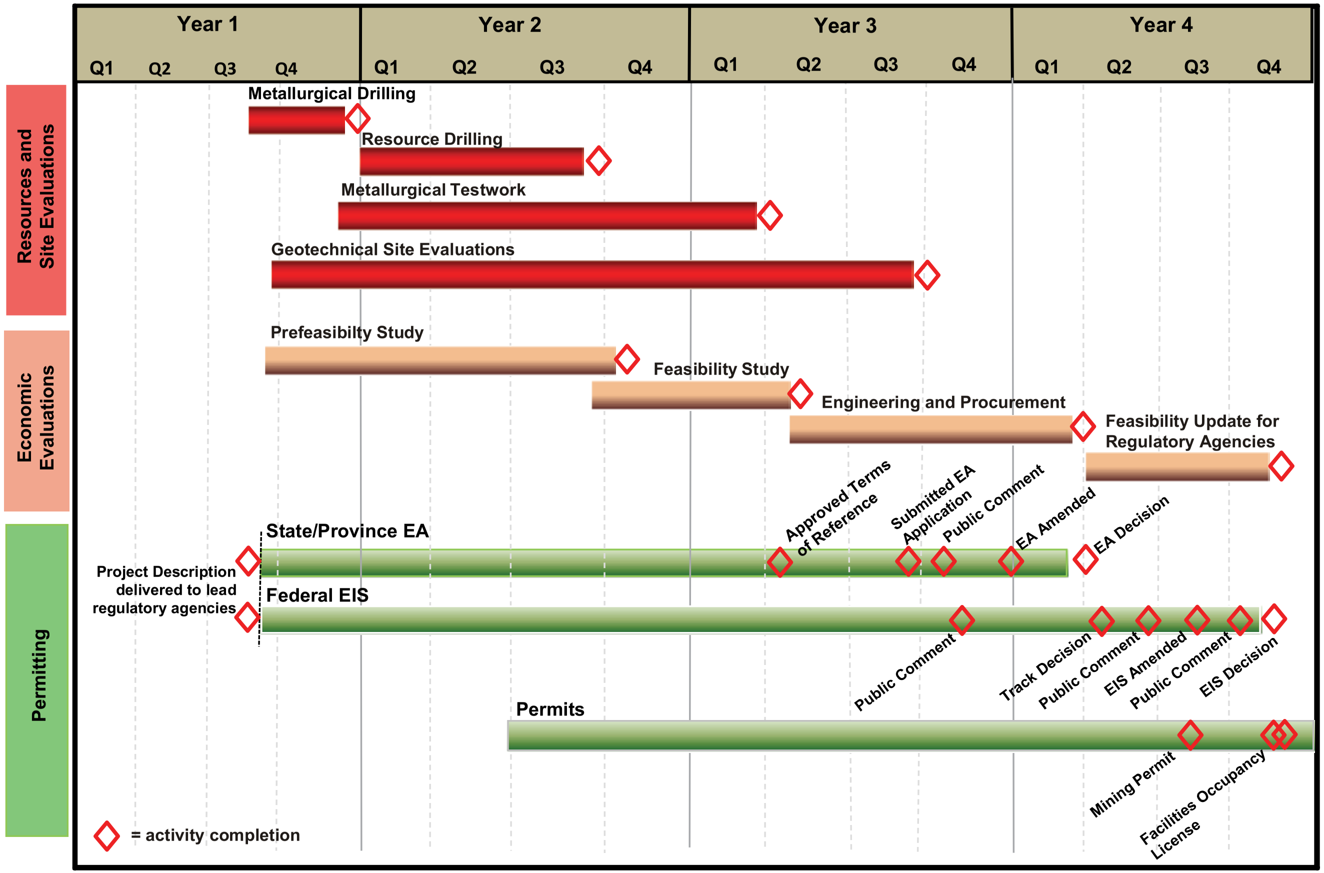


FIGURE 8.1 Permits timeline example

Site-specific environmental sampling and analyses are complete. For greenfield projects, a completed evaluation of all baseline environmental conditions is mandatory. Red-flag issues are fully investigated and evaluated. All major project design considerations that may be influenced by environmental permitting constraints are identified. For example, will the tailings impoundment need a nonconventional liner?

Long lead-time environmental studies would all have been started by this time. Reclamation plans and sediment- and erosion-control plans are prepared. Initial environmental (and some other permitting) applications would usually be submitted during this stage, using the engineering effort in hand.

A comprehensive environmental management plan that covers all environmental issues is produced. This work component is accomplished as part of an EIS or EA in the United States, or as part of a broader environmental evaluation that is often required by a project's foreign location or by the project's lending institutions (e.g., an ESIA is required by the World Bank, EBRD, and OPIC.) The level of work is equivalent to a Phase II, Environmental Due Diligence, and entails the following elements:

- The environmental and permitting considerations are summarized, including
  - A focused characterization of the project's potential environmental impacts,
  - A realistic assessment of the political and public issues, and
  - A detailed characterization of the environmental and permitting risk.
- The management of each red-flag issue is laid out.
- A finalized environmental monitoring program is developed.
- A full listing of the specific environmental and other necessary permits is created.
- The permit acquisition timetable is developed.
- Legal constraints (scope, timing, and cost) to obtain the permits are highlighted.
- Environmental mitigation measures that are necessary for permit approvals are identified.
- Designs are produced to reduce carbon emissions and promote sustainable practices.
- The parties responsible for environmental compliance are identified.

During the feasibility study, the team should not commit on paper to environmental mitigations that are not legally or environmentally necessary just to curry favor with special interest groups. Nevertheless, it is frequently obligatory to go beyond legal requirements to obtain local and stakeholder social acceptance. If this latter situation exists, then the additional cost of so doing needs to be highlighted.

REGULATORY PROCESS FOR PROJECT EXECUTION

The environmental regulatory process involves a series of steps and activities to achieve the overall objective of gaining approval to develop the property (Owen 2014). Social acceptance and sustainability are integral parts of this process.

Successful negotiation of the environmental approval process typically necessitates an embracing and undertaking of the following, in this or an analogous order:

1. The mining company must have a clearly defined and supportable environmental, social, economic, and sustainability charter. The charter has to clearly state the company's standards in terms the general public and government regulators can accept. This will become the touchstone for all relevant discussions along the permitting path.

2. All federal, regional, and local permits and licenses required to gain approval and operate the mine need to be researched, then listed. All laws relating to permitting and licensing in the country and the local regional area of the mine must be fully understood.
3. The company must clearly and realistically set out the environmental permitting steps that it intends to take to arrive at a final determination for approval of the project, along with the cost of those steps.
4. The company needs to accept that the environmental permit decision-making process will always include defined consultation time periods with external stakeholder groups.
5. The initial step in dealing with the regulatory agencies is typically an approval of a Terms of Reference (ToR) document for the environmental permit application. A ToR document defines what has to be accomplished and can encompass any or all of the following:
    - Vision, objectives, scope, and deliverables (i.e., what has to be achieved)
    - Resource, financial, and quality plans (i.e., how it will be achieved)
    - Schedule (i.e., when it will be achieved)
    - Stakeholders, roles, and responsibilities (i.e., who will take part in it)
    - Success factors, risks, and restraints
6. All ToR documents require a project description. Because of the detail required in a project description, it is almost impossible to progress beyond the permit application process prior to the feasibility study being complete. The description needs to focus on the likely areas of concern and why the particular project development path has been chosen.
7. The project description needs to include the following areas at a minimum:
    - Mineral resource
    - Metallurgy
    - Mine operations
    - Mineral recovery process
    - Tailings deposition and storage
    - Water management
    - Concentrates or finished product handling off-site
    - Construction and operations camps
    - Access road(s)
    - Power transmission system
    - Design basis information
        - Avoidance of environmentally sensitive areas
        - Minimization of the mine's or facility's footprint
        - Design for closure
        - Minimization of effluent discharges into the environment
8. Following submittal of the application report that complies with the ToR, stakeholders who have an interest in the project during construction and/or operations or after closure are consulted for input. At a minimum this would include the following:
    - Government agencies (federal, regional, local)
    - Communities in the socioeconomic zone around the property
    - Aboriginal groups
    - Other stakeholders connected to the project.

9. Working groups are then identified and agreed to with government regulators and engaged as part of the consultation process. This includes all the prior identified groups but will now also include the general public.
10. Following the consultation process and regulatory review of the application, guidelines are issued for environmental permit submittal, be it an EA, EIS, or ESIA. These guidelines are generally issued by the designated lead governmental agency.
11. The environmental permit application document (EA, EIS, or ESIA) is then prepared by the mining company, working with all the involved regulatory agencies, in a format that can be shared with the various stakeholder groups.
12. Pertinent information is distributed for use and feedback during this process.
13. Ancillary and supporting permits will typically need to be submitted for approval to the appropriate suite of governmental entities for each individual agency's decision during this EA, EIS, or ESIA document preparation period.
14. Throughout the EA, EIS, or ESIA preparation period, the engagement process with stakeholders continues. All concerns, opportunities, and challenges must be addressed, and where necessary, design changes made to the project that can be accommodated within the economic realities. It is during this stage that the project proponents must be careful not to agree to changes for project approval that will have long-term detrimental effects to the project's future viability.
15. The final submittal is made to the appropriate agency after consultation periods are completed and the changes and challenges addressed such that the approving agency has the relevant information to make a proper determination.
16. Decision is made by the lead agency about whether or not to issue the environmental permit.

SOCIAL ACCEPTANCE

Gaining social acceptance to construct (and operate) a mining project can wreak havoc with financial and engineering schedules. Just ask the owners of Crandon in Wisconsin, Rosia Montana in Romania, or Conga in Peru. It is a mining axiom that mineral deposits are where you find them, and that mineral deposits always have neighbors. The many ways that mines affect neighbors make those neighbors stakeholders. Roads always go through someone's land or affect someone's access. Mines always impact someone's water supply or someone's viewshed. The bigger the project's effects, the more difficult it will be to gain social acceptance (Albanese and McGagh 2011). The project will be under scrutiny from a myriad of directions.

As difficult as it may be to successfully develop a mining project, the project leaders must proactively seek to understand and then respond to the concerns and aspirations of the impacted communities. To succeed, the project must understand the issues important to the community and must take into account people's perceptions of the effects and consequences of the project. Who are the local community stakeholders? Are they municipalities, ranchers, or farmers? Are they residents or migrants, educated or uneducated, affluent or poor? Are they presently for or against the project?

To gain social acceptance, the project team must do its best to accommodate the different cultures, lifestyles, heritages, and preferences of the project's neighbors and community. And this must be a real best effort, not phony words. Disingenuous statements will be seen through and ultimately cause the project more grief than nonaction. Earning social acceptance for a mining project involves a fuzzy relationship that does not fit comfortably into a project planning framework. A project development structure is more typically built around material objectives and deliverables. Social impacts can accumulate and interact; they can trigger other impacts. Big, new projects can quickly get out of step with the community if attention to this relationship is not maintained. Not all impacts can be avoided or mitigated. Similarly, not all impacts can be predicted. So an element of uncertainty, that is, risk, will always be present, and this must be recognized.

The economic and calendar treasure that has to be spent to end up with a community that will accept the project needs to be understood, and then monetarily characterized in increasing detail in each of the viability study stages of the project. The Owner will have to do more than just mitigate project-activity disturbance and fulfill environmental compliance. Corporate social responsibility outreach has to let the company and the community share in the values that the project brings. The project will need to transparently contribute to the well-being of the local society: leverage supply chains, nurture entrepreneurship, develop capacity around the project site, and help create healthier and better-educated communities.

The project team has to formulate and implement a mitigation plan for the socioenvironmental impacts expected *before* the start of construction (Franks 2011). This will involve developing scenarios with the Owner's environmental and social responsibility department to put proactive mitigation plans in place ahead of any environmental or social impact that could emanate from the project (or from future operations).

Potential impacts and concerns that undoubtedly will need attention include the following:

- Degradation of surface water channels, and water quality and quantity
- Restrictions to usage of local roads for community residents
- Negative impacts to the surface and/or groundwater.
- Undesirable discharges and dust from stockpiles, waste, and tailings impoundments
- Energy and greenhouse gas emissions
- Public health, human rights, and Indigenous peoples' claims
- Security fears and property damage
- Artisanal mining presence
- Indigenous rights protection
- Resettlement and/or relocation of affected communities
- Unmet, high expectations of employment and contracts by the local community

Measures to prevent negative social impacts include the following:

- Insert personnel within the project team for handling environmental and social responsibility impacts.
- Take action that will minimize social claims. Implement a mitigation plan prior to project development; then provide timely information to the various interest groups. Manage the local employment expectations in coordination with the community leaders. Monitor the community's well-being, including air and water quality, security, and health on a transparent, ongoing basis.

A positive socioeconomic impact can be created in a project area by training local workers and by sourcing products and services locally. Training the local workforce for the project has the added benefit of helping to fulfill staffing needs for the ongoing operations. Subcontracting locally promotes existing resources in the area and expands local business opportunities. Judiciously giving preferences to local businesses is likely a good additional step.

Allocations of time as well as human and monetary resources to earn this social acceptance, and the opportunities (and risks) that go along with it, has become an essential component of any mining project budget and schedule today. These resources must be fully and honestly depicted within the submittals and presentations for project approval.

Community Definition

This book uses Thomson and Boutilier's (2011) definition of *community*: a heterogeneous network (individuals, groups, and organizations) of stakeholders that share a common interest in the project. They are either affected by or can affect the project. Thus the community might include local ranchers who may lose pasture land if the mine project goes forward (i.e., affected by) and international NGOs (i.e., can affect the project). Thus the community, in this sense, is not necessarily only the local geographic community.

Social License: Social Acceptance Versus Social Approval

What a project seeks in *social acceptance* is "the disposition of the community to tolerate, agree to or consent to the project." This is generally perceived as the lower level of a social license. *Full social license* is when the project has also earned the higher level of social approval, that is, "favorable regard of, agreeing to or being pleased with" the project (Thomson and Boutilier 2011).

Full social license approval of the project by the community is nice to have, but not necessarily required for a project to go forward. Most projects are able to proceed solely on the basis of social acceptance from the local community.

SUSTAINABILITY

The 1987 United Nations Report of the World Commission on Environment and Development produced a document titled *Our Common Future* (commonly known today as the Brundtland Report) that defined *sustainable development* as development "which meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations Brundtland Comission 1987).

Sustainable Development

Virtually all mining companies publically embrace the need for their projects to be sustainable. The concept is simple and appealing to all: that the necessary and desired characteristics of human society and the ecosystem—air, water, food, shelter, and quality of life—be allowed to persist indefinitely.

But the translation of this concept to practical action within a project is much more difficult. Sustainable development for a mining project is typically translated to mean that the project should be undertaken in such a way that the project activities and the products produced together provide a net positive contribution to human and ecosystem well-being over the long term (Hodge 2011).

Sustainability Challenges

Mining companies face internal challenges in delivering project sustainability to their external stakeholders. Investment strategy decision making may overlook opportunities in the sustainability arena that can set up the project for success. Many mining companies see the nontechnical issues as cost risks rather than value drivers. External stakeholders are seen as project impediments rather than potential project allies.

To deliver a successful mining project, the mining business has to recognize and deal with today's sustainability realities:

1. Company culture and leadership has to embrace the sustainability paradigm.
2. "Doing the right thing" for all parties needs to be seen as a justifiable value-generating strategy, not merely a political stance.
3. Long-term project benefits need to be accorded greater recognition within the project reward system rather than short-term milestones.
4. External stakeholder engagement needs to start early. Investments need to be budgeted for stakeholder relationship development.
5. Corporate leadership should not send mixed messages by saying that nontechnical aspects are important, but then providing no support for resolving the nontechnical with the technical and commercial issues of a project.
6. The consequences of nontechnical risks need full articulation at the project's front end.
7. Project managers need to be chosen for their nontechnical management skills as well as their project management and leadership skills, and then accorded the responsibility to resolve nontechnical issues during project execution. Matrix management and unaligned project accountabilities can obstruct the integration of technical and nontechnical issues and negatively affect project delivery.

Success with these stakeholder strategies will result in greater assurance at the project's front end that the external stakeholders are sufficiently on board, and will provide timeline confidence for the executive board to authorize the project to go forward.

Community Sustainability Program

The project's sustainability management plan must reflect the company's commitment to sustainability in the environmental, social, cultural, and economic spheres for those communities close to or affected by the project site (SME Sustainable Development Committee 2013). The plan must facilitate indigenous and nonindigenous community relations and participation. There must be a means to address complaints and advice, and provisions to support existing or new community initiatives (Parker 2013).

A local community sustainability program should:

- Respond to community needs, but at same time manage community expectations;
- Proactively develop collaborative, reciprocal relationships built on trust and respect;
- Set mutually beneficial goals that contribute to community sustainable development;
- Focus on programs that develop skills which benefit the mine and the communities;
- Begin skills training early and support it throughout all the project stages (creating hopes that do not materialize will only lead to adverse effects);
- Facilitate the long-term independence of communities by developing transferable skills that enhance individuals' capacities for income generation postmine closure;

- Serve as a catalyst in the development of activities that will enable the community to thrive economically and socially after mine operations are complete;
- Engage in culturally appropriate consultation with indigenous and other communities; and
- Develop a feedback and conflict resolution program to channel and constructively respond to complaints and advice.

A collaborative approach between project management and the owner's corporate and local sustainability management personnel is requisite (Freeport-McMoRan Copper & Gold 2010). Together they must be able to effectively:

1. Engage the community and gather the necessary data for planning the program, taking into account the social, political, and reputational risks that exist for the Owner;
2. Stay aware of the economic and operational realities of the project and the operations;
3. Develop the program within the company's sustainability and social responsibility framework;
4. Establish the project as a good citizen within the minds of community and regulators; and
5. Implement the program by working collaboratively with the Owner's assigned staff to maintain a competitive return on investment while reducing project risk.

Implementation actions will likely include all of the following:

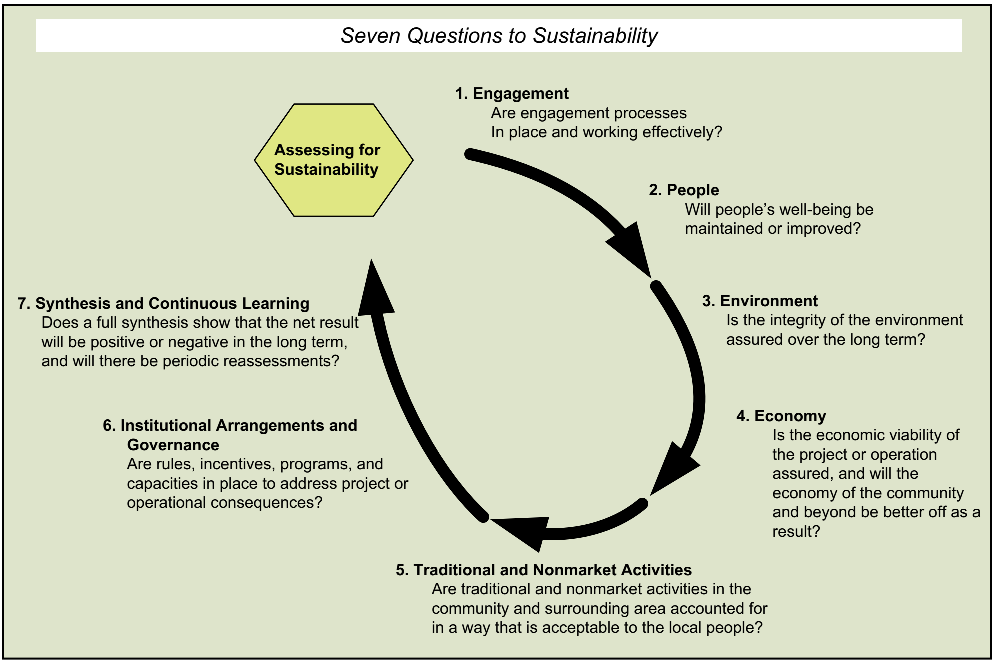
- Maintain a community relations program.
- Report annual objectives internally and externally.
- Survey stakeholders to measure the ongoing status of the project's reputation capital.
- Acquire communications systems and support vehicles.
- Engage employees to support the sustainability process.
- Create strategic partnerships with local enterprises, schools, policy institutes, economic development agencies, and government initiatives.
- Appoint a liaison to work with native peoples.
- Maintain good investor and media relations.
- Name an industry liaison to interface with public Web sites, Facebook, and so forth.

The effective approach is to be proactive, open, and collaborative (Kogel 2013). This requires identification and hiring of personnel with the motivation to engage and the intelligence to maintain the balanced approach required.

Sustainability Review

A pragmatic methodology for bringing the concept of sustainability into practice within a mining project is embodied in the International Institute for Sustainable Development's *Seven Questions to Sustainability* template prepared in 2002 for Mining, Minerals and Sustainable Development North America (IISD 2002). See Figure 8.2.

This template addresses the hard (well-defined) and soft (ill-defined) systems within the project as well as the objective (independent of judgment) and the subjective (dependent on judgment) ideas. Within the sustainability review, these questions must be treated with intellectual rigor as scientifically as possible while respecting site-specific conditions. While these questions are predominantly ethical in nature, the team must never forget that for the project to be successful, it must remain economically viable.



Source: Adapted from IISD 2002.

FIGURE 8.2 Sustainability review

Two key factors will ultimately govern a project's economic viability from a sustainability viability:

1. The permitting and fiscal regimes under which the project takes place must be efficient and not corrupt and must result in security of tenure. Is there a solid "rule of law"?
2. The project outcome must result in an equitable (not necessarily equal) sharing of costs, benefits, risks, and responsibilities between the host government/community and the mining company/investor.

MINE CLOSURE

Mine closure is a concern of the environmental protection plan; it must be addressed to gain social acceptance, and it is a core component of sustainable development. Rather than trying to force this issue into any of the preceding sections, it is prudent to grant mine closure a separate discussion.

Society today places three constraints on a mining project (Ricks 1994):

1. *The polluter pays.* Those who pollute should be responsible for cleanup.
2. *Adhere to the precautionary principle.* Do not advance a project until the consequences are clear.
3. *Practice sustainable development.* The project has to meet the needs of the present without compromising future generations.

To fulfill these objectives, three aspects of closure planning must take place during or prior to feasibility study completion. These aspects are a necessary part of any mining project.

1. Prepare a mine closure plan.
2. Assess the likely environmental impacts associated with the plan.
3. Estimate the implementation costs.

The project planners need to work closely with the environmental and engineering teams to come up with best technical solutions for mine closure.

If the consequences of closure can be foreseen during the feasibility and design stages of the project, then measures can be taken that can mitigate, ameliorate, or, in the best case, completely avoid the undesirable effects of the project. Minimizing and/or eliminating potentially detrimental effects at project outset, in the ESIA stage or before, bestows considerable benefit. Such action speeds up permit approval and will save the Owner expensive modification costs when closure finally does arrive.

The ultimate intention is to create conditions after the cessation of mining activities that pose negligible risk to the local population and the local environment in both the short and the long term. The objective is to create a closeout or walk-away stage for the mine operators to formally sever links with the site and dispose of it on the open market, or in some other way to appropriate it to an after-use.

To achieve mine closure, a phased program of decommissioning, rehabilitation, and restoration is needed. This will comprise stages of active and passive care.

The active care program is the period immediately following mining cessation. Ideally, this period lasts a few years at most, but in reality, this period has stretched into decades for numerous properties. During this period, the following steps, among others, need to be budgeted into the feasibility study (Goodbody 2013b):

- Reemployment efforts for mine personnel
- Mine decommission
  - Removal and/or demolition of fixed plant, buildings, and infrastructure
  - Sealing underground openings and vent raises
- Water management
  - Installation of site drainage
  - Monitoring mine water issues (surface runoff, mine flooding, and tailings drainage)
- Site rehabilitation
  - Reclamation of decommissioned areas back to their premining land use if practical or to some other agreed land use
  - Recontouring of waste dumps and ancillary features
  - Revegetation of tailings areas
- Surface restoration
  - Renovation of areas where mining activity caused environmental damage
  - Seeding, maintaining, and monitoring of native plant growth
- Identification, treatment, and rendering harmless all sources of potential pollutants
  - Protection of the surrounding environment from possible degradation
- Maintenance of the site until such time that it can be shown that all areas are physically, chemically, and biologically stable and do not pose a threat to local inhabitants

The passive care program includes the following elements:

- Sampling and monitoring to clearly show that the active care program was successful and that the walk-away state has been attained
- Demonstration that the site can be self-sustaining for an indefinite period of time

Ideally, a passive care program should take no more than 2 or 3 years, but the duration is very site specific.

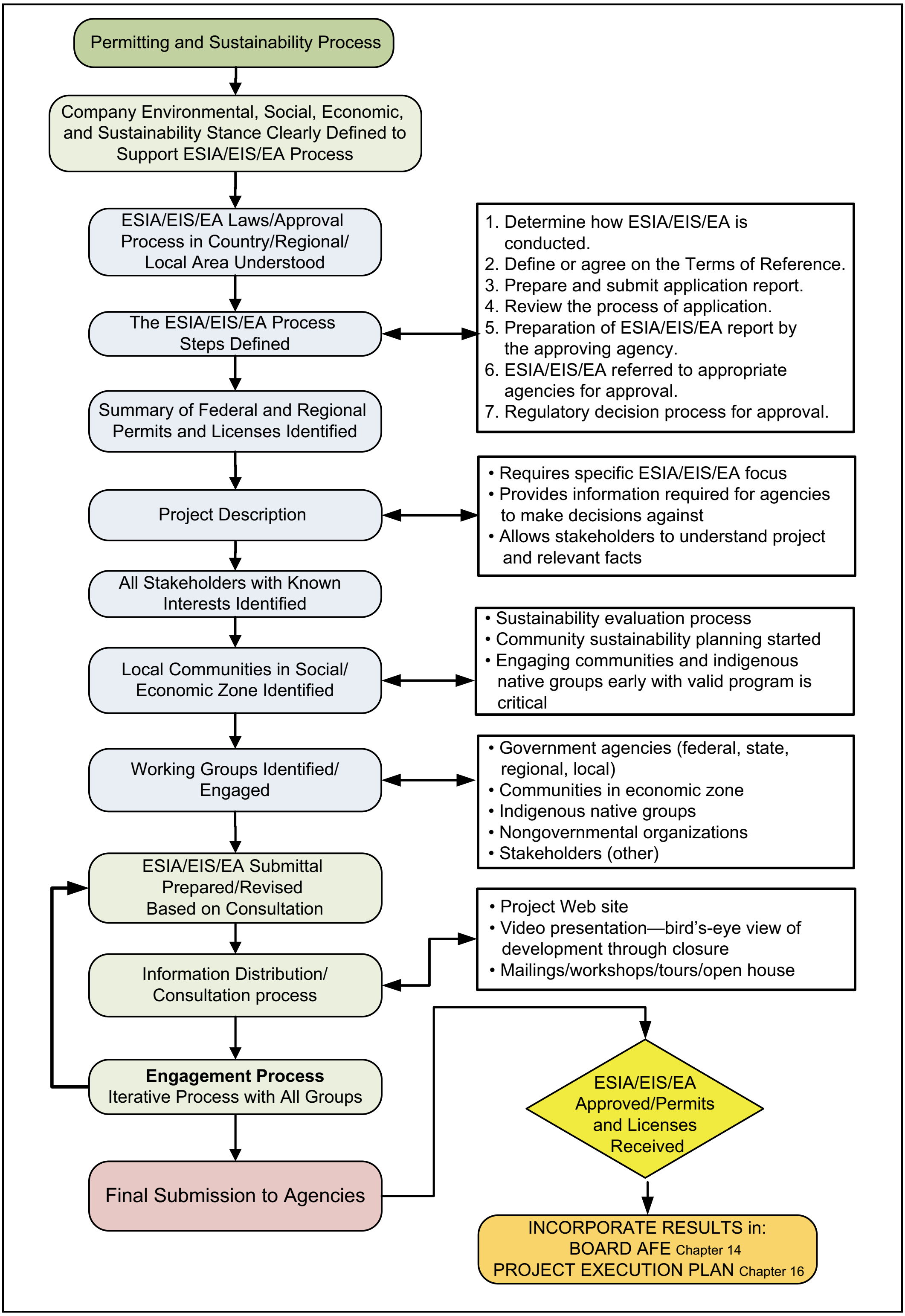
CHECKLIST 8.1 ENVIRONMENTAL IMPACT, PERMITS, SOCIAL ACCEPTANCE, AND SUSTAINABILITY

No.	Item	Status	Date	Initials
1	Owner's environmental, social, and sustainability stance—understood			
	A. Environmental, social, and sustainability charter—in place			
2	Familiarity with current situation at the location of project:			
	A. Scoping evaluation, prefeasibility and feasibility studies—reviewed			
3	Permit regime that governs the project locale—fully comprehended			
	A. Federal (existing and proposed regulations)—determined			
	B. Regional (existing and proposed regulations)—determined			
	C. Local (existing and proposed regulations)—determined			
4	Permit or license list (federal, regional, local)—prepared			
	A. Permitting steps—clearly and realistically documented			
	B. Environmental and permit constraints / risks—identified			
	C. Permit schedule—established (with submittal dates)			
5	Environmental program:			
	A. Environmental specialist team—on-site			
	B. Baseline data gathering—undertaken			
	C. Environmental monitoring and control program—initiated			
6	Environmental studies:			
	A. Sediment and erosion plan—prepared			
	B. Reclamation plan—complete			
	C. Acid rock drainage study—complete			
	D. Geotechnical analysis for tailings and dumps—undertaken			
	E. Chemical reagents handling plan—produced			
	F. Characterization of environmental risks—undertaken			
	G. Environmental impacts and mitigation report—complete			
7	Key environmental management permits (EA, EIS, or ESIA)—determined			
	A. Project description—completed			
	B. Terms of Reference (ToR)—accepted by regulatory agencies			
	C. Ancillary and support permits—identified			
	D. Project impact appraisal and quantification—undertaken			
	E. Red-flag issues—identified and evaluated			
	F. ESIA / EIS / EA (or equivalent)—submitted			
8	Stakeholders (internal and external)—identified and contact established			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
9	Local communities, Indigenous peoples, and interested parties:			
	A. All community parties—catalogued			
	B. Project working group organization—in place			
	C. Community relations program—established			
	D. Critical external stakeholder engagement—achieved			
10	Social acceptance issues—documented			
	A. Baseline study and impact analysis—complete			
	B. Potential negative social impacts—identified			
	C. Consultation process—established			
	D. Issues requiring acceptance by external stakeholders—all identified			
	E. Social management plan—developed			
11	Sustainability process—initiated			
	A. Sustainability review—complete			
	B. Sustainability management plan—produced			
12	Closure plan—produced			
	A. Likely environmental impacts—assessed			
	B. Active and passive care programs—developed			
	C. Implementation costs—estimated			



FLOWCHART 8.1 **Environmental impact, permits, social acceptance, and sustainability**

CHAPTER 9

Risk Management

If no one ever took risks, Michelangelo would have painted the Sistine floor.
— Neil Simon, 1927 to present

OBJECTIVE

This chapter identifies the types of risk faced by a mining project and lays out the steps to best manage those risks.

Risk management is the formal identification, assessment, and prioritization of project risk, followed by the coordinated and economical application of resources to minimize, monitor, and control risks. In other words, risk management seeks to reduce the probability and impact of those risks. Risk management's ultimate goal is to maximize the realization of opportunities.

A risk management framework needs to run through every stage of the project to ensure that the long-term decisions, as well as the day-to-day operational choices, are all made objectively with the project's goals in mind (McVeigh and Rutherford 2013). Risk management has earned an unfortunate reputation of being a laborious, bureaucratic process, but it does not need to be. It can be applied in simple, logical steps, and its implementation can mean the difference between failure and success for the project.

The objective here is for the project team to understand the risks of a mining project, and to apprise the team of the risk management mechanisms that are available to address the factors that underlie these risks.

RESPONSIBILITY

The execution of any capital project requires that all risks associated with the design, construction, and initial operations be properly managed and mitigated.

Risk management is a primary responsibility of the project manager. This responsibility begins during the planning stage and continues through project turnover and completion. The project manager should not stand alone in managing risk, however. The mining company needs to support the project manager's risk control efforts by bringing a corporate focus into the management of risk, starting with the governance framework. Corporate guidance is needed for project risk assessment from both an enterprise risk management and a technical perspective, at the beginning and throughout the project life.

WHAT IS PROJECT RISK?

Risk in its fundamental sense is simply the possibility of suffering harm or loss. *Project risk* can be more specifically defined as an unforeseen event or activity that can impact the project's progress, result, or outcome in a negative way. The opposite of project risk is *project opportunity*, which can impact project progress in a positive way.

To be even more specific for the mining industry, Stantec's *Hard Rock Miner's Handbook* (de la Vergne 2003) defines *mining project risk* as "an alteration of anticipated capital expenditures caused by an unforeseen circumstance or event."

Risk can be assessed using two factors: impact and probability. Thus, if the probability is 1, the risk has already materialized. If the probability is 0, the risk will not happen and it should be removed from the risk register.

The actuarial formula for risk is:

$$\text{risk} = \text{probability} \times \text{magnitude}$$

Therefore, if the probability of an untoward event (such as a power outage) is one chance in 50, and the cost of the event (if it occurs) is estimated to be $500,000, then the risk is $10,000.

This simple formula, while useful, needs the aid of more sophisticated procedures to fully capture mining project risk. But before one can handle risk, one has first to be aware of the inherent threats that reside within a mining project.

MINING PROJECT THREATS

In its July 2012 global analysis of the mining industry, Ernst & Young reported that the threats facing the mining sector in 2013 were becoming more extreme and complex. Resource nationalism remains the number one threat. Many host governments are seeking a greater take from their mining projects and are imposing new requirements, such as mandated beneficiation, export levies, and limits on foreign ownership. Projects around the world are seeing a degraded risk–reward equation and a destruction of project value.

"Global labor skills shortages" and "difficulties with infrastructure access" retain second and third spots on the threat rankings. Both threats highlight the supply capacity constraints that continue to hamper the mining projects world.

Demands for a greater sharing of the project benefits made its debut on the threats list in 2012. Stakeholders ranging from the government to employees, the local community, and suppliers all believe they are entitled to a greater proportion of the mining project revenues. According to Ernst & Young (2012), the top mining threats for 2013 were as follows, in order of concern:

1. Resource nationalism
2. Labor skills shortage
3. Infrastructure access
4. Cost inflation
5. Project execution
6. Social license to operate
7. Price and currency volatility

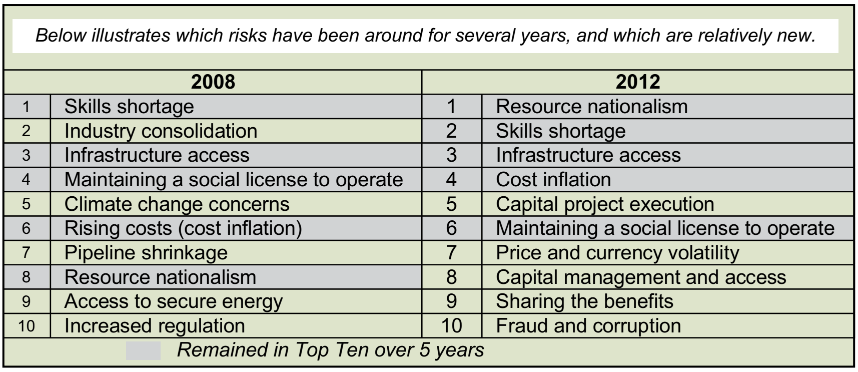
8. Capital access
9. Sharing the benefits
10. Corruption and fraud
11. Access to water and energy
12. Joint venture partner issues and agendas
13. Land use competing demands
14. Climate concerns
15. New technologies
16. Increased regulation
17. Community activism

Five of the threats have consistently remained in the top ten over the past 5-year period, while five have fallen out of the top ten altogether. Consequently, it is imperative for mining companies to remain nimble in how they manage these issues. Figure 9.1 illustrates which threats have been around for several years, and which are relatively new.

In its January 2014 identification of mining issues, Deloitte (2014) had a slightly different ranking than Ernst & Young regarding the current threats, but essentially the same top issues stand out. According to Deloitte, the top mining threats in order of concern are:

1. Cost of contraction (inflation, execution, and water and energy access);
2. Price and currency volatility;
3. Capital access and capital allocation;
4. Local community demands and sharing the benefits (i.e., social acceptance to operate);
5. Resource nationalization;
6. Corruption and fraud; and
7. Labor skills shortage.

The preceding lists contain the broad threats that mining faces; they provide the reader with a flavor of the perils to be faced. Specific project risks will be discussed later in this chapter.



Below illustrates which risks have been around for several years, and which are relatively new.

2008		2012	
1	▨ Skills shortage	1	▨ Resource nationalism
2	Industry consolidation	2	▨ Skills shortage
3	▨ Infrastructure access	3	▨ Infrastructure access
4	▨ Maintaining a social license to operate	4	▨ Cost inflation
5	Climate change concerns	5	Capital project execution
6	▨ Rising costs (cost inflation)	6	▨ Maintaining a social license to operate
7	Pipeline shrinkage	7	Price and currency volatility
8	▨ Resource nationalism	8	Capital management and access
9	Access to secure energy	9	Sharing the benefits
10	Increased regulation	10	Fraud and corruption

▨ *Remained in Top Ten over 5 years*

Adapted from Ernest & Young 2012.

FIGURE 9.1 Top ten mining project threats 2008–2012

WHAT IS RISK MANAGEMENT?

Project risk is essentially defined as any factor that may *potentially* interfere with successful completion of the project. Thus *risk*, by its strict definition, is not a problem; risk is a recognition that a problem might occur. Semantics aside, the objective of the project manager is to recognize any and all potential problems so that a path of appropriate action can be charted to prevent these risks from becoming a problem. This is risk management.

Risk management is the process of identifying, quantifying, and managing the risks that can prevent an organization from achieving its objectives. Risk management uses analysis, assessment, control, avoidance, minimization, and/or elimination to handle unacceptable risks. Note: If risks are acceptable, they do not need to be managed.

Prior to the active management of project risk, a robust project governance approach needs to be implemented to ensure a consistent approach to risk assessment and handling. Once governance is in place (see Chapter 3), risk management can proceed.

THE RISK MANAGEMENT PROCESS

The approach the project team will use to manage risk is defined up-front in the planning stage, captured in the Project Execution Plan, and then executed throughout the project life:

1. Understand the objectives of the project and the project scope.
2. Define expectations and deliverables.
3. Identify the risk "owners" among the project participants.
4. Execute the risk management process.

The risk management plan documents the procedures used to manage project risk. In addition to describing the risk identification and analysis phases, it must cover who is responsible for managing the various areas of risk, how risks will be tracked through the life cycle, how contingency plans will be implemented, and how project resources will be allocated to handle the risks. Risk management encompasses the following distinct elements (Owen 2010):

- **Risk identification.** Identifying the risks is the responsibility of all project team members. A risk register is created.
- **Risk prioritization.** Risks are grouped into risk categories.
- **Risk criteria quantification.** Likelihood and potential impact of each risk is quantified.
- **Risk analysis.** An analysis is prepared for risk, using the actual data collected and/or assumptions made. The analysis contemplates what can go wrong within the project.
- **Risk "ownership" assignment.** Accountabilities for developing and successfully executing mitigation plans are established.
- **Risk mitigation.** The risk mitigation, that is, the risk treatment, is implemented.
- **Risk monitoring.** Risk monitoring tracks risk mitigation activity.
- **Risk reporting.** Risk reports review status and update the risk register. Reports should additionally refresh mitigation plans and incorporate any new identified risks.

The process of risk assessment against the strategic, business, and operational objectives of the project is central to project management. The risk registers have to be maintained and regularly updated, and actionable controls for the identified risks must be implemented.

Risk Identification

Risks are present in all phases of just about every project. The question to initially ask is thus, "What adverse things can happen to our project?"

To answer this question, an appropriate group of senior executive, operations, and project personnel need to come together as a group in a working session and agree on the specific list of risks for this particular enterprise. Company and prior project experiences, along with the project stages ahead, need to be considered. Any assembled list would certainly need to include the following elements, among others, such that all potential risks to the project are captured:

- Constructability
- Installation cost
- Operations
- Geology
- Technology
- Environmental impact, permits, social acceptance, and sustainability
- Market
- Political, country, and business climate
- Financeability, tax, and foreign currency

To provide a flavor of the likely effort involved, a list of the unique issues to review for a country risk analysis is shown in Figure 9.2.

The end step of risk identification and the precedent step for risk prioritization involve the creation of the risk register document. The risk register should capture the key element of each identified risk.

Risk Prioritization

After identifying the risks, the next step is grouping the risks into logical categories, such as strategic, financial (cost), operational, execution, schedule, quality (reliability), safety, environmental, customer, and reputation.

A simple risk register for a fictitious Ruff Terrain Mine is shown with the risks prioritized in Figure 9.3.

Risk Criteria Quantification

The next question after risk prioritization is, "How likely is it that the events listed in the risk register will actually occur?"

Criteria have to be developed to prioritize the likelihood of the risk occurring, ranking likelihood from one extreme to the other for the particular project, to allow the process of managing the risk to be appropriately handled. The following five criteria are common likelihood levels:

▪ Rare	<5% chance of occurrence
▪ Unlikely	5% to 19% chance of occurrence
▪ Possible	20% to 49% chance of occurrence
▪ Likely	50% to 94% chance of occurrence
▪ Almost certain	≥95% chance of occurrence

No.	Item	Status	Date	Initials
1	Economic and Monetary Factors			
	A. Real growth, inflation, employment, diversification of economy			
	B. Currency stability, profit repatriation, trade balance, donor agency role			
2	Political Factors			
	A. Democracy or one-party; socialist or market-driven, succession			
	B. Power of leader, judicial system, military, social factors			
3	Policy, Legal, Government			
	A. Corporate law—integrity, practice, enforceability			
	B. Limitations to foreign ownership			
	C. Land status, mining rights, third-party rights, tenements			
	D. Foreign investment incentives—existence,enforceability			
	E. Import/export restrictions, price/currency controls			
	F. Foreign corrupt practices act			
4	Business Practices			
	A. General ethics, productivity of labor, red tape, profitability			
	B. Honor of contracts, ease of administrative matters			
5	Infrastructure			
	A. Roads, railways, telecom, power, water—efficiency and cost			
	B. Availability, maintenance, quality			
6	Geographic Factors			
	A. Accessibility, proximity, climate, and impact on productivity			
7	Labor			
	A. Availability and trainability—technical skills, managerial skills			
	B. Labor unions, salary costs and benefits, work ethic			
8	Tax			
	A. General tax ethics, corporate tax rate, customs duties, value-added tax, etc.			
	B. Incentives, corruptibility of officers, fairness, enforceability, stability			
	C. Royalties, state participation through tax			
9	Financing			
	A. Local banks, international financing, political risk insurance			
	B. Offshore accounts, currency convertibility, profit repatriation			
10	Expatriate Living			
	A. Quality of life—social, recreational, education, health			
	B. Violence, cost, and availability of goods, medical services			
11	Operating History			
	A. Experience of mining and other companies in the country			
12	Environmental and Permitting			
	A. National, provincial, local level			
	B. Guaranty and nondiscrimination agreements			
13	Land Owners and Community			
	A. Issues, compensation, community development programs			
	B. Social disruption, other stakeholders			

FIGURE 9.2 Country analysis—risk areas to review

Relative weights for each level of likelihood are assigned after the risk is identified, grouping the risks and thus leveraging them into standard risk categorizations. This step takes place before placement in the risk analysis matrix engine.

Figure 9.4 illustrates the five-criteria ranking that most mining organizations use to rank risk, along with the rationale for the likelihood assignments. Some firms use three criteria (high, medium, and low), while others use four (very high, high, moderate, and low). The authors favor a five-criteria ranking as it seems to better segregate risk. The actual number of criteria in the scale makes little difference; the important thing is the logical assignment of relative likelihood to each identified risk.

Project: **Ruff Terrain Mine**

				Risk Criteria				Potential Mitigation	
Rank	**Risk ID**	**Risk Description**	**Area of Risk**	**P**	**I**	**RR**	**Risk Assessment**	**Remediation Options**	**Risk Champion**
1	3.1	Outstanding design issues	Quality	4	4	16	H		Engineering Manager
2	4.5	Delay in project approvals	Schedule	5	4	20	H		Permit Coordinator
3	2.7	Additional third-party requirements	Cost	3	3	9	M		Corporate Executive Team
4	4.6	Changes to project information or design	Cost	2	4	8	M		Project Manager
5	1.1	Failure to meet environmental targets	Environmental	2	4	8	M		Environmental Supt
6	1.2	Failure to meet safety targets	Safety	3	4	12	H		Project Manager
7	1.5	Inadequate communications		4	2	8	M		Engineering Manager
8	1.7	Plant construction	Schedule	3	3	9	M		Construction Manager
9	2.5	Design basis changes	Cost	3	3	9	M		Engineering Manager
10	1.6	Ventilation conversion	Safety	3	2	6	M		Safety Supt
11	2.13	Poor availability or reliability of plant	Cost	4	4	16	H		Operations Manager
12	4.4	Delays in permitting	Schedule	5	4	20	H		Permit Coordinator
13	4.13	Competing with other projects for labor	Schedule	4	4	16	H		Project Manager
14	6.5	Powerline contractor performance	Quality	2	4	8	M		Project Manager
15	6.7	Poor industrial relations or strikes	Schedule	3	4	12	M		Industrial Relations Supt
16	6.9	Indigenous peoples' impacts or road closures	Schedule	1	2	2	L		Industrial Relations Supt

Key: P= Probability / Likelihood (1 = Rare, 2 = Unlikely, 3 = Possible, 4 = Likely, 5 = Almost Certain)
I = Impact (1 = Insignificant, 2 = Minor, 3 = Moderate, 4 = Major, 5 = Catastrophic)
RR = Relative Risk
Risk Assessment: H = High, M = Moderate, L = Low.

FIGURE 9.3 Risk identification—simple risk register example

Level		
1	Rare	Doubt it could happen in present, or even in a changing, environment. **Conceivable** but highly improbable. The aspect or event may occur in **very exceptional** circumstances.
2	Unlikely	**Less likely** to happen in present, or even in a changing, environment, but **could occur** at some time. The aspect or event has happened elsewhere under **slightly similar** circumstances.
3	Possible	It **could happen** in present, or even in a changing, environment. **Would not be a surprise** to see it happen. The aspect or event **has occurred** before here or in similar circumstances elsewhere.
4	Likely	It **probably will** happen in present, or even in a changing, environment. It is **expected** to occur. The aspect or event **occurs** in most circumstances.
5	Almost Certain	Happens **all of the time** in present, or even in a changing, environment. The aspect or event occurs in **almost all** circumstances.

FIGURE 9.4 Risk likelihood table

Since the assignment of likelihood values is mostly qualitative and subjective, it requires validation from knowledgeable players, the project management team, and the Owner (including Owner executive representation). These are not necessarily the same people who identified the risks and compiled the risk register, but they likely include many of the same individuals. Consensual concurrence on values is needed from the group, not necessarily agreement.

Along with the assignment of likelihood to each risk, a necessary parallel step is to determine the impact of that risk on the project. The tool to accomplish this is the *impact assessment scorecard*. On this scorecard, quantitative parameters are subjectively assigned for different levels of impact by the same group that subjectively assigned the likelihood parameters. Typical impact levels for a five-criteria scale are the following:

1. Insignificant: no material effect on project conduct or outcome.
2. Minor: causes modification to Project Execution Plan, but does not impact outcome.
3. Moderate: causes project disruptions and needs resources and actions to fix.
4. Major: reduced ability to achieve project budget and/or schedule goals.
5. Catastrophic: loss of ability to complete the project.

Figure 9.5 shows a five-criteria impact assessment scorecard for a fictitious OK Gold Mine project. The scorecard allows a quantitative impact to be assigned to each identified risk in the risk register.

Risk Analysis

After each risk has been quantified for likelihood and impact, an analysis has to be prepared for the overall risk of each activity, using the data collected and the assumptions made. The standard way of assessing and displaying overall risk for each activity identified by the risk register is graphically, within a risk matrix. Such a matrix is shown in Figure 9.6, where impact is measured on the *y*-axis and likelihood on the *x*-axis.

Impact assessment scorecard—criteria to consider

Project: OK Gold Mine

Impact

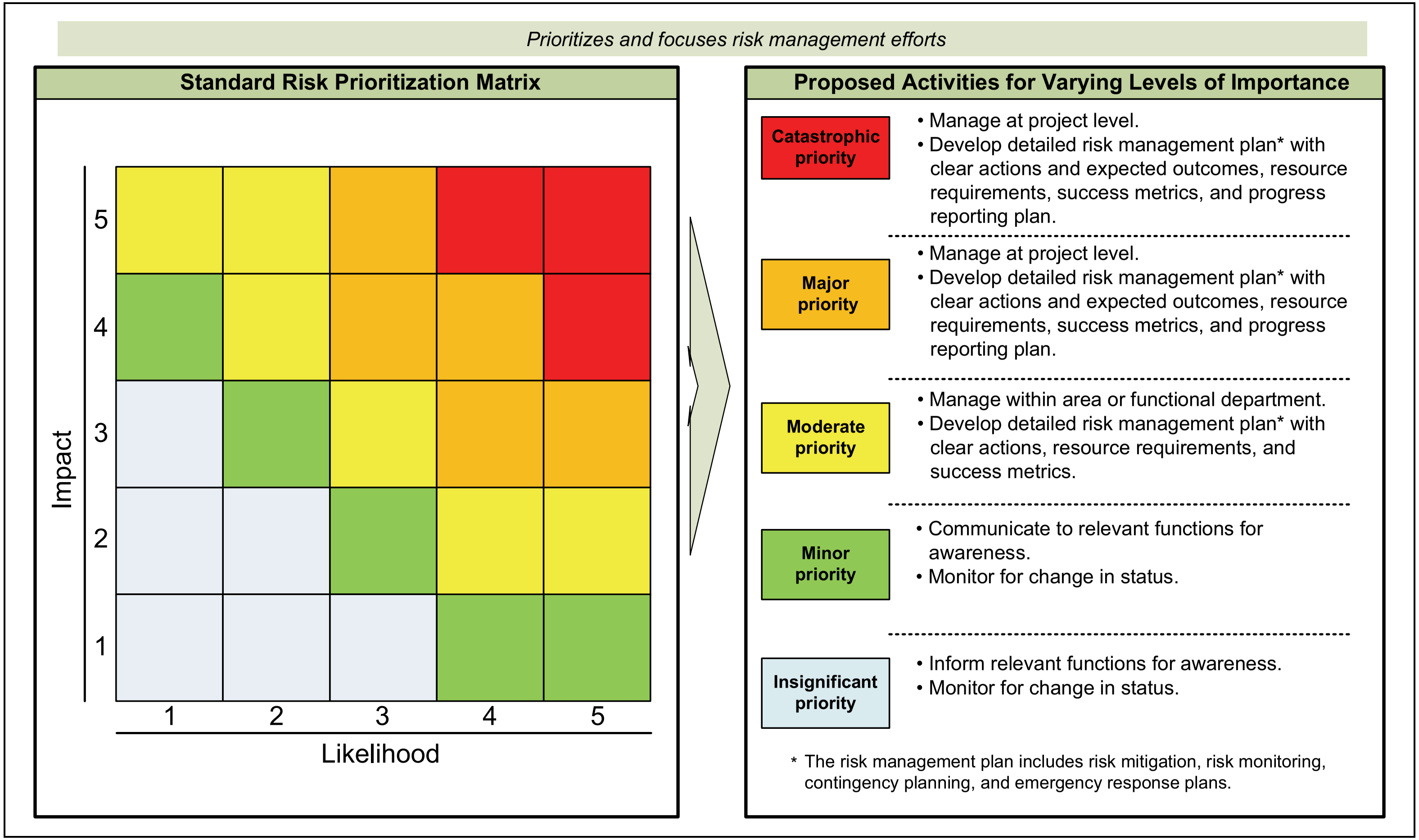
Impact Score	Financial Impact;* $ millions	Schedule†	Environmental	Reputation
5	>15	>10 days	Very serious long term	International coverage
4	10–15	7–10 days	Serious medium term	International coverage
3	5–10	3–7 days	Moderate short term	National coverage
2	1.5–5	1–3 days	Minor impact	Local/regional coverage
1	<1.5	<1 day	Minimal	No coverage

Likelihood

Probability Score	Frequency Descriptor	Percentage Frequency	Annual Frequency
5	Almost Certain	≥95% chance of occurrence	Occurs more than once per year
4	Likely	50–94% chance of occurrence	Occurs at least once every other year
3	Possible	20–49% chance of occurrence	Occurs once every 2 to 5 years
2	Unlikely	5–19% chance of occurrence	Occurs once every 5 to 20 years
1	Rare	<5% chance of occurrence	Occurs less than once every 20 years

* Financial impact is determined in terms of operating cash flow (before tax).
† Schedule impact is calculated to be equivalent to the financial impact assuming 1 million oz/yr, $1,000/oz, 35% effective tax rate.

FIGURE 9.5 Risk criteria quantification



Prioritizes and focuses risk management efforts

Standard Risk Prioritization Matrix

Impact					
5	🟨	🟨	🟧	🟥	🟥
4	🟩	🟨	🟧	🟧	🟥
3	⬜	🟩	🟨	🟧	🟧
2	⬜	⬜	🟩	🟨	🟨
1	⬜	⬜	⬜	🟩	🟩
	1	2	3	4	5
	Likelihood				

Proposed Activities for Varying Levels of Importance

🟥 **Catastrophic priority**	• Manage at project level. • Develop detailed risk management plan* with clear actions and expected outcomes, resource requirements, success metrics, and progress reporting plan.
🟧 **Major priority**	• Manage at project level. • Develop detailed risk management plan* with clear actions and expected outcomes, resource requirements, success metrics, and progress reporting plan.
🟨 **Moderate priority**	• Manage within area or functional department. • Develop detailed risk management plan* with clear actions, resource requirements, and success metrics.
🟩 **Minor priority**	• Communicate to relevant functions for awareness. • Monitor for change in status.
⬜ **Insignificant priority**	• Inform relevant functions for awareness. • Monitor for change in status.

* The risk management plan includes risk mitigation, risk monitoring, contingency planning, and emergency response plans.

FIGURE 9.6 Typical standard risk matrix

Each risk is reflected against the sliding scales of likelihood and impact, producing an instantaneous evaluation of exposure for the project. The potential impact of each risk is literally displayed (assessed) within the predefined evaluation grid of the risk matrix.

Figure 9.7 shows the same OK Gold Mine project featured in Figure 9.5 with various hypothetical activities within a risk matrix chart. The matrix provides an easily understandable visual impact of risk. The scales help put the project's multiple risks into a relative ranking.

To arrive at actuarial relative risk for each individual risk identified in the risk register, the assigned likelihood of risk score is multiplied by the risk impact score. The resultant number provides a relative answer to the key risk criteria quantification question, "How severe would the consequence be if this risk event happened?"

When all identified risks in the risk register have been assigned likelihood and impact scores, the resultant risk quantification (or relative risk) can be inserted into the risk register (see the relative risk column in Figure 9.3) and grouped by category into a summary table for the project as a whole, as illustrated in Figure 9.8.

The risk analysis essentially contemplates what can go wrong if the project does or does not go ahead. Many larger mining organizations and specialty management consultant firms have developed sophisticated risk assessment models for quantifying and analyzing risk. Whether these steps are done via sophisticated model or manually by intelligent groupthink, they just need to be completed.

Risk quantification and analysis (assessment) from scrutiny of the risk register needs to predominantly take place *before* completion of the feasibility study. Knowledge of the level of the risks and the likely costs of mitigation has to be part of the approval decisional basis by the mining company executive management and executive board. However, risk ownership assignment can take place after project approval, when the project deliverer and major construction contractors have been appointed.

Risk Ownership Assignment

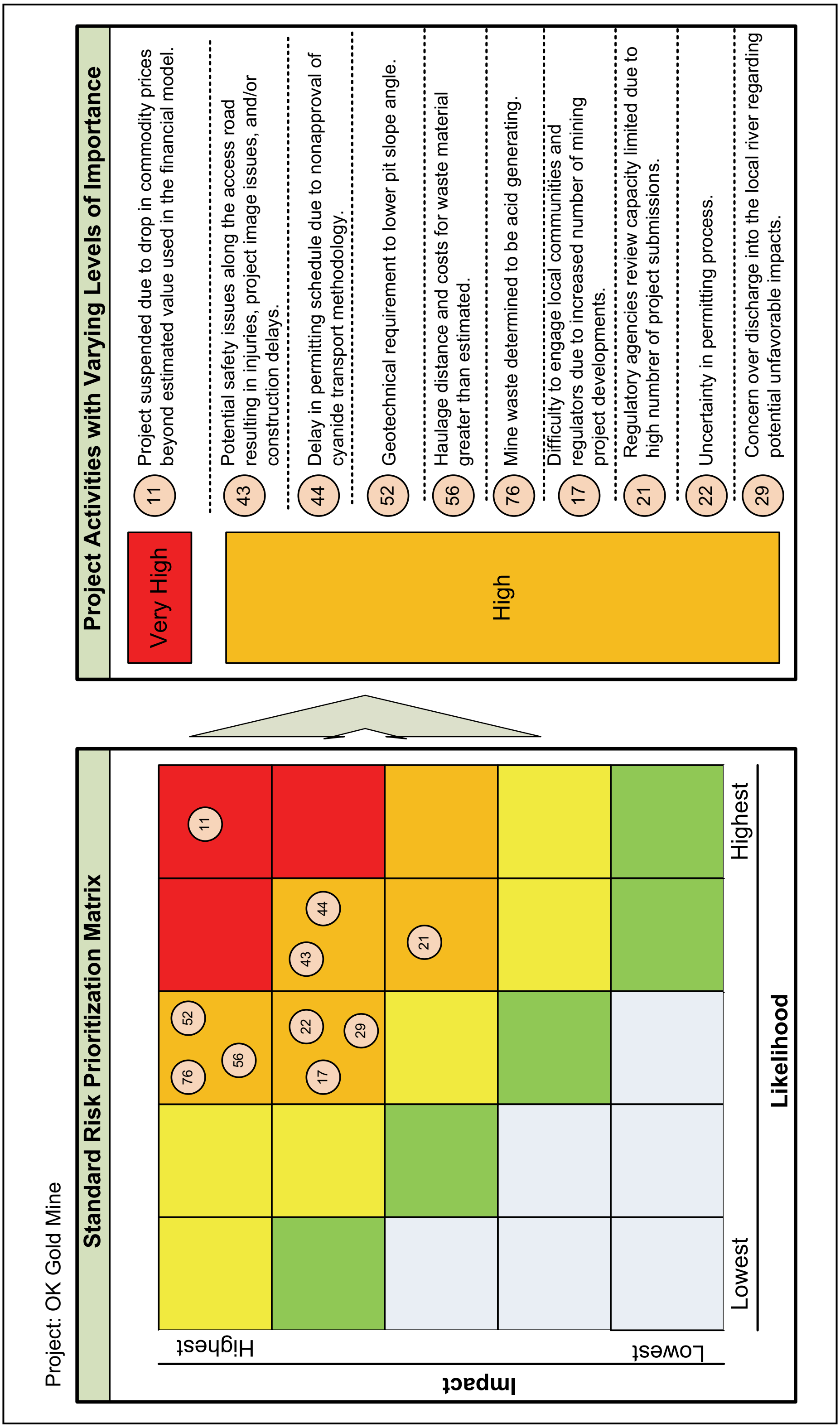
After all the risks are identified, logged in the risk register, and quantified, then the question becomes, "Who is best placed to handle the risk?" The chosen entity to handle (or "own") the risk is often characterized as the "risk champion" for that particular risk. The key here is to assign risk ownership and accountability to the entity best qualified to handle that risk. The mining company—the real Owner—will ultimately pay for the risk management, wherever it is assigned, so it is always smart to assign risk to the entity with the best chance of minimizing it. For many risks, the Owner will end up being the best entity to handle it, but for some risks, it could be the construction company or the engineering, procurement, and construction management (EPCM) firm. Owners' attempts to shed risk from themselves to less qualified "others" generally backfires and ends up just diminishing the chance of project success.

Risk Mitigation

Risk mitigation (or risk treatment) involves addressing the risks identified in the risk register. The questions to ask here are "What can be done to manage the risk?" and "What are the relative merits of the management options?"

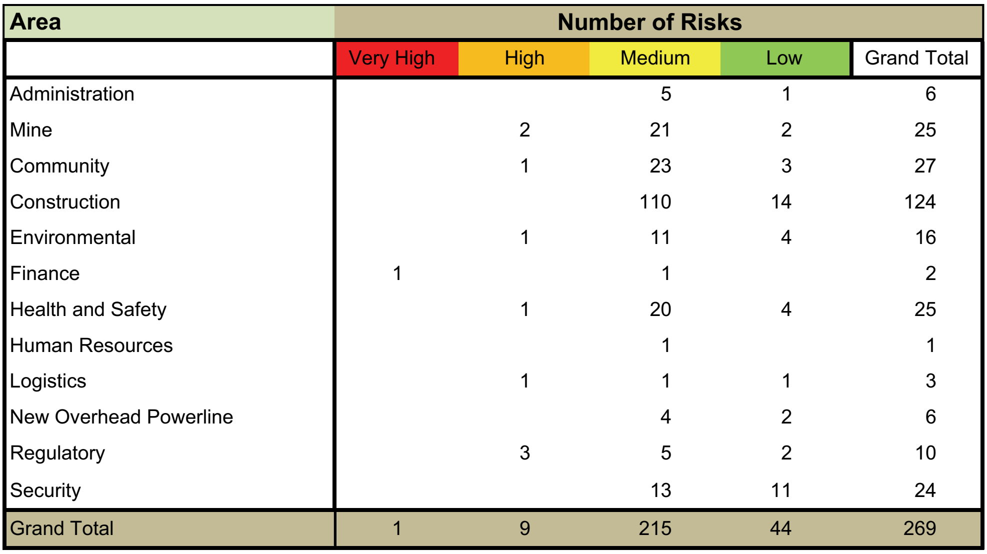
There are essentially four ways of handling risk:

1. Avoidance—take action to avoid the risk.
2. Alleviation—define actions to take if and when the risk occurs.



11	Project suspended due to drop in commodity prices beyond estimated value used in the financial model.
43	Potential safety issues along the access road resulting in injuries, project image issues, and/or construction delays.
44	Delay in permitting schedule due to nonapproval of cyanide transport methodology.
52	Geotechnical requirement to lower pit slope angle.
56	Haulage distance and costs for waste material greater than estimated.
76	Mine waste determined to be acid generating.
17	Difficulty to engage local communities and regulators due to increased number of mining project developments.
21	Regulatory agencies review capacity limited due to high number of project submissions.
22	Uncertainty in permitting process.
29	Concern over discharge into the local river regarding potential unfavorable impacts.

FIGURE 9.7 Risk matrix



Area	Number of Risks				
	Very High	High	Medium	Low	Grand Total
Administration			5	1	6
Mine		2	21	2	25
Community		1	23	3	27
Construction			110	14	124
Environmental		1	11	4	16
Finance	1		1		2
Health and Safety		1	20	4	25
Human Resources			1		1
Logistics		1	1	1	3
New Overhead Powerline			4	2	6
Regulatory		3	5	2	10
Security			13	11	24
Grand Total	1	9	215	44	269

FIGURE 9.8 Risk summary table

3. Transfer—have someone else handle the risk (e.g., insurance, bonds).
4. Acceptance—identify the risk as acceptable and let it happen.

Within the context of this book, the umbrella term *mitigation* embraces all these ways of handling risk. Determining which of the four options to choose for risk mitigation is primarily financial, but schedule, resources, and personnel will also come into play.

The first task when commencing the risk mitigation process is to identify the key risks that need immediate action. One or two risks may even need elevating out of the project domain and into the hands of others within the mining company. While most risks will require some type of action plan, a few risks will be fine to accept, monitor, and possibly reevaluate at a later date.

Mitigation methodology generally follows this logic:

- Discuss the identified risk with the present risk owner; evaluate any ongoing actions.
- Assess current mitigation initiatives against other mining industry and company practices.
- Identify gaps.
- Identify, evaluate, and quantify alternative options to manage the risk.
- Determine risk interdependency. Could risk failure have a cascading effect?
- Determine an appropriate mitigation course of action ("horses for courses" pertains). Mitigation could mean:
  - Transfer of risk to a new "owner,"
  - Taking project action to manage the risk,
  - Taking on additional project insurance or bonding,
  - Assigning contingency if this is a systematic risk, or
  - Establishing a management reserve if this is a major but unlikely project risk from external events (see Chapter 12).
- Calculate the potential costs for the selected mitigation actions.

- Determine if any residual risks will remain even after mitigation.
- Document the impact of each risk if it were to occur, monetarily and otherwise.
- Establish key performance indicators for monitoring.
- Document the action plans, risk champions, key performance indicators, mitigation timeline, and milestones.
- Update the risk register.

Proprietary software is available to assist with figuring the costs of the alternative mitigating actions. Most EPCMs, major mining companies, and the leading management consultants either own or have access to such software.

While, for the main part, no protection or remedy, beyond management reserve, exists for risk mitigation from external force majeure events, there are exceptions to keep in mind. Insurance from a home country foreign development agency or the Multilateral Investment Guarantee Agency of the World Bank can protect against some levels of political risk. Negotiating a "no strike/no lockout" agreement with the jurisdictional union(s) before committing funds to a project can remove a portion of the labor strife risk.

Risk Monitoring

When monitoring risk, the questions to ask are "What measures best capture the outcome?" and "Are the enacted measures having the intended effect?" Periodic and ongoing reviews to monitor the effectiveness of the risk management program are essential.

The risk-monitoring process has to incorporate the following:

- Identification of the individuals making the decisions on management of the risks
- Clarification of the information needs for the managers of the risks
- Development of the reporting requirements
- Escalation procedures for when risk tolerances are in danger of being exceeded

Risk Reporting

When reporting risk, the question to ask is "Who needs to know the status of the risk?"

The original risk register created at the end of the risk identification stage should be populated with the relative risks from the risk criteria quantification exercise as well as with the risk champions' names from the risk ownership assignment step. The register thus becomes the prime deliverable from the risk management analysis. The register can be used to highlight the top ten or the top twenty risks, or whatever the situation demands.

Reports are developed to meet the specific information needs and to provide transparency to leadership on progress. Risk status updates need to be a standard component of all weekly meetings, monthly reports, and periodic (quarterly?) reviews with the Owner. Weekly meetings facilitate issues resolution. The monthly reports will update the Owners by:

- Tracking mitigation actions and providing a review of the status of the risk exposures,
- Providing a forum for securing support and intervention to handle obstacles, and
- Ensuring that mitigations are being conducted according to program requirements.

Periodic review meetings with the Owner's leadership and the governance board:

- Provides a comprehensive update of exposure,
- Disseminates an early warning of issues that can impact the Owner,

- Informs the Owner of any new risk exposures and/or required interventions, and
- Maintains the visibility on overall risk assessment.

When set up properly, the reporting process is a tool to help discern how and where the risk management process can be improved.

Because of the criticality of risk management, a risk dashboard page is frequently established as a second support page to the summary project dashboard management page. Major risks can be tracked on a project dashboard. (See Figure 9.9, which displays a risk dashboard for the same hypothetical OK Gold Mine project as presented in Figures 9.5 and 9.7).

BENEFITS OF RISK MANAGEMENT

Deployment of risk management procedures will provide the following benefits:

- Provide assurance to Owner executives that the risks are being proactively handled
- Focus project management's attention on the highest risk areas
- Improve capital allocation decisions and investment returns
- Enhance the interface with contractor management

RISK TOLERANCE THRESHOLD

If risk tolerances are exceeded at any stage and the risk cannot be sufficiently mitigated, the project should theoretically be suspended until measures can be implemented to bring the risk down to an acceptable level. This sounds like common sense—take an action that will prevent erosion of company value and reputation—but it is not so easy to do.

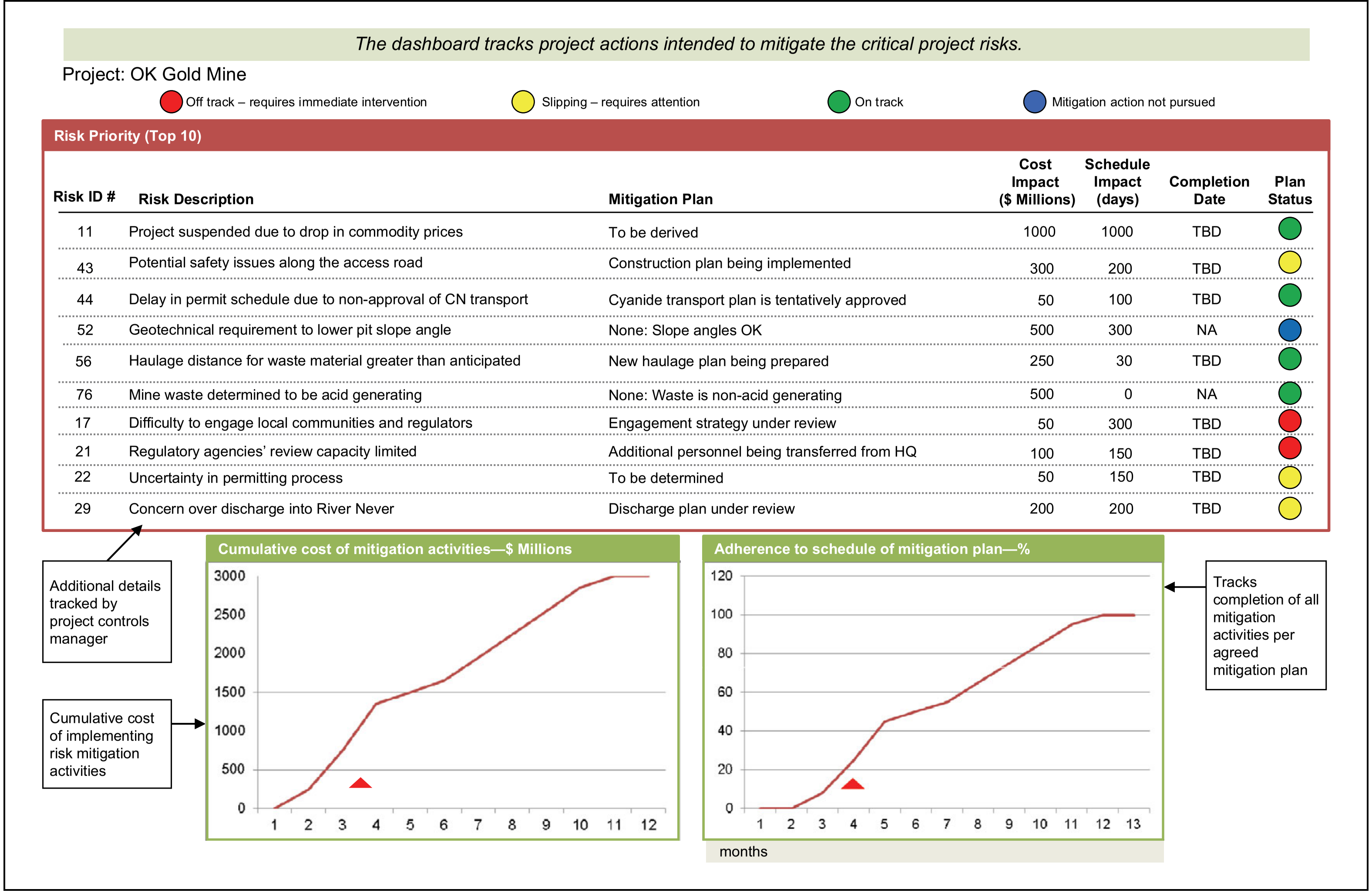
Suspending a project is generally a very last resort for an Owner. The project manager will discover that many Owners lack the fortitude to enforce such discipline. More often than not, the Owner's reaction to a new or higher risk is to simply raise the risk tolerance level and hope the outcome is bearable (but unfortunately this is rarely the case).

The project manager's role here is straightforward:

- Install sufficient internal controls into the risk management process to keep risks within acceptable levels.
- Manage the decision-making process so that risks do not approach predetermined risk tolerance levels.
- Make sure there is sufficient transparency and communication within the reporting process for all stakeholders to be cognizant of the project's risk management conduct.
- If, in spite of all efforts, a set risk tolerance is exceeded, then the project manager has to immediately bring the issue to the Owner's attention, along with the likely implications and repercussions of any project suspension.
- The Owner decides the course of action; the project manager carries it out.

SCHEDULE PERILS

In *Identifying and Managing Project Risk,* which author Tom Kendrick (2009) produced to align with the Project Management Institute (PMI) *Guide to the Project Management Body of Knowledge* (*PMBOK Guide*), the perils that will likely be encountered in a project are grouped according to the project's three key constraints: scope, schedule, and resources (PMI 2008). The project team needs to utilize Kendrick's list of perils in their risk search and identification process. The identified top-five perils in each constraint category are the following.



The dashboard tracks project actions intended to mitigate the critical project risks.

Project: OK Gold Mine

🔴 Off track – requires immediate intervention 🟡 Slipping – requires attention 🟢 On track 🔵 Mitigation action not pursued

Risk Priority (Top 10)

Risk ID #	Risk Description	Mitigation Plan	Cost Impact ($ Millions)	Schedule Impact (days)	Completion Date	Plan Status
11	Project suspended due to drop in commodity prices	To be derived	1000	1000	TBD	🟢
43	Potential safety issues along the access road	Construction plan being implemented	300	200	TBD	🟡
44	Delay in permit schedule due to non-approval of CN transport	Cyanide transport plan is tentatively approved	50	100	TBD	🟢
52	Geotechnical requirement to lower pit slope angle	None: Slope angles OK	500	300	NA	🔵
56	Haulage distance for waste material greater than anticipated	New haulage plan being prepared	250	30	TBD	🟢
76	Mine waste determined to be acid generating	None: Waste is non-acid generating	500	0	NA	🟢
17	Difficulty to engage local communities and regulators	Engagement strategy under review	50	300	TBD	🔴
21	Regulatory agencies' review capacity limited	Additional personnel being transferred from HQ	100	150	TBD	🔴
22	Uncertainty in permitting process	To be determined	50	150	TBD	🟡
29	Concern over discharge into River Never	Discharge plan under review	200	200	TBD	🟡

Additional details tracked by project controls manager

Cumulative cost of implementing risk mitigation activities

Tracks completion of all mitigation activities per agreed mitigation plan

FIGURE 9.9 Risk dashboard

Scope Risk

1. Scope creep—individuals (generally the Owner) adding tasks to the original scope.
2. Hardware or software input defects—mischaracterizations of the true project scope.
3. Scope gap—project-necessary activities missing due to an ill-defined scope up-front.
4. Dependency change—unexpected and unanticipated regulatory, legal, or political changes.
5. Integration defect—change required from unexpected behavior by a project participant.

Schedule Risk

1. Project dependency failures—the other party not delivering its work on time.
2. Parts delays—equipment and/or materials not being delivered on schedule.
3. Estimation errors—poor or improper sources used for estimating project activities.
4. Decision delays—untimely decisions causing schedule delay.
5. Equipment malfunctions—insufficient attention to quality in the procurement process.

Resources Risk

1. Outsource entity delays—project contractors not mobilizing or progressing as planned.
2. Insufficient funds—for items (equipment, people, etc.) overlooked in the estimate.
3. Attrition of resources—equipment breakdowns, personnel and contractor desertions.
4. Late staffing—project workforce buildup falling behind plan.
5. Skills scarcity—workforce skill sets not available or trained to match project needs.

SPECIFIC MINING PROJECT RISKS

Specific project risks encountered by project managers are myriad, with each requiring different approaches and its own unique mitigation. For illustrative flavor, the following is a variety of 20 real risks that have been faced by actual mining project teams in the past two decades:

1. Local building code requirements not incorporated into plant design.
2. Mine development schedule based on using old, unreliable equipment, with no spares.
3. A mineral recovery set from an extrapolation of unrepresentative high-grade samples.
4. A heap leach cycle design of less than one-fifth of the actual duration of the lab tests.
5. A dump leach lift height 10 times the lab test height with no inner liners between lifts.
6. A heap leach design based on model evaporation rather than from real site data.
7. No quality control specified for site contractor placement of leach pad liners.
8. Project facility locations set without benefit of any geotechnical investigation work.
9. A 98% plant availability design criteria for a first-in-the-world plant facility.
10. A cost-saving removal of a design fire protection system from within a solvent extraction plant.
11. A 2.7 construction labor productivity factor in a locale where 3.9 is achieved.
12. Oversize equipment required on-site, but no transportation study undertaken.
13. Owner's access road not complete prior to contractor mobilization date.
14. Contractor bid based on using unlicensed, untrained, unqualified machinery operators.
15. No allowance in the schedule for the locale's known historic weather delay cycles.
16. A capital budget that excluded significant necessary expenditures, such as the access road, camp, mine development, shop, power line upgrade, office, and communications.

17. A 60-year life project designed for a 7.0 Richter peak seismic acceleration with a 100-year return event in a country with a history of 8.0 seismic activity in the past 20 years.
18. A 50-year life property design using an inadequate 100-year-period precipitation event.
19. An environmental study ignoring the risk of depleting waters in local springs and river.
20. Contingency set unrealistically low to meet a net present value (NPV) hurdle.

OTHER PORTRAYALS OF MINING PROJECT RISK

The notion of risk is portrayed in two other aspects of the mining project, as described in the next sections, but neither are candidates for any of the forms of risk management already described.

Variance Analysis

Every physical mining resource has a recognized uncertainty in its estimate of grade, recovery, tonnage, operating cost, price of mineral product, and so forth. This uncertainty is portrayed in the feasibility study by a sensitivity (variance) analysis. Such analysis may demonstrate that a low-grade deposit is sensitive to operating costs and commodity price. A variance analysis, however, merely portrays risk; it does not manage or mitigate risk.

Risk Addressed by Financial Analysis

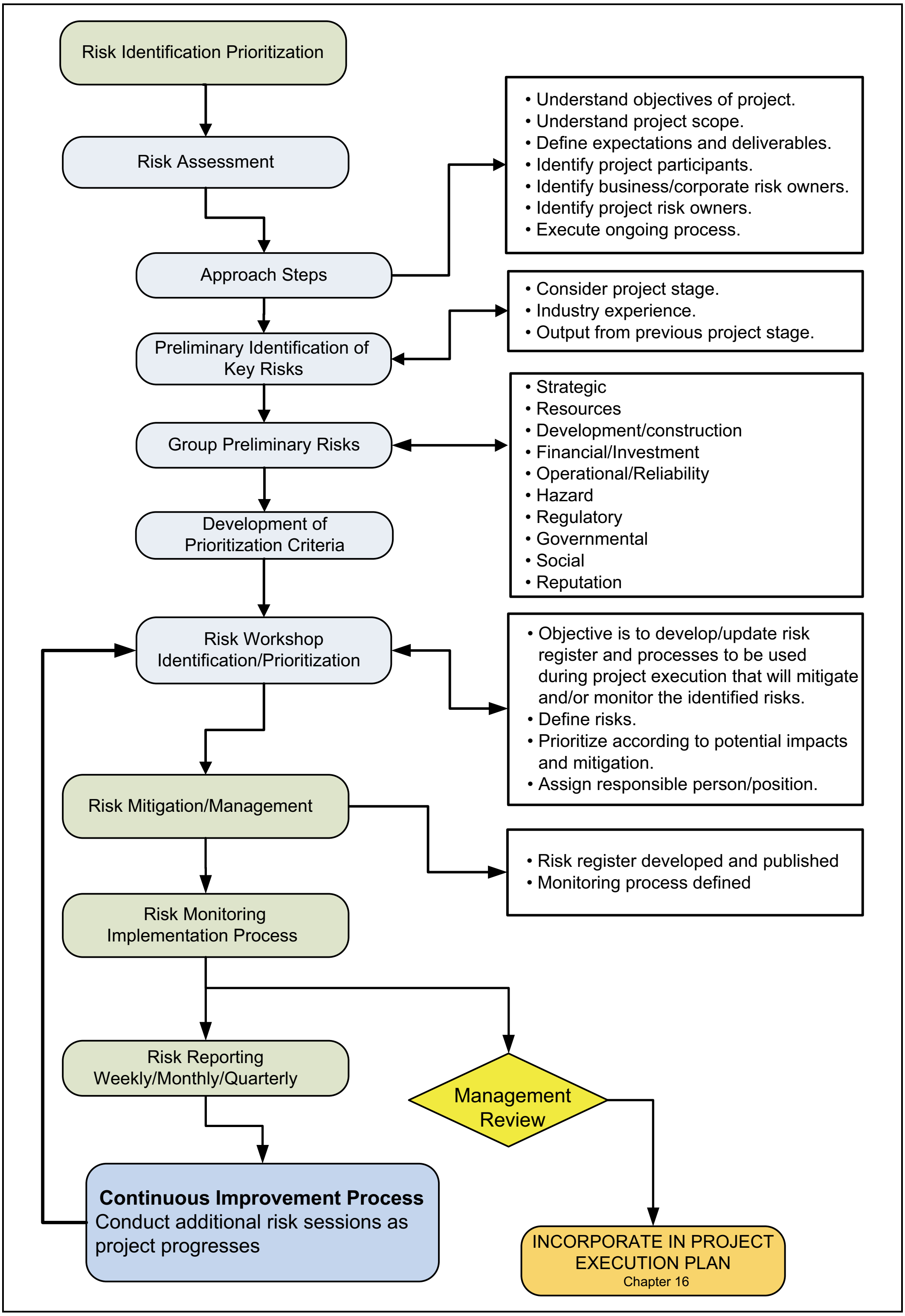
In the financial analysis, risk is considered in two places, both expressed as a percentage.

1. Risk is a component of the discount rate used to determine NPV.
2. Risk is also a component of the hurdle rate (threshold value) established for the required minimum discounted cash flow return on investment.

Regrettably, the risk factors adopted in the financial analysis do not emanate from a rational or statistical origin that can encapsulate the applicable risks within the project; rather, they are solely notional amounts related to the corporate cost of money.

CHECKLIST 9.1 RISK MANAGEMENT

No.	Item	Status	Date	Initials
1	Project objectives, expectations, and deliverables—understood			
2	Risk identification—complete			
3	Project risks addressed by a typical project:			
	A. Ownership			
	B. Installation cost (including inflation concerns)			
	C. Constructability			
	D. Infrastructure and utilities access			
	E. Operational			
	F. Labor (including skills availability)			
	G. Geographic (including climate issues)			
	H. Geological			
	I. Technological			
	J. Environmental impact, permits, social acceptance, and sustainability			
	K. Foreign currency exposure			
	L. Political, country, and nationalization business practices			
	M. Tax and business climate			
	N. Economic, financeability, and capital access			
	O. Project execution			
4	Risk register—published			
5	Risk categorization and prioritization—completed			
	A. Risk workshop—conducted			
6	Risk criteria quantification (likelihood and potential impact)—scored			
7	Risk analysis—undertaken			
8	Risk matrix—produced			
9	Risk ownership accountability—assigned			
10	Risk mitigation or treatment—action plan developed			
	A. Proprietary software—selected			
	B. Implementations initiated (either avoidance, alleviation, transfer, or acceptance)			
11	Risk monitoring			
	A. Key performance indicators—developed			
	B. Monitoring individuals—selected			
12	Risk reporting—initiated			
	A. Reporting format—established			
	B. Status update frequency—determined			
	C. Risk dashboard—created			
13	Owner's risk tolerance threshold—established and known by project manager			



FLOWCHART 9.1 Risk management

CHAPTER 10

Schedule

> *Leadership is the art of getting someone else to do something you want done because he wants to do it. —Dwight D. Eisenhower, 1890–1969*

OBJECTIVE

This chapter lays out the essential steps for creation of a first-rate project schedule. After the feasibility study and project task list are produced, then the project schedule and project budget can be completed. The schedule and budget are normally created simultaneously because they are so interconnected, but for purposes of clarity, they are dealt with separately within this book.

The levels of effort required to create the different levels of schedule for the discrete stages of project are described. These levels increase the density of information as the project progresses in complexity from scoping, through feasibility, and into construction. The objective here is to ensure that the project personnel know the elements that constitute a good schedule and understand the work effort and detail that are required to create the individual schedules for the different stages of project development.

PURPOSE

The project schedule provides the road map to complete the project successfully; it guides project accomplishment (Weaver 2013). The schedule is a dynamic tool that initially reflects the most realistic vision of the project's life span; later it can aptly react to changes in progress, scope, and resource availability over the project life.

Schedules define the path forward for the project, underpin the chosen delivery strategy, and support the functions of project management. A well-crafted schedule model can be used to predict when the project work remaining can be reasonably expected to be accomplished. It allows the project team to look at the performance of the project to date and use that information to make more accurate projections about future work. While no schedule can control time (there are still only 24 hours in a day, all running sequentially), a schedule does help the project team manage the use of its available time in the most beneficial way.

The project schedule describes what work is to be done, who will undertake the work, and when it should be done. How to do the work is defined by the Project Execution Plan. Thus the schedule does not control the work of a project; the schedule provides a guide for management to use in determining what influence to apply to the workflow.

The project schedule is the key to managing and accomplishing projects effectively. The schedule commits team members to the project, enables the project team to plan and track performance of the work, and identifies problems with work progress or expenditures. Undertaking a project without a good schedule is similar to taking a trip without a map—you may reach your destination, but probably not by the quickest or most efficient route.

SCHEDULING VERSUS PLANNING

While project scheduling and project planning are allied disciplines, they are not the same. It is not good practice to plan the work while attempting to schedule it.

Project planning is a mostly scientific team exercise involving project management staff, the Owner, engineering designers, cost estimators, quality engineers, and project controls personnel.

Scheduling is more a mixture of science and art, involving the interpretation of the results of project planning by using appropriate software tools and techniques to ascertain, among other things, the start and finish dates of activities and their sequence. Scheduling essentially completes the planning process. Scheduling then continues as an integral element of project performance control.

Scheduling is a modeling process that can help communicate the chosen strategy and, at the same time, sequence and coordinate what might happen in the future.

WHAT SCHEDULES ARE GOOD FOR AND WHAT THEY ARE NOT GOOD FOR

Schedules are good for (Weaver 2010):

- Providing an agreed-upon vision of the project for the project team to use;
- Sequencing the work breakdown structure (WBS) activities and work packages, and optimizing the work flow;
- Keeping the progress of the project activities coordinated and aligned;
- Evaluating the consequences of change;
- Developing and testing an optimum delivery strategy for the project;
- Aiding day-to-day decision making;
- Assisting in replanning of the project to deal with variance;
- Enabling quantification of variations to the project plan as they occur; and
- Providing a valid time baseline for earned value (EV) and earned schedule (ES) calculations.

Schedules are not good for:

- Controlling work in the field or at the tunnel face (you need skilled people for this),
- Measuring productive efficiency (EV does this),
- Realistically predicting end dates (ES coupled with EV can achieve this).

CHARACTERISTICS OF A GOOD SCHEDULE

Every good schedule has the same basic attributes.

Easily communicated. The people doing the work and the Owner must understand the schedule. Schedules in graphic form convey information best.

Realistic. An overly optimistic schedule will rarely be achieved; it just frustrates the Owner, project team, and funding entities. When tasks extend beyond scheduled finish dates, budgets are exceeded, and other projects expecting to use team members are impacted.

Commitment of the project team. The key project team members need to be involved in developing the schedule, agree with it, and believe it to be achievable. Without such commitments, the schedule has minimal chance of attainment.

Task interrelationships. Tasks are never done in isolation; tasks rely on information or results from other tasks. The schedule must show how tasks interrelate.

Flexibility. It is a fact of project life that schedules change. The schedule should be capable of being revised to reflect the current situation.

Milestones (checkpoints). Milestones at appropriate points in a schedule allow progress to be more easily monitored as the project moves forward. Milestones (e.g., "feasibility report published," "construction permit received," "first cathode produced") are powerful motivators; they help individual team members monitor their own progress. Each milestone should be managed as seriously as the overall project deadline. Frequent, short-term milestones enable delays to be evaluated in a timely manner and corrective action to be taken.

Calendar time, not number of workdays. People think in terms of calendar time (just try and state the date 120 workdays from today). So use the calendar when preparing schedules. This eliminates excuses regarding holidays, vacations, religious observances, and so forth.

Early deadlines. Parkinson's law states that activities expand to fill the available time. If the deadline is June 1, everyone will be scrambling to finish last-minute tasks just before that date. The same thing would happen if the deadline were June 30 or July 15. Just set the deadline early enough to give everyone time to focus on it.

Schedule modifications following each review. Changes follow reviews just as night follows day, but too often, time is only scheduled for the review, not the ensuing modifications.

Appropriate contingency time (free float) for schedule slippage. Allocate periods of time within the schedule, outside of the critical path, for catch-up on those tasks that have not been synchronized as forecast or have just fallen behind.

Extension beyond the completion date of the project facility. There will always be activities that arise after the facility start-up date: Owners ask questions, "little changes" will be requested, extra closeout meetings will be held, and project records will need reorganizing. Anticipate such activities and include them in the schedule.

SCHEDULING TECHNIQUES

Over the years, project-scheduling techniques have evolved for the better.

Milestone Chart

A milestone chart is the project task list converted into graphic format, with the person or group responsible for the work now shown and the target task completion date (the milestone) appended.

While milestone charts (as illustrated in Figure 7.3) are simple and easy to prepare and communicate reasonably well through graphics, they provide no indication of interrelationships between tasks, and there is no easy way to determine the relative importance of the tasks. As such, milestone charts are not very effective for project work stages beyond the study phases, except perhaps for serving as a reminder of upcoming tasks.

Gantt Chart

The Gantt (bar) chart is the basic scheduling method used today. A chart of tasks versus calendar time is plotted with horizontal bars used to block out the time period for each task. The bars indicate the start, duration, and finish of each task. An example of such a chart is shown in Figure 10.1, an Executive Summary Master Schedule taken from a 2014 Canadian project.

Because of their clean graphic depiction, bar charts are easy to understand. They are simple to prepare either manually or by any one of the wide variety of project-scheduling programs available today, and they are easy to update. While bar charts illustrate well the sequence of tasks, they do not indicate the interrelationships between tasks. Nor do they indicate which tasks are most crucial for completing the project on time.

Wall Scheduling

Wall scheduling involves the entire project team. It brings together the Owner, project staff, contractors, specialist consultants, key vendors, and, on occasion, regulatory agencies to develop a schedule to which everyone is committed.

Wall scheduling takes place in a room with a wall divided into a grid. Each column represents a project period, usually a week or month; each row represents a key project participant. Two colored sticky notes are prepared for each task, one labeled “start” and one “finish,” and given to the participant responsible for the task. Various colors are used to represent the different disciplines. Figure 10.2, taken from a 2014 Project Execution interactive planning session for a Middle Eastern gold project, illustrates the sticky-note phase of the wall-scheduling process.

The participants each post their notes in the grid cells that represent the periods when their work will start and finish; thus the schedule assembles and task dependencies quickly become apparent. Unanticipated tasks or subtasks are added as they become apparent, and conflicts can be resolved with everyone present.

The cost and logistics of getting the entire team together for a wall-scheduling session can be onerous, and the requirement for a skillful project manager facilitator to get all the participants to work together constructively can be daunting. However, this interactive scheduling method is a recommended technique for all major projects. It enables project team members to work together to develop a mutually satisfactory plan. The technique helps garner the personal commitment of the participants as they each determine their own deadlines. The technique forces everyone to better understand how the details of others’ involvement affect their own task durations.

Critical Path Methodology

Critical path methodology (CPM) is a project schedule modeling technique that integrates task (activity) sequences and durations, and then graphically displays the relationships between tasks along with their relative importance. CPM has become a necessity for large and complex projects.

CPM constructs a model that lists all the activities required to complete the project, the time (duration) to complete each activity, and the dependencies among the activities. Using these values, CPM calculates the earliest and latest that each activity can start and finish without making the project longer. This process identifies which activities are critical (i.e., on the

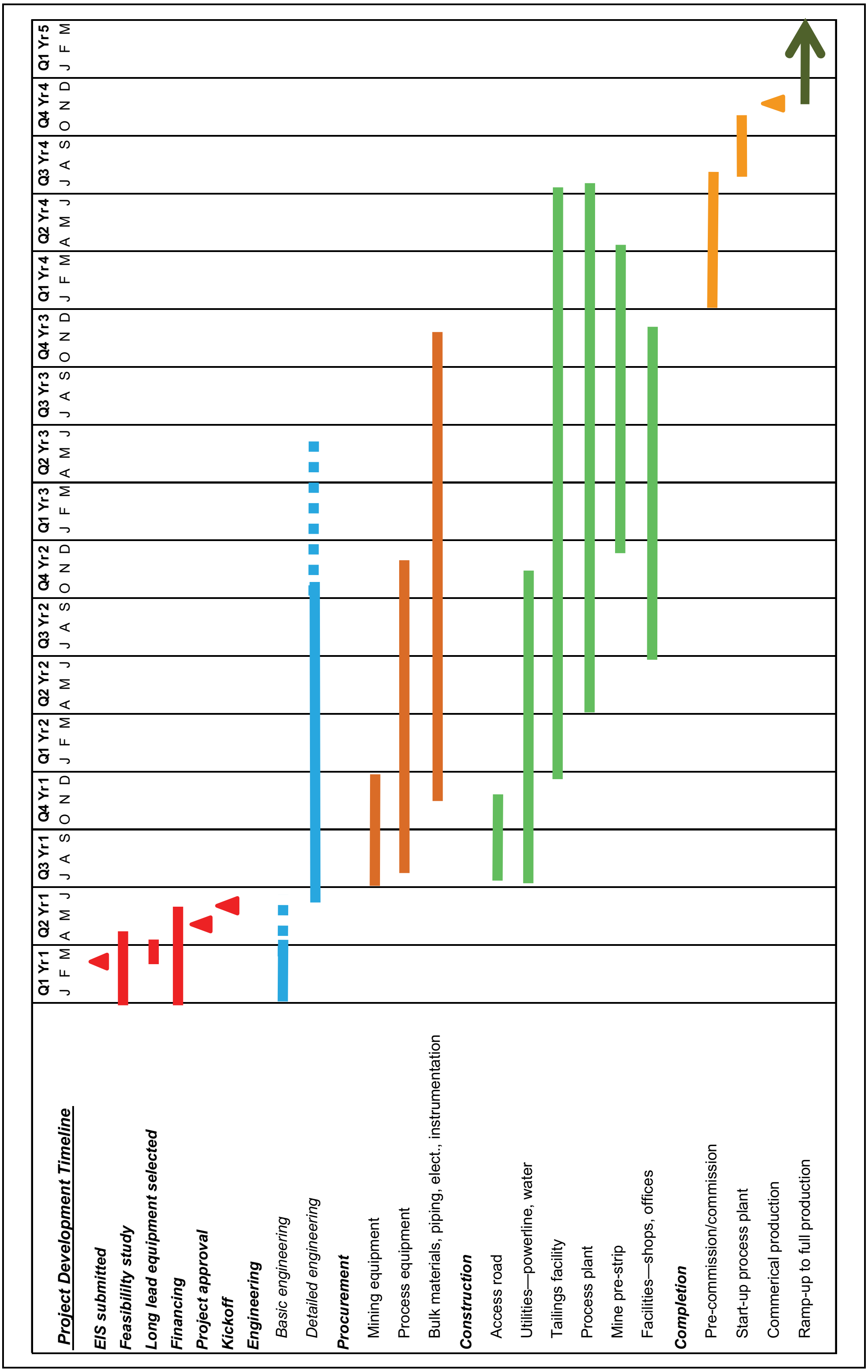
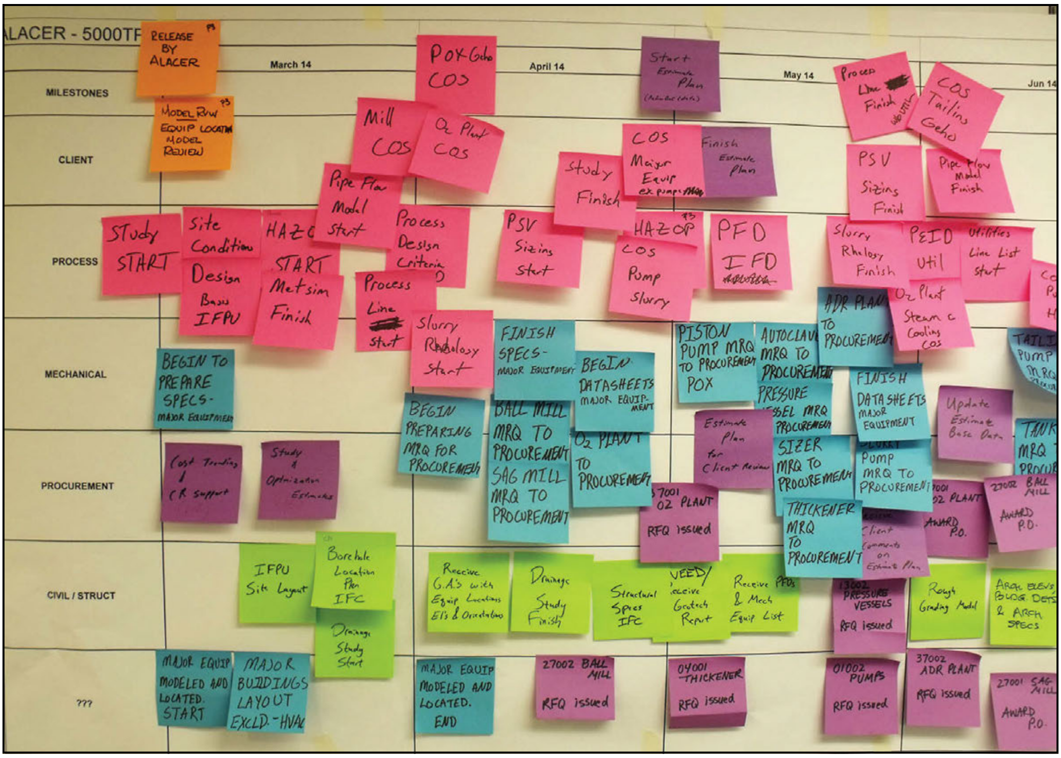


FIGURE 10.1 Level 1 schedule—greenfield project



Courtesy of Jacobs Engineering.

FIGURE 10.2 Wall chart schedule

longest path, where slippage in any one activity will affect the completion date of the overall project) and which have float (i.e., can be delayed without making the project take longer).

The CPM mechanism determines the critical path within the schedule. The critical path is the sequence of project network activities that are of the longest overall duration. The path determines the shortest time possible to complete the project, that is, the shortest duration sequence or course through the series of critical tasks. Any delay of an activity on the critical path directly impacts the planned project completion date (by definition, there is no float on the critical path).

A prime benefit of CPM is to identify where to concentrate efforts to stay on schedule. If a slipping schedule needs shortening, the tasks that have the most impact on the length of the schedule are easily identified. Another important facet of CPM is its clear identification of slack or "free float" time. This is the amount of slippage that a noncritical task can endure before it affects the overall schedule and becomes critical.

On simple projects, the critical tasks and the associated critical path can be determined by identifying the precedence of tasks on a bar chart. But for large, complex mining projects, a CPM computer program such as Primavera is needed to establish the schedule.

Critical Chain

Critical chain project management (CCPM) is a method of planning and managing projects that was introduced in 1997 by Eliyahu M. Goldratt. CCPM puts the main emphasis on the resources required to execute project tasks. This is in contrast to the CPM that emphasizes task order and rigid scheduling (Goldratt 1997).

A critical chain project network focuses on keeping the project resources evenly loaded, but at the same time requiring them to be flexible in their start times. That way, the network can quickly switch between tasks and task chains to keep the whole project on schedule.

The *critical chain* is defined as the sequence of both precedence- and resource-dependent terminal elements that prevents a project from being completed in a shorter time, given finite resources. If resources were available in unlimited quantities (which they never are), then a project's critical chain would be identical to its critical path.

The critical chain is an alternative to critical path analysis, but nowhere near as prevalent. The following are the main features that distinguish the critical chain from the critical path:

- The use of resource dependencies.
- No search for an optimum solution. Finding the optimum is unlikely, and the difference between optimum and good enough is less than the estimate uncertainty.
- The identification of buffers—project buffers, feeding buffers, and resource buffers.
- Project health monitoring by buffer consumption rate rather than task performance.

CCPM uses buffer management instead of earned value management (EVM) to assess project performance, because EVM does not distinguish progress on the project constraint (the critical chain) from progress on nonconstraint paths.

With a CCPM plan, resources are assigned to each task, and the plan is resource-leveled, using aggressive 50% probability durations. A second, "safe" duration (e.g., a 90% probability of completion) is also assigned. The longest sequence of resource-leveled tasks that lead from beginning to end of the project is then identified as the critical chain. The justification for using 50% probability estimates is that half of the tasks will finish early and half will finish late; thus the variance over the project life should balance out to zero.

Recognizing that tasks tend to take more rather than less time than scheduled, buffers are used to monitor project schedule and financial performance. Buffers are the extra duration of each task on the critical chain—the difference between the safe durations and the 50% durations. The buffers are then gathered together in one buffer at the end of the project. This allows a baseline to be established, which enables financial monitoring of the project. When the plan is complete and the project is ready to kick off, the project network is fixed and the buffer's size is locked (i.e., its planned duration may not be altered).

Because of their 50% probability, there is no slack in the duration of individual tasks; thus people are, theoretically, encouraged to complete the current task and hand it off to the next person. The goal here is to eliminate harmful multitasking and overcome the tendency to delay work or to do extra work when there seems to be time.

Ease of monitoring is one of the advantages of CCPM. Because individual tasks will inevitably vary in duration from the 50% estimate, the focus is not on forcing the task to complete on time. Estimates can never be perfect. Instead, the buffers created during the planning stage are monitored. If the rate of buffer consumption is low, the project is on target. If the rate of consumption is such that there is likely to be little or no buffer at the end of the project, then corrective actions or recovery plans must be developed to recover the loss. When the buffer consumption rate exceeds some critical value (i.e., a rate where all of the buffer may be consumed *before* project end, resulting in late completion), alternative plans need to be implemented.

Earned Schedule

Earned schedule (ES) is a fairly new extension of EVM. See Chapter 21 for an explanation of EVM. ES was introduced in 2003 by Walter Lipke and is designated as an emerging practice by the Project Management Institute (Lipke 2003).

Traditional EVM tracks schedule variances not in units of time, but in units of currency (e.g., dollars) or quantity (e.g., labor hours). This is inherently unnatural, given that people relate to schedules in terms of time. The real schedule issue with EVM, however, is that near the end of a project—when schedule performance is often a primary concern—the usefulness of EVM schedule metrics can become inadequate. The reason for this is that with EVM, a schedule variance (SV) of 0 or a schedule performance index (SPI) of 1 indicates the project is precisely on schedule. But when a project is complete, its SV is mathematically always 0 and SPI always 1, even if the project is delivered massively late. Similarly, a project can languish near completion (e.g., SPI > 0.9) but never be flagged as outside acceptable tolerances.

To correct these issues, ES splits SV and SPI into two separate domains: currency and time. These are named SV($) and SPI($) to indicate that they relate to currency, and SV(t) and SPI(t) to indicate they relate to time. Implementation of ES requires no new data collection processes; it only requires an update of EVM. The advantage of ES is that it contains formulas for predicting the project completion date.

No scheduling technique is a panacea, but ES can provide a useful link between traditional EV analysis and conventional project schedule analysis.

CREATING THE PROJECT SCHEDULE

For the project schedule to be a useful tool for influencing project progress, optimizing outcome, and communicating information regarding work progress, the project team needs to consider several factors when creating it:

- Determine if one schedule is adequate, or if a number of levels are needed to facilitate project management. (See discussion on schedule levels later in this chapter.)
- Establish the amount of detail necessary to understand the activities. Too much detail produces a confusing and overly large project schedule that is difficult and costly to manage; too little provides insufficient information to effectively manage the project.
- Set the time scale for the activity durations (e.g., hours, days, weeks, months). The optimum time scale theoretically depends on the frequency of the control processes and the level of detail needed, but in practicality, days are the duration almost always chosen for mining projects.
- Agree on the reporting requirements that the schedule has to fulfill.
- Select the scheduling method, and then select the scheduling model. In most cases this means selecting the scheduling software, for example, CPM using Primavera P3.

The best scheduling solution for any particular project will be influenced by the current phase of the project (feasibility, engineering, construction, etc.), the business norms of the Owner organization, and the preferences of the stakeholders.

Schedule Correlation with Scope

The project scope documents provide the background information needed to develop the project schedule. The project scheduler must review and become fully familiar with these documents, particularly the project's adopted WBS.

Each activity entered into the project schedule model represents an element of the work scope that produces the deliverables identified in the WBS. Thus all the work elements listed in the WBS can be directly traced to an activity or group of activities in the project schedule. Conversely (and perhaps more importantly), each schedule activity should only roll up into one WBS element. Adhering to this WBS linkage process ensures that all aspects of the project scope have been properly included in the project schedule.

Project Update Cycle

Settle on an appropriate frequency for updating the schedule status. The period between updates needs to be long enough for the project team to have had a chance to act on information. The key is to select a cycle time that provides management with an optimum level of control information without being overly burdensome on the people who are reporting and analyzing. For most mining projects, a monthly status cycle is appropriate. For volatile, high-risk projects, more frequent updates would be required, possibly even weekly.

Project Activity List

The scheduler, in conjunction with the project management team members, creates the list of activities that need to be performed to complete the project. A properly designed activity contains the following characteristics:

- The activity is a discrete element (or block) of work.
- One project entity should be responsible for the performance of an activity. That entity should be the same one who will report on the activity's progress.
- Activities describe work that must be accomplished. For example, "install pipeline from A to B" or "review hoist RFQ [request for quotation]." Each activity description should be unique and leave no room for interpretation or ambiguity.
- Preferably, the work represented by an activity should, once started, be capable of proceeding to completion without interruption (except for naturally occurring nonwork periods in the calendar). If the work of an activity must be interrupted, it is better that the activity be split into two or more activities at natural break points. Unfortunately, the reality is that this desirable CPM characteristic will not be able to be adhered to for a multitude of the mining industry's inherently long-duration activities.
- Ideally, the work contained in an activity should be scoped so that the activity duration is less than three times the update cycle. This allows the reporting of the start and finish of an activity within one or two updates, thus allowing management to focus on performance and corrective action as needed. Again, mining projects contain numerous long-duration activities that are naturally continuous and have no obvious break points, and thus will force exceptions to this general rule, for example:

- Boring a tunnel that is 5-km long, or laying 200 acres of leach pad liner
- Procurement activities, where one work item (e.g., fabricating and shipping a crusher to a remote site) takes much longer than three update cycles

When complete, the activity list must describe 100% of the project work scope.

Project Schedule Identifiers

Every project schedule issued has to have a unique name and identification number to identify the project and the version of the project schedule. This is essential for proper archiving of project documents and for auditing.

Project Calendars and Work Periods

Appropriate work periods have to be selected for the project. This includes determining:

- The number of working days in a work week,
- The number of shifts to be worked each day,
- The number of hours to be worked each shift or day, and
- Any periods of scheduled overtime work or nonworking time (e.g., holidays).

All of these elements play a role in determining the number and structure of the project calendar required for the schedule. Avoid using more than one calendar; multiple calendars introduce significant complexity to the calculation of float and critical path.

Schedule Activity Coding Structure

A rational activity code structure that facilitates selection and sorting of schedule data, along with maintenance and reporting of the project schedule during project execution, are mandatory. Each activity number must be unique and follow a scheme appropriate to the project. A well-designed code structure helps analyze project performance data by facilitating activity aggregation and sorting that can highlight trends and anomalies.

A structured activity ID will have multiple code components, each code representing a separate property, thus allowing outputs to be customized for different purposes. For example, codes can be used to identify project phases, work location, and the responsible person and/or organization doing the work. A structured activity ID or numbering scheme also allows schedule users to gain a better understanding of how a particular activity fits into the overall project.

Schedules as a Resource Planning Tool

The schedule should also be structured to take personnel resource availability into account. Just as activity codes can be used to classify and organize activities, assigned personnel resource codes can classify resources according to organization, skill type, skill level, reporting structure, and the like. Resource IDs are structured into schemes similar to those of activity IDs.

Schedule Integration Requirements

The schedule should be integrated into the risk management system to ensure that all planned risk mitigation tasks are properly incorporated into the schedule. Similarly, an appropriate level of integration with the cost management system is normally required to facilitate transfer of data (e.g., labor hours expended). On the other hand, the integrity of the schedule must not be compromised just to mesh with other software.

The schedule also needs to be integrated into the EVM system. The EVM system will dictate part of the schedule coding system and the project WBS. The schedule design has to honor the EVM requirements without compromising its other requisite design aspects and the schedule's overall usefulness to the project team.

Project Milestones

When the project team has a solid grasp of the overall project, the milestones can be set. Milestones have zero duration and are used as benchmarks to measure schedule progress. They can also reflect the start and finish points for various project events or conditions and/or identify external constraints or interim deliverables. At a minimum, each project must have a start and a finish milestone.

ESTABLISHMENT OF PROJECT LOGIC

Connecting the activities and milestones together logically is the bedrock of any dynamic project schedule such as CPM. The method of connection is termed a *schedule relationship*. Every activity and milestone, except for the first and last, must be connected to at least one predecessor and one successor.

In most instances, a schedule activity finishes before its successor activity (or activities) start. This is known as a finish-to-start (FS) logic tie. Where this FS logic is not the case and it is necessary to overlap activities, one uses start-to-start (SS), finish-to-finish (FF) or start-to-finish (SF) links. However, whenever possible, the FS logic relationship should be the one used.

In addition to logic ties, duration lag(s) between activity start and prior-activity finish can be assigned. For example, if an activity has an FS lag of 5 days, it would delay the start of the successor activity until 5 days after the predecessor activity has finished. Lags must be used with care and caution; one must fully understand their impacts. Lags should never be used to represent a period of time when another activity is actually occurring.

It is also possible to assign constraints to those activities and milestones that require the activity or milestone to start or finish at a specific point in time. For example, access to a work area will not be available until February 1. A "start no earlier" constraint of February 1 on the activity is thus sensible and reflects reality.

Constraints should be used sparingly. Every fixed date in the schedule limits the ability of the overall model to respond dynamically to other changes in logic or to changes in actual progress during status updates. Every constraint changes (distorts) the float information calculated by the schedule model. Neither constraints nor lags should ever be used to replace logic.

ACTIVITY DURATION

The duration is an estimate of how long it will take to accomplish the work involved in the activity. In many cases, the resources available to accomplish the activity will determine the activity's duration; in other cases, it is simply the volume of work.

An increase or decrease of resource availability will have a direct effect on the activity duration (and frequently this is *not* a simple, straight-line relationship). Other factors influencing duration are the type or skill level of the resources available to undertake the work, resource calendars, and the intrinsic nature of the work. Some activities take a set amount of time to complete regardless of resource allocation (e.g., a 24-hour concrete test).

Although the duration for an activity can be determined at any time, generally accepted good practice recommends defining the activity first, tying it logically into the overall schedule sequence, and then focusing on how long it will take to accomplish the work. By this juncture, the relationship between the activity and other work in the schedule will be better appreciated, and resource flows, team size, and the like, can begin to be determined.

Realistic estimates of the time required to accomplish tasks must be used. The extremes of "if everything went perfectly, how long would it take" (the zero free-float scenario) to "if lots of problems occur, how long would it take?" help frame the most likely scenario of how the work will progress. Task complexity, as well as the aforementioned task interrelationships and resource allocations, have to be considered.

ANALYZING SCHEDULE OUTPUT

Once the project schedule model contains all the project's unique activities with their various durations, all logically linked together, the schedule can be analyzed to calculate early start and late finish dates, float, and other schedule values. Four discrete steps compose this analysis:

1. A start date is assigned to the start milestone (or first activity). Then, moving from left to right through the network from activity to activity, in the sequence defined by the logical relationships and respecting assigned durations, start and finish dates are calculated for each activity and milestone. This is called the *forward pass*, and it establishes the early dates for each activity and milestone. When the analysis reaches the end of the network, it has established the earliest possible finish date for the full project.
2. Next, a finish date is assigned to the end milestone (or last activity). The analysis process then works back through the network, from right to left, until it arrives at the start milestone; and thus another set of start and finish dates have been calculated for each activity. This is called the *backward pass*, and it establishes the late dates for each activity and milestone.
3. Float (i.e., project slack) values are calculated by comparing the early and late dates.
   - Free float for an activity is the time period calculated by subtracting the early finish date of the activity from the earliest start date of any of its successors. Free float is never negative. An activity on the critical path will have zero free float.
   - Total float on a noncritical network path is the time period calculated by subtracting the early start date from the late finish date (of the network path) and then deducting the duration (of all the activities on the network path).
   - Total float of a network path is thus the combined free float values of all activities in a path. Total float represents project schedule flexibility.
4. After the float values are derived, resource smoothing or leveling can be conducted to minimize resource allocations or reduce fluctuations in resource demand. Most project-scheduling software has multiple options and settings to create the resource-leveled schedule. Manual resource leveling by adjusting logic or adding constraints to delay the start of certain activities is not recommended because it distorts the software's internal computations and will create problems over time.

Note: Schedule expert Murray Woolf (2007) recommends that all paths with a total float value of less than 2.5% of the original project duration be treated as critical; this means that any project schedule duration with 2.5% total float or less is not realistic.

The project team then reviews the expected project end date, milestone completion dates, and resource requirements (compared to resource availability) to determine acceptability of the schedule. Where alterations are required, variations are made to the schedule logic, resource allocations, or durations. These iterations continue until an acceptable project schedule is developed, one that all relevant project stakeholders can agree with.

FAST TRACKING

The most pursued schedule alteration is to reduce the overall duration of the schedule. The key technique used to compress the schedule is fast tracking.

As practiced within the mining project universe, fast tracking has an absolutely miserable record, mainly because its proponents force activities to start before the necessary predecessor activities are complete, resulting in faulty assumptions, work errors, rework, cost overruns, and ultimately, a longer project schedule. While prudent schedule analysis and optimization are heartily endorsed, the authors do not advocate or support fast tracking, because it has a history of leading to unrealistic, unachievable schedules.

BASELINE SCHEDULE

Once agreed to and approved, the final version of the schedule is captured and becomes the project baseline schedule. This baseline schedule becomes the benchmark against which project performance is measured. The baseline schedule must be in place before execution of the project work commences.

Once created and approved, the baseline can only be changed for authorized changes in scope, but even then the baseline is never discarded. Each update becomes a dated, numbered schedule reforecast, and project progress is then compared against the latest reforecast *and* the original approved baseline schedule.

SCHEDULE LEVELS

The WBS provides the basis for development of the schedule structure. As a simplified explanation, Level 1 is the highest level schedule and shows the milestones to complete the project. Level 2 shows the scope of work to achieve the milestones. Level 3 displays all the deliverables to achieve the work scope. Level 4 captures the tasks to complete the deliverables, and Level 5 shows the tasks fully resourced (AACE International 2010).

Level 1 Schedule—Executive Summary or Project Master Schedule

The Level 1 schedule is a major milestone timetable that usually takes the form of a one-page milestone chart or simple bar chart. It outlines the strategy and objectives of the overall project and highlights the major project activities, milestones, and key deliverables. This is a very-high-level summary schedule for use in reports that do not require detail.

A Level 1 schedule is generally developed as part of the scoping evaluation. It is frequently inserted into bid and contract documents to illustrate the schedule conformance required of contractual terms and other milestones. The audience for this schedule level includes Owners, senior executives, and general managers. Figure 10.1 is an illustration of a Level 1 Executive Summary Schedule, extracted from a completed 2014 grassroots Canadian project.

Level 2 Schedule—Management Summary or Summary Master Schedule

The Level 2 schedule is customarily developed as part of the prefeasibility study to determine the viability of the project. Typically created as a bar chart, it outlines the strategy and objectives of the overall project, but with more highlight detail than a Level 1 schedule. It expands the Level 1 information to show activities by area or major item of capital equipment. The Level 2 schedule is typically a couple of pages with 50 or so line items. Each item on a Level 2 schedule is generally a subcategory of a Level 1 item.

If an engineering, procurement, and construction management (EPCM) firm is used for the prefeasibility publication, the Level 2 schedule is often used to integrate the different project schedules of multiple contractor bidders to arrive at an overall schedule for the project.

After the prefeasibility study is done, the Level 2 schedule is ordinarily only maintained as a summary of the Level 3 Project Coordination Schedule. It depicts the overall project broken down into its major components; its prime use is for senior management reports.

Level 3 Schedule—Project Coordination or Publication Schedule

The Level 3 schedule is initially developed as a comprehensive, integrated CPM overview of the project. Developed by the project team for the feasibility study and the accompanying Project Execution Plan, the Level 3 schedule spans the whole of the project and is used throughout the project execution stage as a key control tool. It includes all the major milestones and the major elements of design, engineering, procurement, construction, testing, commissioning, and start-up.

If the Level 4 schedules are primarily developed by trade subcontractors for the construction execution phases of the project, then the Level 3 schedule provides the schedule framework and constraints for these contractors to develop their initial tenders and then their field plans. A Level 3 schedule is typically broken out into the agreed-on project work packages, generally resulting in 250 to 300 line-item activities.

A generic example of a project coordination schedule is shown in Figure 10.3. This Level 3 schedule is three-page précised extract from a schedule created for a 1999 South American oxide leach feasibility study at an operating site.

During the execution stage of the project, the Level 3 schedule defines the overall critical path and is the primary coordination tool for the whole project. The Level 3 schedule is maintained in the execution stage as the integrated roll-up or summary of the Level 4 schedule activities for reporting monthly status to project management (project manager, construction managers, superintendents, and general forepersons) as well as the Owner.

Level 4 Schedule—Execution or Project Working Level Schedule

Level 4 is the detailed working-level schedule. Each Level 4 schedule is an expansion of a Level 3 schedule; each is established within the integrated project schedule. The Level 4 schedules are the key working-level CPM schedules that display the activities to be accomplished by the project workforce, and *they are required for every project*. The dates generated by the Level 4 schedule activities denote the anticipated start and completion work dates for the project.

Level 4 schedules are normally developed by the field contractor and subcontractors prior to commencing work on the project construction phase of the project. The Level 4 schedule may be for the whole of the project or, depending on project size and complexity, it could be a breakout area schedule for a portion of the work scope. Mega-projects often have more than

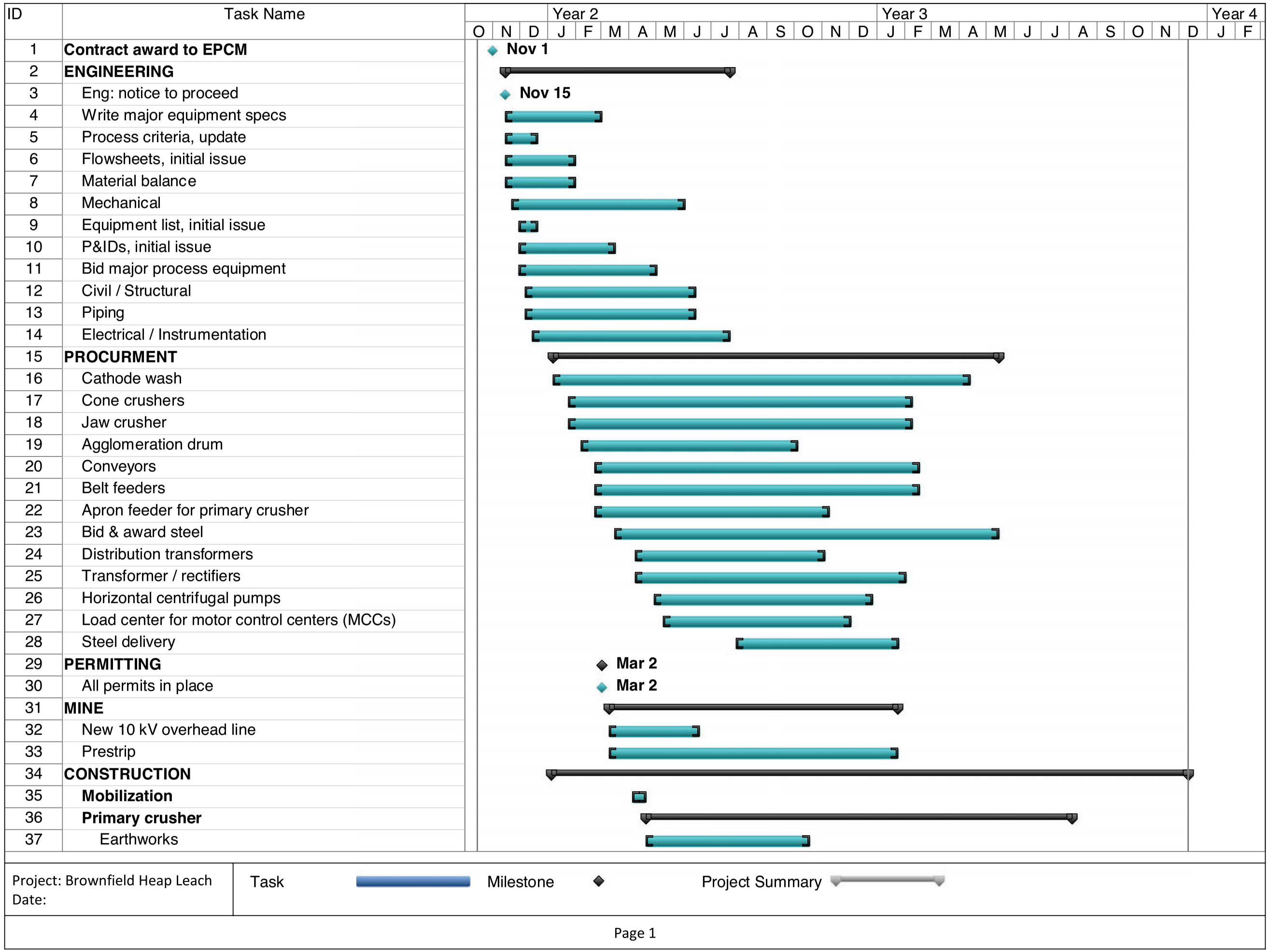


FIGURE 10.3 Level 3 schedule—brownfield project

(Continues)

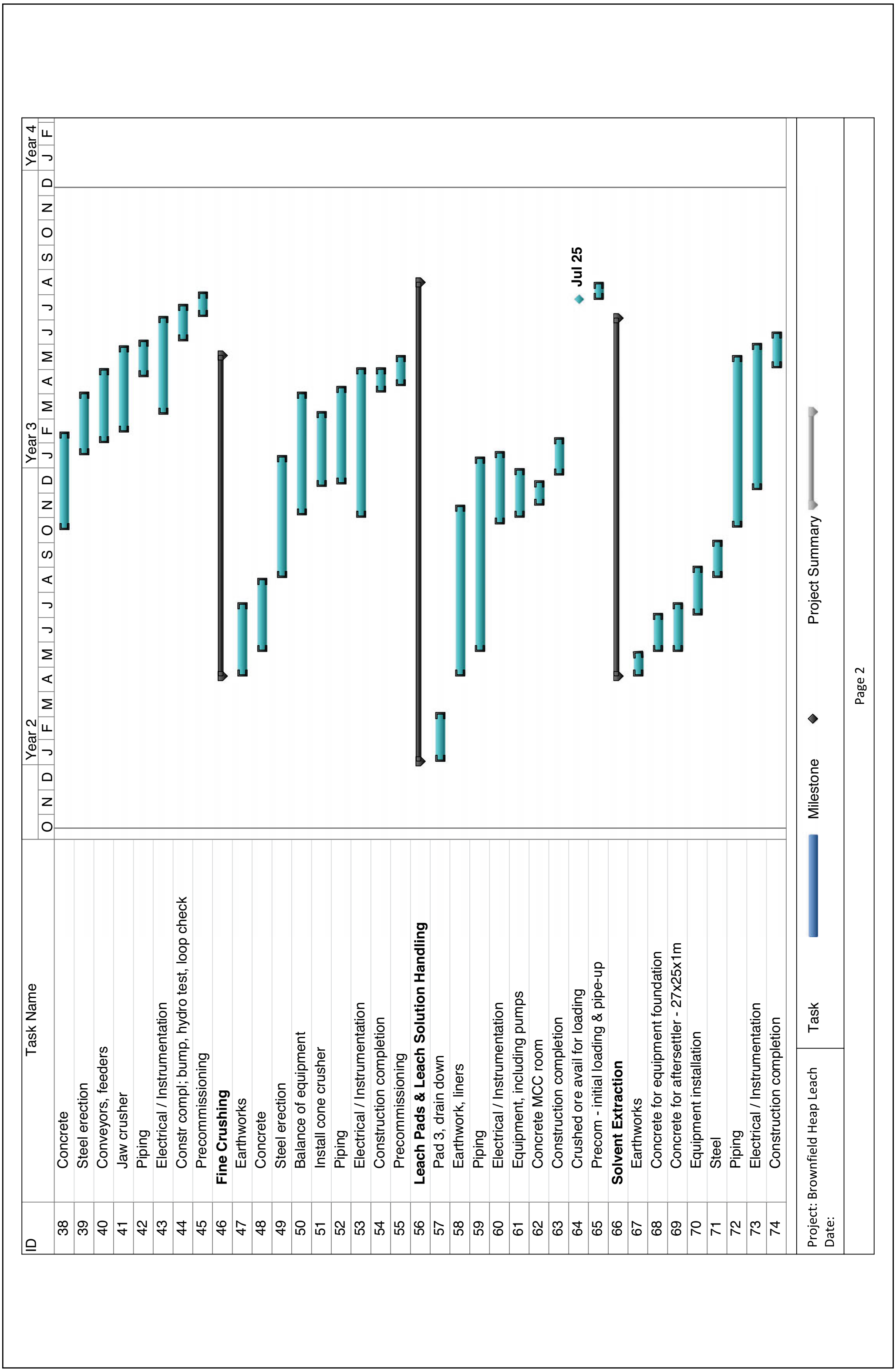


FIGURE 10.3 Level 3 schedule—brownfield project (continued)

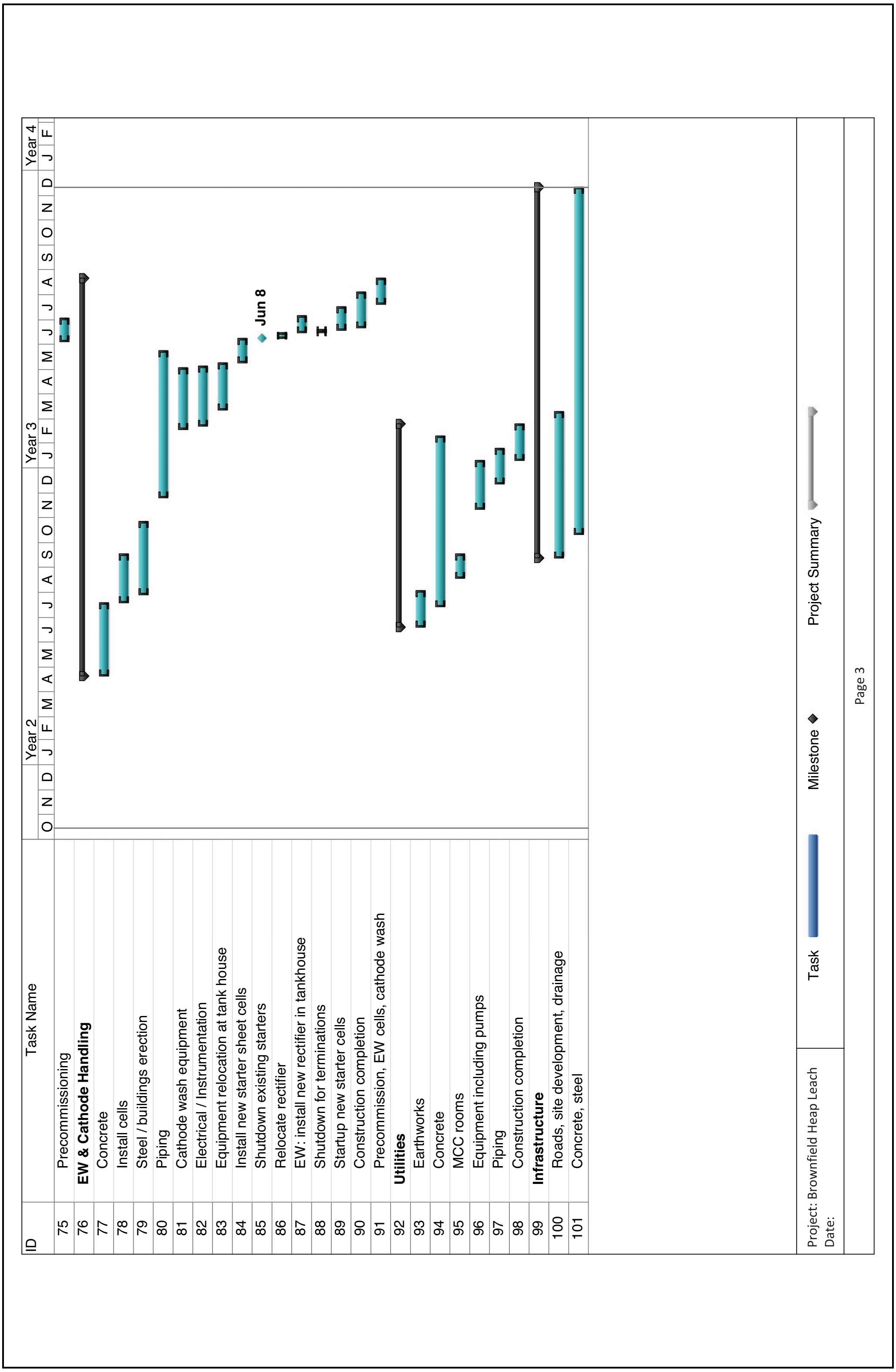


FIGURE 10.3 Level 3 schedule—brownfield project (continued)

one Level 4 schedule. The critical factor is keeping each Level 4 schedule to a sensible size that can be easily managed, updated, and validated. Level 4 schedules can be broken out by area (e.g., a port site) or by discrete process such as the commissioning schedule. Generally, the Level 4 schedule represents the area of authority of an area manager, so that one person is responsible for all of the work within that schedule. Activities within the schedule are generally more than a week in duration, are resource loaded, and include detailed crew movements and other measures to ensure viability.

There are diverse views on the optimum maximum size for a Level 4 schedule. Most experts recommend less than 1,000 tasks per schedule (ideally 500 to 600) because:

- The cause and effect of schedule changes need to be visible and understandable to the responsible team members using the schedule, and
- The schedule needs to be capable of being printed and viewed as a whole.

Most scheduling tools allow linking to external project files, so having several Level 4 schedules will not degrade the overall integrity of the project schedule. Short-term look-ahead Level 5 schedules are produced from the Level 4 schedules; typically these are 3-week look-ahead schedules, which are updated every 2 weeks. Level 4 schedules are for project managers, superintendents, and general forepersons.

Level 5 Schedule—Detailed Short-Term Schedule

Level 5 is the further breakdown of the Level 4 schedule activities. It is a short-term schedule used to map out the detailed tasks needed to coordinate day-to-day work in a specific area. Level 5 schedules are temporary documents based on the Level 4 look-ahead.

Level 5 schedules are developed by workforce supervisors to plan and coordinate their work at the detail level. Workarounds and critical areas can be exploded as needed. These bar-chart schedules are replaced every 1, 2, or 4 weeks, depending on the complexity of the work. The schedules extend for 1 or 2 weeks beyond the date the replacement Level 5 schedule is due. For example, a weekly schedule will extend for 2 weeks and be updated or replaced each week. This aids work continuity. Audiences for this schedule include superintendents, general forepersons, and crew leaders.

Level Schedule Factors

Level 1 and 2 schedules are usually developed top-down, but then updated and maintained using information from Level 3 and 4 activities.

Level 1 and 2 schedules are often continued for reporting purposes during the execution phases as roll-ups of data from the working-level schedules (either Level 3 or Level 4). However, generally only mega mine projects will maintain both Level 1 and Level 2 schedules. Most projects will do fine with only a Level 2 roll-up.

On projects with multiple Level 4 schedules, the Level 3 schedule is always maintained as the project's overall, integrated CPM control schedule, because the overall size of this schedule needs to be manageable. Level 3 schedule continuation is crucial for the overall coordination of the project whenever more than one Level 4 schedule is in use.

Today's project scheduling tools can allow a high degree of integration between individual schedules. It is feasible for just one computer file to produce and maintain the Level 1, 2, and 3 reports. Similarly, the Level 3 schedule can be directly linked to the Level 4 schedules, but here *full* integration is *not* recommended because of the resultant size of the files and the difficulty people would have in sorting through the data.

A competent scheduler supported by professional software should be able to develop and maintain schedules containing 2,000 to 3,000 activities. Asking one scheduler to handle more than 5,000 activities (as some projects currently do) is a flawed practice. It inevitably leads to errors, reduction of quality, and generally larger project losses than the salary of another scheduler.

SCHEDULE DENSITY

Tasks within a schedule (portrayed as bars on a schedule chart) should progressively expand to greater levels of density as more information becomes available (Weaver 2010). This translates into more and shorter-length activity bars appearing on the schedule chart for project work undertaken earlier in the schedule than for work scheduled later. Thus, work that is 12 months or more in the future can be appropriately portrayed on the schedule as low density, with a few bars of long durations over several months. Detail is not necessary on tasks that are far out in the future.

A medium density of task bars should appear on the schedule chart for work that is to take place 3 to 9 months out. Task durations here would typically be less than 2 months.

High-density scheduling is a prerequisite for undertaking work less than 3 months out, such as on Level 4 or Level 5 schedules. The schedule should show a very high density of short-duration task bars for work that is imminent. Such schedules are best prepared with the people actually doing the work. Task durations in these high-density schedules should preferably be set to no more than an update cycle.

SCHEDULE FACETS

When preparing a schedule, keep in mind the following:

- Do not plan only for tasks relating to the project facilities. Include time for activities like team meetings and keeping the Owner and regulatory agencies informed. Provide time for Owner and review agency approvals and sign-off. Make sure the Owner has bought into the review time limits and understands its role in keeping the project on track.
- Allow ample time for assembly of the Owner's paper (and electronic) deliverables. Underestimating the time and effort needed to prepare and assemble final reports, plans, specifications, and the like is a common mistake (and an irritation for the Owner).
- Deliberately insert enough skilled staff into the project team to maintain the schedule. Do not presume that the requisite skill sets will magically be available.
- Do not assume that everyone on the project team has accepted the published schedule just because it has been printed. Take the time to meet with all key players and ensure that they have seen, understood, and agreed with the durations and milestones established.

SCHEDULE MAINTENANCE DURING PROJECT LIFE

Establishing a realistic and achievable schedule is one of the most critical initial actions in setting up a project. But equally important are the regular updating of project status and schedule in support of the ongoing management and control of progress as work is executed.

The project manager is responsible for preparing the project schedule. But before engineering work begins, the schedule requires the approval of each of the engineering discipline managers and the approval of the EPCM project sponsor (if an EPCM firm is involved). Before construction begins, the schedule needs to be accepted by all the major site contractors and their area construction superintendents.

When negotiating the contract with the successful construction bidder, it is common practice to require a CPM schedule to be submitted by the bidder within 7 to 14 days of award. The contractor's submitted schedule is then modified as necessary to fit into the overall project baseline schedule. The resultant product becomes the project baseline schedule and is typically incorporated as an attachment to the contract agreement with the bidder. This is done deliberately to provide a contractor-agreed reference point for changes occurring after the award.

The project schedule model is maintained by updating and incorporating authorized changes as work progresses and creating new instances of the schedule as needed. Effective schedule change control is necessary, including the tracking of each approved schedule change as it occurs throughout the project life cycle. The schedule status update process occurs on a set, regular basis. The following steps are involved:

1. Collect and record the status of the work, including actual start dates for all activities that commenced and the actual finish dates for all activities that are completed during the reporting cycle. Where an activity is in progress, the amount of work accomplished and the time needed to complete the remaining work are determined. Additional information gathered would include data on resource use and incurred cost.
2. Update the schedule with any changes from actual work in progress or about to start. This may involve altering logic ties, durations, resource allocations, and so forth.
3. Compare the project schedule model update with the stored baseline. Lock in gains and/or recover losses; that is, manage SVs by proactively using the change management process.
4. Ensure that the project schedule still represents 100% of the work scope.
5. In parallel, review the overall momentum of the project to ensure that adequate work is being accomplished overall. Maintaining an adequate performance intensity is critical to achieving the overall completion of the project. EV analysis is the best measure of overall performance.
6. Reforecast the baseline for any authorized scope changes in the project schedule.
7. ES is a good tool for reforecasting the completion date.
8. Maintain records of all changes in activity durations and/or logic.
9. Distribute reports in accordance with the project's communication plan. Each newly issued schedule is uniquely named, saved, and kept for future reference.

The status update process is the key element in making the schedule an effective project management tool. It progressively corrects those errors (or incorrect assumptions) that are embedded in every schedule, and it can positively influence the perceptions and attitudes of the project team.

Regardless of whether the official project schedule is updated monthly, biweekly, or weekly, the reporting frequency for field installation work needs to be done weekly, and the contractor needs to staff resources accordingly. Many events occur in a 14- or 30-day period; therefore, less frequent than weekly reporting deprives the Owner of the opportune time to take corrective action.

The project manager is the primary user of the schedule information: to decide project strategy, test decisions and resolve dilemmas, coordinate workflows, and balance resource demands. Ownership of the project schedule always remains with the project manager and the project team. It must not be allowed to be taken over by the project scheduler, no matter how skillful or competent that individual may be.

During project reviews the most up-to-date project schedule is always used to conduct the review with the project team, the contractors, or the Owner. The schedule used in the review needs to graphically illustrate the scheduled and actual progress on project tasks along with the status of all relevant milestones.

The project schedule should always reflect the most realistic dates for project accomplishment, even if this means a schedule reforecast. Whenever a new schedule forecast is made, however, the original schedule completion dates are retained, so that any overall schedule slippage or gain is transparently known by all parties. On project completion, the schedule model should be archived for future reference.

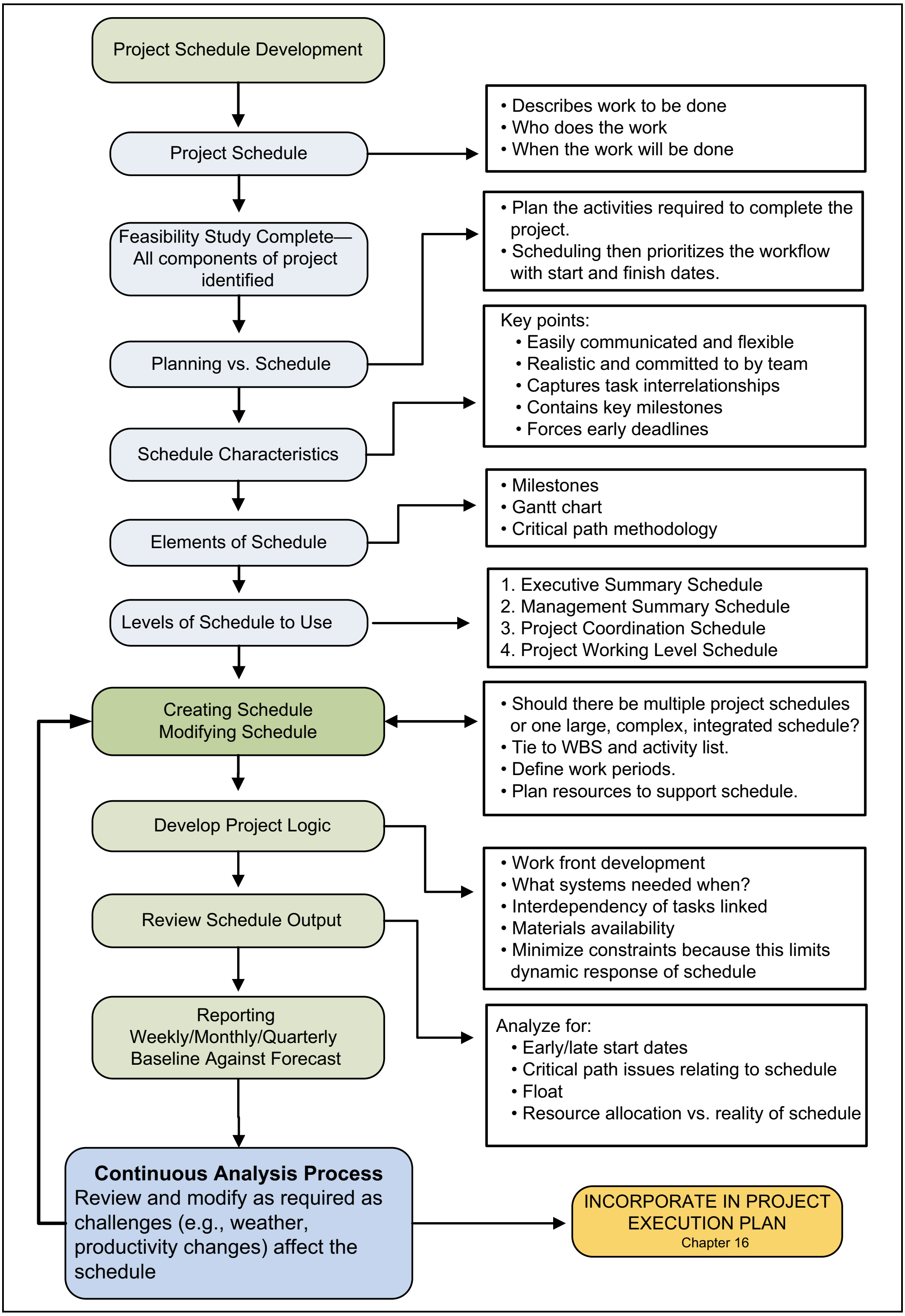
COMMON PITFALLS AFFECTING SCHEDULES

The following schedule issues have caused problems in numerous projects:

- Including excessive detail within the published schedule. Too much detail hides useful information and impedes knowledge flow. More detail does not improve accuracy.
- Trying to turn a detailed schedule into a contract. This will merely encourage parties to distort the schedule for political ends: to build in "fat" and restrict the making of necessary change during project execution.
- Overselling what a schedule can do for the project. A schedule is a tool that provides information for people to use. In itself, it controls nothing.
- Overstating the accuracy of estimated durations. These are estimates, not facts.

CHECKLIST 10.1 SCHEDULE

No.	Item	Status	Date	Initials
1	Level of schedule and detail required for stage of project—determined			
	A. Scoping—Level 1 Executive Summary			
	B. Prefeasibility—Level 2 Management Summary			
	C. Feasibility—Level 3 Project Coordination			
	D. Project delivery—Level 4 Execution and Level 5 Detailed			
2	Level of effort involved to achieve scope—understood			
3	Prerequisite work elements for schedule development:			
	A. Support study for the schedule—complete			
	B. Density of information required—understood			
	C. Scope of work—issued			
	D. Level of detail—defined			
	E. Level of accuracy—set			
	F. Planning of work process—completed			
	G. Task list—produced			
	H. WBS linkage—in place			
4	Schedule components:			
	A. Project activity list—complete (covers 100% of scope)			
	B. Project activity coding structure—prepared			
	C. Project calendar and work periods—set			
	D. Time scales for activity durations—selected			
5	Scheduling method or techniques selection:			
	A. Wall scheduling—utilized			
	B. Critical path methodology (CPM) technique—chosen			
6	Schedule development process			
	A. Project logic—developed			
	B. Gantt chart—created			
	C. Task interrelationships—shown			
	D. Milestones—set			
	E. Free float—built in			
	F. Resource smoothing or leveling—undertaken			
	G. Schedule output analysis review—complete			
7	Schedule integration:			
	A. With cost management system—accomplished			
	B. With earned value management (EVM) system—accomplished			
	C. With risk management system—accomplished			
8	Final schedule—peer reviewed			
9	Schedule update cycle—established			
10	Reporting requirements against baseline schedule—defined			
11	Schedule acceptance by Owner and key stakeholders—achieved			



FLOWCHART 10.1 Schedule

CHAPTER 11

Budget

No one would remember the Good Samaritan if he'd only had good intentions; he had money as well. — *Margaret Thatcher, 1925–2013*

OBJECTIVE

This chapter presents the steps that are needed to produce the project budget. The different effort levels required for an accurate cost estimate for each study phase are portrayed in the chapter, but the relevant details can be found in the individual sections of this book that separately deal with each study. These study estimates are steps on the path to creating the project budget, and effort levels increase as the project progresses in complexity from scoping, through prefeasibility and feasibility, and into execution.

When the components of the feasibility study and the project activities list are assembled, the preparation of project budget and the project schedule can be undertaken. Because the two are interconnected, the budget and schedule are normally prepared simultaneously; but for purposes of clarity, they are dealt with separately in this book. The objective here is to make sure that project personnel know the work effort, necessity of detail, and accuracy needed to create the project's control budget.

WHAT IS A COST ESTIMATE?

A cost estimate is produced to approximate the cost of the project. It has a total value with identifiable component values. The cost estimate is used to establish the budget as the project's cost constraint. The project budget is a necessity to support feasibility evaluations for project funding requirements and to facilitate project control.

The U.S. Government Accountability Office (GAO 2009) defines a cost estimate as "the summation of individual cost elements, using established methods and valid data, to estimate the future costs of a program, based on what is known today."

The authors favor Larry Dysert's (2006) more succinct portrayal, wherein he defines a cost estimate as "a prediction of the probable cost of a project, for a given and documented scope, to be completed in a defined location and point in time in the future."

Within the context of this book, the cost estimate is used as a forecast of the required funding for the project capital investment. That is, the fixed capital that provides the physical facilities and the working capital (the revolving fund) that keeps the facilities operating. It is only valid for the scope of work on which it is based.

After receiving the contractor's submitted cost estimate, some Owners try to characterize it as a "guaranteed maximum price" rather than what it truly is: an opinion of probable cost. Unless the submitter has actually proffered in writing the estimate as a "not-to-exceed price," any such characterization by the Owner is inappropriate and unfair.

Cost estimates not only communicate project costs to the Owner, but they also aid the procurement function when soliciting for goods and materials. They function as a data information source for the construction contractor when submitting a tender to compete for contract award.

In an attempt to manage liability risk, some organizations have started to avoid the use of the word *estimate* and instead refer to the estimate as an *opinion of probable cost*. This book stays with the term *estimate*.

THE TRUTH BEHIND A COST ESTIMATE

In preparing any capital cost estimate, the reality is that everything will not be known, specified, measured, or quantified. To prepare an accurate estimate, one must first assess what is known about the project and what is not known. The prepared costs will then fall into one of three categories:

1. What we know we know
2. What we know that we do not know
3. What we do not know that we do not know

What We Know We Know (The Known Knowns)

The known knowns reflect the quantities and unit rates developed from first principles. This component of the estimate is generally known as the *base estimate* and is derived from design criteria, process descriptions, process flow diagrams, equipment lists, vendor quotations, labor rates within contract agreements, drawings, quantity takeoffs, and so forth. The accuracy of this base estimate is primarily related to the development and level of maturity of the input information, that is, the project definition at the time of the estimate.

What We Know That We Do Not Know (The Known Unknowns)

The known unknowns are referred to as *growth allowances*. Experience tells us that by the time construction is complete, many variations and changes will have occurred in design quantity and cost, generally as a result of more detailed knowledge as the project progresses. Growth allowances are included in the estimate to cover these unknown but expected increases in design quantities and costs. The rules for assigning growth allowances can be summarized as follows:

- Growth allowances apply to the defined scope of work; they do not cover scope changes.
- Growth allowances apply only to direct costs, and not to indirect costs such as engineering, procurement, and construction management (EPCM) services.
- Growth allowances vary with the status of the study and the quantity development.
- No growth allowance is applied to lump-sum allowances (including provisional sums).
- Growth allowances are estimated in detail for feasibility studies and shown against the relevant line items. For prefeasibility studies, they can be represented by a single line-item global sum.

Quantity Takeoff Factors*†		Pricing Factors*		TOTAL, %
Description	**%**	**Description**	**%**	
PLANT EQUIPMENT				
Equipment List—Final	0.0	Quote—Firm	1.0	1.0
	0.0	Quote—Budget	2.0	2.0
	0.0	Quote—Prelim.	3.0	3.0
	0.0	Estimated	4.0	4.0
	0.0	Allowances	0.0	0.0
Equipment List—Preliminary				
	1.0	Quote—Firm	1.0	2.0
	1.0	Quote—Budget	2.0	3.0
	1.0	Quote—Prelim.	3.0	4.0
	1.0	Estimated	4.0	5.0
	1.0	Allowances	0.0	1.0
BULK MATERIALS				
Design Drawings	1.5	Quote—Firm	1.0	2.5
	1.5	Quote—Budget	2.0	3.5
	1.5	Quote—Prelim.	3.0	4.5
	1.5	Estimated	4.0	5.6
	1.5	Allowances	0.0	1.5
Conceptual Drawings‡	2–7.5	Quote—Firm	1.0	3.0–8.6
	2–7.5	Quote—Budget	2.0	4.0–9.7
	2–7.5	Quote—Prelim.	3.0	5.1–10.7
	2–7.5	Estimated	4.0	6.1–11.8
	2–7.5	Allowances	0.0	2.0–7.5
Historical Factors‡	3–10	Quote—Firm	1.0	4.0–11.1
	3–10	Quote—Budget	2.0	5.1–12.2
	3–10	Quote—Prelim.	3.0	6.1–13.3
	3–10	Estimated	4.0	7.1–14.4
	3–10	Allowances	0.0	3.0–10.0
Allowances	0.0	Quote—Firm	1.0	1.0
	0.0	Quote—Budget	2.0	2.0
	0.0	Quote—Prelim.	3.0	3.0
	0.0	Estimated	4.0	4.0
	0.0	Allowances	0.0	0.0

* These factors are for guidance only; they will vary with project-specific conditions.
† An increase in quantities should capture associated labor, installation, and freight costs.
‡ The percentages vary with material. Earthworks generally have the highest percentage.

FIGURE 11.1 Typical growth allowance factors

- Assigned growth allowances need to be auditable.
- Growth allowances must be based on historical justification, calculated either as a percentage of quantity or cost.

A listing of typical growth allowance factors is provided in Figure 11.1.

What We Do Not Know That We Do Not Know (The Unknown Unknowns)

The unknown unknowns are captured within the estimate by the application of contingency. The contingency allowance is the amount required to adjust the base estimate and growth allowances to produce a budget estimate that has the desired probability of overrun and underrun. See Chapter 12 for a discussion on the application of contingency.

Contingency is never hidden within the estimate; rather, it is highlighted as a separate line item. No "fat" should ever be deliberately built into the estimate. Work and quantities measured must not be inflated to cover perceived estimating inaccuracies, design growth, Owner changes, or anything else unrelated to delivering the scope as defined.

Another type of unknown unknown is risk. While systematic risk is intended to be covered within contingency, *project-specific risk is separate to, and never a part of, contingency*. Project-specific risk amounts, if recognized by the project, are part of the "management reserve" allowance.

COST ESTIMATE CLASSIFICATIONS

Methods used to prepare the estimates range from stochastic guesstimates or judgments at early definition to deterministic with later definitions. A frustrating issue within the classification of cost estimates is that the two prime categorizers, the U.S. Department of Energy (DOE), and the American Society of Professional Estimators (ASPE), classify their estimates in reverse order to each other. This makes cost estimate classification terminology extremely confusing to the uninitiated.

Historically, these have been the most common cost estimate classifications:

- Order of magnitude (corresponds to DOE Class 5)
- Preliminary/budget (corresponds to DOE Class 3)
- Definitive (corresponds to DOE Class 1)

The DOE (2004) actually uses a five-class system of estimates:

Estimate	Name	Purpose	Project Definition
Class 5	Order of magnitude	Screening	0% to 2%
Class 4	Intermediate	Concept study or feasibility	1% to 15%
Class 3	Preliminary	Budget authorization	10% to 40%
Class 2	Intermediate	Bid tender and/or control	30% to 70%
Class 1	Definitive	Check estimate and/or bid	50% to 100%

The Association for the Advancement of Cost Engineering International (AACE International 2012) adopted a five-class system in 2012, very similar to the DOE system. The AACE International system, which is the system that most mining EPCM firms follow, is in the same order as the DOE, that is, with Class 1 being the greatest level of definition:

Estimate	Methodology	Purpose	Project Definition
Class 5	Factoring and judgment	Screening	0% to 2%
Class 4	Parametric models	Concept study or design	1% to 15%
Class 3	Semidetailed	Budget authorization	10% to 40%
Class 2	Detailed unit costs	Control or bid tender	30% to 75%
Class 1	Detailed takeoff	Check estimate or change	65% to 100%

The United Kingdom's Association of Cost Engineers (ACostE 2013) uses a three-class system of estimates, in the same order as the DOE, that is, with the greatest level of definition being first in the order:

Estimate Class	Name and Purpose	Project Definition Level
Class III	Prebudget	Not specified
Class II	Semidetailed	Not specified
Class I	Definitive	Not specified

The ASPE (2004) uses a five-class system but defines the estimate levels in reverse order, that is, with the least defined first in the order:

Estimate Class	Name and Purpose	Project Definition Level
Level 1	Order (range) of magnitude	Not specified
Level 2	Schematic/conceptual design	Not specified
Level 3	Design development	Not specified
Level 4	Construction document	Not specified
Level 5	Bid	Not specified

Adding to the confusion, there are a plethora of other names used by a variety of professional entities to differentiate estimate class qualities.

Initial estimates (roughly corresponding to DOE Class 5) can also be known as conceptual, evaluation, predesign, prebudget, parametric, rough order of magnitude or SWAG (scientific wild-assed guess) estimates. Intermediate estimates (roughly corresponding to DOE Class 3) are sometimes called scope or sanction estimates. Final estimates (roughly corresponding to DOE Class 1) are also classified as detailed, final, control, as-bid, or as-sold.

The authors prefer the progression levels hierarchy of the ASPE, where the least defined cost estimate is the first number in the order of its five-class system, thus matching the progression order of the schedule levels used by the Project Management Institute (PMI). Unfortunately, most cost estimates published by the mining community follow the AACE International reverse-order progression.

To escape from this morass of names and numbers (and, ideally, to avoid confusion), this book will not use class or level numbers for characterizing cost estimates but instead will rely on illustrative names, as shown in Figure 11.2. To help the reader, each name is listed alongside its closest numbered level from the ASPE, DOE, ACostE, and AACE International cost estimate classes (AACE International 2005b).

ESTIMATE QUALITY

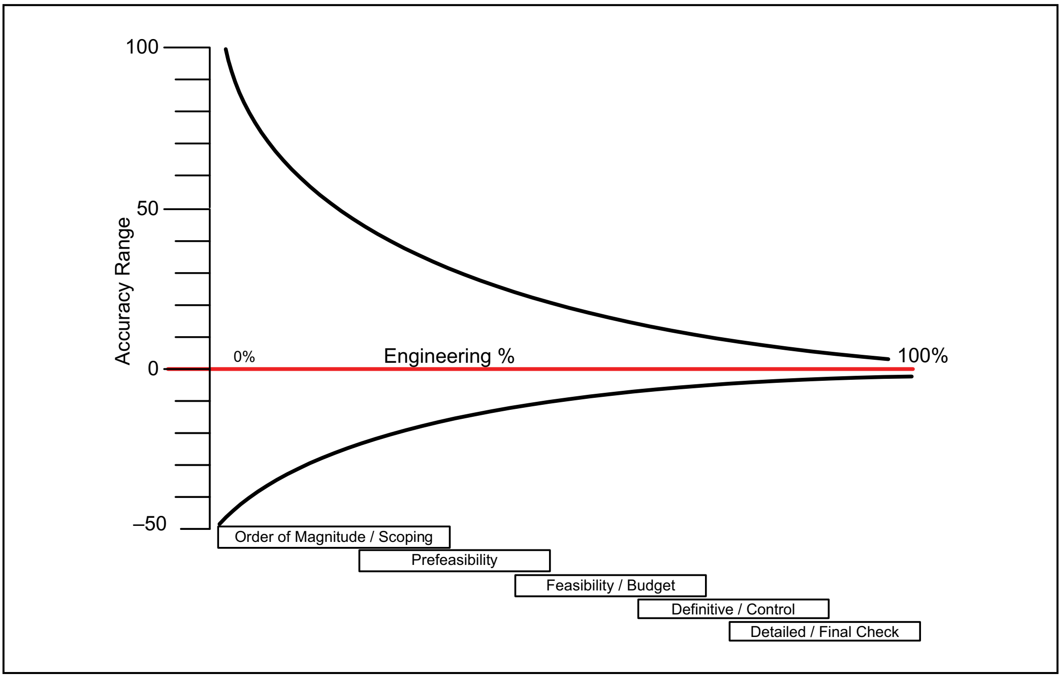
Estimate quality refers to the fulfillment of estimate quality requirements in accordance with the formal quality assurance requirements. An estimate's quality requirements are mostly concerned with accuracy, but they also take into account credibility, confidence level, precision, risk, reliability and validity, thoroughness, uniformity, consistency, verification, and documentation.

ESTIMATE ACCURACY

Accuracy is the degree to which a measurement or calculation varies from the actual value; thus, estimate accuracy informs us of the degree to which the project final cost outcome may vary from the single point value depicted by the estimated cost. Because the cost estimate is an approximation of the cost of a project, the estimate accuracy is a measure of how closely the estimate is able to predict the actual project expenditures. Unfortunately, this can only be known with certainty *after* the project is completed.

Estimate Name and Purpose	ASPE	DOE	ACostE	AACE Int.
Order of Magnitude (Scoping)	Level 1	Class 5	Class III	Class 5
Prefeasibility Study	Level 2	Class 4		Class 4
Feasibility Study Budget	Level 3	Class 3	Class II	Class 3
Definitive (Control)	Level 4	Class 2	Class I	Class 2
Detailed (Final Check/Lump-Sum Bid)	Level 5	Class 1		Class 1

FIGURE 11.2 Cost estimate classifications—institution comparisons



Source: Adapted from AACE International 2005b, and Oberlender and Trust 2001, with permission from American Society of Civil Engineers.

FIGURE 11.3 Estimating accuracy curve

Estimates involve assumptions and uncertainties, and must therefore be associated with some level of error. This level of error can be correlated with the probability of overrunning or underrunning the predicted cost. Thus, estimate accuracy is really a probabilistic assessment of how far the project's final cost may vary from the single point value originally selected to represent the estimate. Given the probabilistic nature of the estimate, it should not be portrayed as a single point value. Rather, an estimate should be shown within a range of potential outcomes, with any one outcome associated with a probability of occurrence.

Determinations of estimate accuracy should therefore accompany every estimate. Estimate accuracy is traditionally represented as a plus-or-minus percentage range around the point estimate, with a stated confidence level that the actual cost outcome will fall within this range. For example, the accuracy of a definitive estimate might state that the estimate has a 90% probability of being within the range of −5% to +10%; that is, the estimator is 90% confident that the final value will fall within that range.

For any one project, the range of uncertainty about the total estimate decreases as the estimate accuracy increases, as shown in Figure 11.3. This illustration is an adaptation of concepts

Estimate Name	% Engineering	Accuracy @ 90% Confidence
Order of Magnitude (Scoping)	0 to 2%	±40% (Range –50% to +100%)
Prefeasibility Study	5 to 12%	±25% (Range –30% to +40%)
Feasibility Study Budget	12 to 30%	±15% (Range –20% to +25%)
Definitive (Control)	60 to 80%	±8% (Range –10% to +12%)
Detailed (Final Check/Lump-Sum Bid)	>85%	±5% or better

FIGURE 11.4 Typical cost estimate accuracies at 90% confidence level

captured by the "Cone of Uncertainty" in Oberlender and Trost (2001) and the "Estimating Accuracy Curve" in AACE International (2005b).

Typical accuracies that should be sought with 90% confidence at the different levels of estimates are shown in Figure 11.4. As shown in Chapter 12, the distribution of possible costs is generally skewed. Thus, for a given probability, the magnitude of an overrun is always greater than an underrun. The accuracy of an estimate is measured by how well the estimated cost compares to the actual installed cost. The accuracy of an early estimate depends on four determinants:

1. How was the estimate prepared?
2. What was known about the project?
3. Who was involved in preparing the estimate?
4. What factors were considered while preparing the estimate?

At each phase of the project, the estimate should reliably predict the cost to deliver the project, given the scope and assumptions reflected in the estimate. The key point is the estimate should always provide sufficient accuracy to support the impending decision.

If the project ends up having a different scope, or encounters changed conditions from those predicted at the outset, it will be impossible to retroactively assess the accuracy of the estimate.

ESTIMATING RIGOR

Credible cost estimates require compilation rigor. The GAO suggests that the following issues need addressing and/or defining:

1. Purpose of the estimate
2. Project background
3. Project description
4. Project schedule
5. Scope of the estimate (in terms of time, and what is and is not included)
6. Ground rules and assumptions
7. Data sources
8. Estimating methodology
9. Estimating rationale
10. Results of the risk analysis
11. Detailed description of how the estimate was derived
12. Conclusion about whether the cost estimate is reasonable

The kind of factors to consider for item 9, estimating rationale, are:

1. What is the economic climate? How “hungry” are the contractors?
2. Are materials and labor readily available; or is this a remote area?
3. Will work occur in the summer or the winter? The dry or the rainy season?
4. Is access to the site limited or easy? What is the site elevation?
5. Is it specialty work that very few contractors will bid on?
6. Is it a project with many subcontracts?
7. Will the work be unusually difficult or routinely easy?
8. Are government-stipulated wage rates required?

WORK BREAKDOWN STRUCTURE

The first step in creating an estimate for a budget is to agree on and create a work breakdown structure (WBS). A WBS is defined as “a deliverable-oriented hierarchical decomposition of the project work that has to be executed to accomplish the project objectives and create the required deliverables” (PMI 2008).

The WBS organizes and defines the total scope of the project. Within the WBS the project scope of work is broken down into distinct, controllable-size elements. Each element is assigned a distinct cost. The project’s WBS cost elements are then used by the project’s cost engineers and accountants to produce the project budget line items in the establishment of control, and for variance analysis reconciliations. The same WBS needs to be maintained throughout the life of the project to allow meaningful assessment of differences from the control budget.

WBS Overview

The WBS represents a physical identification of the mine facilities, infrastructure, services, and utilities required on the project. It is a top-down, tree-structure breakdown of the project scope, flowing logically into levels (typically four levels or more), such as area into subarea, facility into subfacility, system into subsystem, component into subcomponent, task into subtask, and so forth.

The WBS is developed by starting with the project’s end objective and successively subdividing it into manageable components in terms of size, duration, and responsibility. Thus the WBS captures the steps necessary to achieve the objective. The WBS provides a common framework for control of the project; it is the basis for dividing work into definable increments from which the scope of work can be developed, and the technical, schedule, cost, and labor hour reporting can be established.

For each element of the WBS, a description of the task to be performed is generated. The WBS permits summing of the subordinate costs for tasks, materials, and the like, into their successively higher-level parent tasks, materials, and so on. This technique thus defines and organizes the total scope of the project.

WBS elements are numbered sequentially to reveal the hierarchical structure. For example, “1.3.2 Rear Wheel” identifies this item as a Level 3 WBS element, since there are three numbers separated by decimal points. The coding scheme helps WBS elements to be recognized in any written context. The PMI *Guide to the Project Management Body of Knowledge* (*PMBOK Guide*) provides a good overview of the WBS concept (PMI 2008).

WBS Design Principles

The 100% Rule

One of the most important WBS design principles is called the 100% rule. The 100% rule states that the WBS must include 100% of the work defined by the project scope and capture all the deliverables—internal, external, and interim—in terms of the work to be completed, including project management.

The 100% rule is one of the most important principles guiding the development and decomposition of the WBS. It applies to all levels within the hierarchy: The sum of the work at the child level must equal 100% of the work represented by the parent. The WBS must not include any work that falls outside the actual scope of the project; that is, it cannot include more than 100% of the work. It is important to remember that the 100% rule also applies to the activity level. The work represented by the activities in each work package must add up to 100% of the work necessary to complete the work package.

Mutually Exclusive Elements

In addition to the 100% rule, there can be no overlap in scope definition between two elements of a WBS. Overlap would cause confusion for project cost accounting, and such ambiguity could result in duplicated work or miscommunication about responsibility and authority.

Planned Outcomes, Not Planned Actions

The WBS is organized around the primary products of the project (planned outcomes) instead of the work needed to produce the products (planned actions). Since the planned outcomes are the desired ends of the project, they form a relatively stable set of categories in which the costs of the planned actions needed to achieve them can be collected. Defining elements by outcomes ensures that the WBS will not prescribe methods, but will instead allow for greater ingenuity and creative thinking by the project participants.

Level of Detail

A question to be answered in determining the duration of activities necessary to produce a deliverable defined by a WBS is when to stop dividing work into smaller elements. There are several heuristics or rules of thumb used for determining an appropriate duration for an activity or group of activities to produce a specific WBS deliverable.

The first is the “80-hour rule,” which means that no single activity or group of activities to produce one deliverable should consist of more than 80 hours of effort. The second rule of thumb is that no activity or series of activities should be longer than one reporting period. Thus, if the project team is reporting progress monthly, then no single activity or series of activities should last longer than one month. The last heuristic is the “if it makes sense” rule. Applying this rule of thumb, one can apply common sense when creating the duration of an activity or group of activities necessary to produce a deliverable defined by the WBS.

The question then becomes, how many WBS elements are appropriate for a project? Generally, the number will be between 300 and 500. If it is fewer than 200, the mutually exclusive principle is probably not being adhered to. If it is more than 1,000, then it is getting too close to the activity level and as such becomes too cumbersome to manage.

The WBS needs to be established to best serve the project. Certainly, the mining company accountants will want to use the WBS to track their future operations asset register, but this should be solely an outcome of the system, not a restrictive input component.

Terminal Element

A terminal element is the lowest element (activity) in a WBS; it is not further subdivided. Terminal elements are the items that are estimated in terms of resource requirements, budget, and duration, linked by dependencies and schedule. A terminal element at the activity level is a task that:

- Can be realistically and confidently estimated,
- Makes no sense practically to break down any further,
- Can be completed in accordance with one of the heuristics previously defined,
- Produces a deliverable that is measurable, and
- Forms a unique piece of work that can be outsourced or contracted out.

COST ESTIMATING METHODOLOGY AND BEST PRACTICES

All capital cost estimates, other than the initial scoping estimates, are derived from either original data or historical costs. The basic characteristics of effective estimating include the following:

- Preparation of an estimate plan
- An unambiguous scope of work
- Understanding of the accounting protocols to be used for segregating costs (i.e., what is capital, what is operating, what are to be direct costs, and what are to be indirect costs for this Owner?)
- A set of agreed standard units and one agreed currency (with identified exchange rates)
- Establishment of one common WBS
- Clear identification of task or activity
- Availability of valid data for the level of estimate being prepared
- A standardized structure for the estimate
- Broad participation in preparing estimates
- Strict quantification protocols for drawing takeoffs, commodities, allowances, and the like
- Identification of the data source, cost, time, and resources required for each activity
- Full details of assumptions made, factors used, and allowances incorporated
- Proper development of contingency provision
- Inflation recognition: transparent escalation of all estimate costs to a nominal basis
- Documentation of excluded costs and qualifications
- Provision for program uncertainties
- Independent checks and review of estimates
- Revision of estimates for significant program changes
- Maintenance of an estimate change tracking register to document estimate progression

The choice of method for preparing the cost estimate is largely defined by the class of estimate being produced. In the early stages of project evaluation, large expenditures for detailed estimates are not warranted.

Simplified methods will have been developed for the early estimates, such as factoring or cost modeling, that are appropriate to the decisions made at that stage of the project. Final estimates require more accurate costs that need to be derived from zero-based first principles, that is, detailed, activity-based, hard, bottom-up costs.

Whatever the method used, best practice requires that the overall estimating process use established, repeatable, comprehensive methods that can be portrayed with an accuracy range that can be easily and clearly traced, replicated, and updated (GAO 2009). Such best practices will lead to high-quality cost estimates that are credible.

The source of any estimate needs to be carefully checked to ensure that the development of the estimate is appropriate for the purpose for which it is being prepared. To avoid problems with cost overruns, a credible, reliable, and accurate cost estimate is necessary is for all levels of estimate beyond scoping. This estimate would be prepared by a professional estimator (possibly aided by quantity surveyors and cost engineers) and supported by appropriate technical input to ensure completeness, compliance, and consistency.

Estimates should be unbiased. Uncertainty needs to be captured by the estimate accuracy range, not in the padding of cost components. The proper use of risk analysis provides the means of assessing uncertainty and determining the contingency input amount that will allow the project budget to be the single-value figure required for funding.

The basis of estimate (BOE) captures the scope basis, pricing basis, methods, references used, assumptions, inclusions, and exclusions, and it always accompanies a well-documented cost estimate. The BOE describes how the estimate was derived and how the expected funding will be spent to achieve the given objective. Additional documentation may accompany the estimate, including quantity takeoff documentation and supporting calculations, quotes, and the like. The BOE's purpose is to clearly communicate to the stakeholders the various approximations, assumptions, and interpretations behind the estimate to avoid misunderstandings and/or misuse. The BOE thus provides an indication of the level of risk and uncertainty (Westney 1997).

TYPES OF COST ESTIMATE

Facilities cannot be specified in detail until a substantial amount of engineering work has been undertaken. The conundrum is that detail engineering can rarely be justified before reaching a decision to proceed, and engineering cannot be completed until a significant commitment has been made. Resultant estimates are therefore only partly well-defined, the remainder being based on judgment and assumptions.

The proportion of an estimate that is based on judgment is obviously greater in the early stages than in later ones when more firm information becomes available. The estimating process has to be able to distinguish between what is well defined and what has to be assumed so that the appropriate level of judgment can be applied.

Each of the following estimate types requires a related level of knowledge, scope of work development, and quality of engineering effort to achieve the accuracy desired. Some broad discussion of the first three estimates has already taken place in Chapters 4, 6, and 7, but the next sections describe them in more detail. Given that a detailed (final) estimate (DOE Class 1, ASPE Level 5) is only rarely undertaken, mostly in lump-sum bid cases, it is not specifically covered here.

Order-of-Magnitude Estimate (DOE Class 5, ASPE Level 1)

An order-of-magnitude estimate for the preliminary scoping evaluation is prepared when little or no design information is available for the project. It is called order of magnitude because that may be all that can be determined at an early stage. Techniques employed for these estimates rely heavily on the experience and judgment of the individuals involved, aided somewhat by historical values and charts, rules of thumb, and simple mathematical calculations.

Factoring, which involves taking the known cost of a similar facility and factoring in the cost for size, place, and time, is one of the more popular methodologies employed for order-of-magnitude estimates. Cost modeling is another common technique. In cost modeling, the estimator models the various parameters of the facility and applies generic costs to the derived scope. This estimate is thus mostly a top-down estimate of capital expenditure using throughput capacity and/or shelter volume, experience, historic factors, estimating manuals, and unit costs (if known and applicable).

Production methods and process flow diagrams are usually assumed for a typical installation based on broad and general concepts. A plant layout may be drawn, but usually no design drawings are prepared. Some level of preliminary metallurgical test work is desirable, but not a necessity if the deposit and process are well known. Infrastructure requirements will be very broadly defined.

The estimate of Owner's preproduction expense and working capital uses historic factors and generic industry estimates, moderated by what specific information is available. Cost indexes are one of the tools used in this preliminary cost estimation process. When up-to-date costs are not readily available, these indexes provide broad, generic factors for time adjustment of historic capital costs, as well as factors for availability of materials, labor, technology changes, and inflation. These cost index and inflation tables are available from multiple commercial and governmental sources. Escalation is normally excluded at this stage.

An overall percentage contingency is applied to the total project cost at this early stage. A 40% figure is common, and a percentage as high as 70% might be appropriate for a new, remote site. Even with these high contingencies, accuracy is likely to be no better than –50% to +100%.

Prefeasibility Estimate (DOE Class 4, ASPE Level 2)

The prefeasibility study estimate is primarily prepared for the assessment of alternatives in value-engineering exercises to determine the optimal plan to take forward into the feasibility study. Reserve tonnages and grades, stripping ratios, and metallurgical bench-scale testwork will be sufficiently well advanced to determine the process flow diagram, materials balance, and annual production outputs.

The project engineers prepare layout and general arrangement drawings for the plant and infrastructure, with sufficient detail for the engineer's concepts and intentions to be understood by the estimator. Equipment lists are prepared from the engineer's drawings and specifications, and single-source budget quotations solicited for those items. Bulk materials are calculated from the engineer's preliminary quantities, generally using unit rates specifically derived for the project, but some factoring based on historic information and industry norms will inevitably have to fill in the data gaps.

Feasibility Estimate (DOE Class 3, ASPE Level 3)

The feasibility study estimate is used for the project budget appropriation. The single-value figure of this estimate is generally the key decision element of whether the project is approved by the corporate executive body. Because the feasibility study is intended to be a reflection of what will actually be built should the project move forward into construction, the project scope and criteria have to be frozen and comprehensively defined for the feasibility estimate to be termed *complete*.

Reserve tonnages, grades, and stripping ratios need to have been confirmed, the mine planning completed, and the mining methods determined. The process flow diagram and materials balance will have been set by a suite of confirmatory metallurgical tests. Mine life annual production outputs will have been calculated. Contour maps will have been prepared and soil investigations completed sufficiently to allow foundation design and earthwork costs to be estimated accurately.

General arrangement drawings supplemented by sufficient basic engineering design drawings will need to have been created, to permit accurate calculation of materials for concrete, steel, piping, electrical work, and instrumentation by the estimator for essentially the full facility. Information gaps needing judgment or factoring should be very minor.

The cost impact of environmental and permit regulations, along with social and sustainability requirements, will need to have been determined, as these all have to be built into this level of cost estimate.

Labor costs are estimated in detail at the feasibility stage and applied to an estimate of the construction labor hours for each work task. The estimator will establish specific unit rates for labor and labor productivity as well as for materials, freight, subcontractors, and so forth, from real data sources and quotations solicited solely for this project at this specific location.

Labor costs will include base salary, overtime, location allowances, statutory burdens, benefits, accommodation, and transportation expenses. Major equipment and bulk material costs will be derived from firm engineering specifications and written budget quotations from appropriate suppliers. Engineering project management and all related costs will have been determined in detail by likely project participants, based on a real construction schedule produced by a viable contractor.

Any gap data are filled in first from historical information, then second from industry norms for the task and location. At the feasibility stage the expectation is that the project has been well enough defined that less than 5% of the direct cost will be made up of provisional sums, that is, monies to cover items that have been identified as being required but lacking in sufficient definition to be quantified in terms of scope, design, or cost.

Definitive (Control) Estimate (DOE Class 2, ASPE Level 4)

The approved budget needs to be reviewed and reestimated at least once during the project execution stage. This update is called the definitive estimate, and it is prepared from fully designed plans and specifications.

The standard method for producing a definitive estimate is to review and understand the design package and then take off the project scope (i.e., perform a quantity survey) by itemizing the scope into line-item activities, each with measured quantities. Note: Some jurisdictions define this itemization and measurement in very specific terms and may have rigid rules for development of a bill of quantities. For instance, the ASPE best practice standard for the quantity survey requires using the Construction Specifications Institute's uniform numbering system (*MasterFormat*) when assembling the estimate to ensure that all the necessary work is fully accounted for and that no items have been overlooked. Costs are then applied to the quantified line items. For an Owner, this is the costing part; for the contractor, this is the pricing component.

The following are steps for a definitive cost estimate:

1. Fully define and understand the scope.
2. Take off and/or quantify the scope.
3. Apply costing to the scope.
4. Add up the costed activities to arrive at a total cost.
5. Properly document, check, and then have a separate party review the cost estimate.

ASPE recommends the "quantity times material and labor costs format" for figuring the estimate. Determining quantities is usually the easiest part of the estimating process; costs are generally more difficult to establish.

The definitive estimate is prepared by spread (including installation), respecting the project's activity-based WBS, using zero-based, bottom-up cost-estimating techniques. At this stage, there should be no gap issues to be filled top-down because, in principle, an estimate cannot be defined as definitive if it includes top-down factored cost estimating. All major contracts and contract packages will now have been awarded.

Actual prices from the project's selected vendors (based on actionable rather than budgetary quotes) are used for all the major equipment. Indeed, more than 90% of the total project equipment should have firm prices by the time the definitive estimate is being done.

The estimates for civil, structural, piping, mechanical, instrumentation, HVAC, electrical, and architectural costs use quantity takeoffs from issued-for-construction completed drawings. While most civil, structural, piping, and mechanical drawings should be fully developed, some electrical and instrumentation drawings may still be preliminary. Engineering should be well over 60% complete at this stage, approaching 75% to 80%.

Material pricing is from actual supplier submittals. Material volumes and amounts are takeoffs, not factors. Bulk commodities should have firm supplier prices and be accurately quantified from plot plans and design drawings. Initial fills and spares are based on actual vendor quotes. With construction typically at more than 25% complete at the definitive estimate stage, construction costs (indirect costs, overhead, profit, etc.) can be extracted from the formal contractor and subcontractor bids accepted for the project.

Note: Very large projects with multibillion dollar expenditures will require more than one budget update. If a second definitive estimate is deemed necessary, it should not take place until engineering and procurement are both more than 90% complete and construction has gone past the midway [50% completed] milestone.

For construction labor, the estimator should determine basic production rates for the specific geographic locale and multiply them by the units of work to determine total hours for the work, then multiply the hours by the actual contractual per hour labor rates to arrive at costs. Labor burdens, material costs, construction equipment costs, and, if applicable, subcontractor costs are all included on the estimate detail form.

The labor requirements are often the most variable, and historically they have been the biggest cause of project cost error; thus, they are a primary focus of cost estimators. The labor

	Mining Projects U.S. Gulf Coast Multipliers									
Project Location	**Chile**	**Panama**	**Indonesia**	**Chile**	**Peru**	**Alaska**	**Russia**	**Peru**	**Turkey**	**Canada (AB & SK)**
Year	1987	1988	1992	1995	1996	1997	1997	2011	2012	2013
Earthwork—Mass		1.5						1.9	2.5	1.6
Earthwork—Foundations		1.9						2.3	2.8	2.2
Concrete		2.0						2.5	2.1	1.5
Steel		2.0						3.7	2.8	1.5
Architectural		2.0							2.8	
Piping	2.8	3.0						4.4	2.7	1.5
Mechanical Equipment		2.5						5.5	2.9	
Electrical	2.8	3.0						3.3	2.6	1.4
Instrumentation	2.8	3.0						3.3	2.5	
Miscellaneous (Painting, Insulation Cleanup, etc.)		2.0							2.7	
Weighted Average	2.8	2.5	3.5 to 4.0	2.3	3.7	0.9 to 1.2	4 to 5	3.8	2.7	1.6

Note: Empty cells reflect information not divulged because of client confidentiality.

FIGURE 11.5 Labor productivity factors

hours required to construct each installation item are calculated by using a labor-hour rate times the takeoff quantity. If there is insufficient actual site labor productivity history available at the time of the estimate, the estimators will use a labor-hour norm reference for standard labor hours (e.g., the U.S. Gulf Coast productivity rate) and then apply adjustment factors for project or task conditions. Adjustments will be needed for weather, location, methods, equipment, craft crew mix, union jurisdictional rules, daily work-hours, work schedule, turnarounds, overtime requirements, labor skill, incentives, workplace congestion, and so on, to compensate for the cumulative anticipated effects on real labor productivity (Pietlock 1994; Whiteside 2006).

Figure 11.5 captures a bevy of productivity factors experienced by the authors at various projects during their careers. The rates vary widely over time, even in the same country. One important item is that these are back-estimates of the actual productivities experienced, not the engineer's preexecution forecast figures. Forecast productivities by most EPCMs have a miserable record of being unrealistically low. For instance, the 2011 forecast productivity for Peru was 2.7; the actual was higher than 3.8. A 2010 initial forecast for Turkey was 1.5; the actual was closer to 2.7. Forecast productivity in Russia in the mid-1990s was 2 to 2.5; the actual was near 5. These understatements have a huge impact on the project's economics, including camp size, work schedule progress, and other factors. The project manager needs to aggressively challenge any and all suspiciously low factors.

Regional, national, or international trade productivity indices can be used to validate productivity estimates, for example, labor hours per cubic meter of concrete installed or labor hours per metric ton of structural steel erected, but they should not be relied on for the actual estimate as they are generally too broad.

For the definitive estimate, the engineering, procurement, and construction management costs are based on actual submittals. A simple percentage (as would be used for the prefeasibility study estimate) is no longer acceptable. Owner's cost and preproduction expense are estimated from a zero-based budget. Owner's cost is one of the most prevalent areas for budget error, being frequently underestimated. It is vital that *all* elements of Owner's cost be included.

Environmental compliance costs are detailed from design engineering and the specific permit requirements. Other costs that need to be added into a definitive estimate include contractor profit (if applicable), sales or use taxes, and payment and performance bonds. Working capital is prepared from detailed zero-based budgets by the EPCM and the mining company's accounting personnel together, using similar local area experience.

All changes agreed to since original project approval are included in the definitive estimate (both in and out of scope), and all identified trends are rolled in. Exclusions are kept to an absolute minimum.

Contingency is allocated by assessment of the accuracy of the takeoffs and costs and the remaining project risks. Overall contingency should be below 10% by this stage, typically in the 5% to 8% range. (See Chapter 12 for details on applying contingency.) Escalation could now be by area, coupled with risk, but generally this is still likely to be inserted as a single figure, using the latest company forecast. The level of effort for a definitive estimate is shown in Column 4 of Figure 13.1.

If there are any minor line-item gap costs remaining in the definitive estimate, they are generally filled in from a cost book (either internal or external) or from a cost database. The best EPCM contractors meticulously track and compile data records and trends from their completed projects, as well as from past estimates. They compile data from equipment and materials suppliers and the various labor markets—all to create their own proprietary cost databases. One of the advantages for the Owner in hiring an EPCM firm is to gain access to the EPCM's up-to-date cost database. Other references such as RSMeans or CostMine's *Estimator's Guide* can assist, but these sources cannot be considered definitive; one always has to use intelligent judgment to modify "cost book" costs to suit the actual project in hand.

A known or local contractor or supplier can also be a credible source to assist with gap cost items. Most will share their knowledge on current costs, particularly if only limited, specific information is being sought that they can easily obtain from a recent bid. A definitive level cost estimate is normally the level of estimate prepared by construction contractors and/or subcontractors for their submittals in a competitive bidding process.

THE PROJECT "CONTROL" BUDGET

The published budget set at project kickoff as the control budget is derived from the feasibility study cost estimate. It will not yet have all of the elements for it to be called a definitive estimate. Engineering will not be more than 60%, construction will not be at 25%, but there will be a few more items known than when the feasibility study was produced and approved.

Most major contracts will have been awarded; the EPCM will be in place; initial key project staff will be on board; long lead-time equipment will have been ordered; and one or two contractors will likely have their costs established in written agreements. Thus one expects the published control budget to be a better (more accurate) number for managing the project than the feasibility study estimate, but it is still not accurate enough to be termed definitive. So, as soon as the detail engineering reaches the right level, when all the major equipment has been ordered and all the major contractors are on-site, then a definitive estimate is needed to ensure that the approved project capital is still adequate for the work scope ahead.

ELEMENTS OF THE CAPITAL COST ESTIMATE AND PROJECT BUDGET

The capital cost estimate is a prediction of the total installed cost (TIC) of the facilities described in the scope of work. The principal elements of the estimate are the direct cost, indirect cost, Owner's cost, and contingency. The sum of the direct cost and indirect cost is called the "field cost," which is a term for the cost of all the actual work carried out at site.

In addition, the project budget presented to the authorizing body has to capture the cost of the EPCM services, financing cost (including capitalized interest), working capital, and any portion of the operations ongoing sustaining capital that requires upfront approval from the project-authorizing body.

Herein is one of the key difficulties that the project manager faces. Nobody separates costs among direct, indirect, and Owner in the same way. It almost seems like every Owner, EPCM, and government agency deliberately strives to be different. But ultimately, it really does not matter which "cookie jar" the costs are placed in; the important thing is to make sure all costs have been estimated and counted, somewhere.

Thus, going forward, the cost categorizations shown are those that seem to make the most sense, not necessarily those followed by all mining organizations. Figure 11.6, created from a combination of three South American open-pit projects, illustrates the breakout of the capital budget categories used within this book.

DIRECT COSTS

Direct costs are all of the costs of installation that can be directly attributed to the project. The classic definition of a *direct cost* is that it is "quantity based": such as a length of pipe, an hour of work, or a cubic meter of excavation. Direct costs encompass all the permanent equipment, materials, and labor associated with the physical construction of the facilities, infrastructure, utilities, and so forth. Direct costs include the following.

Plant equipment. The basis of all equipment cost has to be defined, for example, FOB, CIF, or delivered to site. If freight and transportation to the site and insurance are not included in the price quotations, these must be separately estimated and added. Similarly, any necessary vendor engineering or site representation during erection and commissioning has to be included (as a separate line item from feasibility onward).

First-fill consumables. These consumables include fuels, lubricants, grinding media, and the like; they are a component of the direct costs.

Bulk materials. These include the cost of all concrete, steelwork, civil works, pond and pad liners, roofing and siding, piping, valves, electrical trays, raceways, wiring and cabling, instrumentation, control systems, and the like, including transportation and delivery costs.

Construction installation labor. This comprises the labor costs of all the constructed facilities (including infrastructure).

DESCRIPTION	COST, $ Millions
DIRECT COSTS	
Preliminary Works (Access Road, etc.)*	7
Mine-Related*	56
Process-Related*	263
Tailings Storage Facility*	45
Infrastructure*	31
Contractor Mobilization and Demobilization	2
Contractor's Overhead and Profit	63
Other Direct Costs (Insurance, Freight, etc.)—Items not included above	21
Direct Duties and Taxes (Import Duties, Sales Tax, VAT, etc.)	15
Subtotal Direct	**503**
INDIRECT COSTS	
Camp	18
Temporary Facilities	4
Construction Support Services (Warehouses, small tools, etc.)	10
Subtotal Indirect	32
Subtotal Field Costs	**535**
EPCM	
Engineering and Procurement	48
Construction Management	25
Fee	12
Subtotal EPCM	**85**
OWNER'S COSTS	
Project Management	31
Owner's Project Support Staff	9
Owner's Project Expenses	5
Specialist Consultants	4
Taxes, Insurances, Bonds (not in Direct Costs)	14
Subtotal Owner	**63**
CONTINGENCY	102
SUBTOTAL PROJECT CAPITAL	**785**
Financing	**0**
OTHER COSTS	
Future Study Costs	0
Working Capital	41
Capitalized Spare Parts	18
Initial Operating Costs—Capitalized	28
Intial Operations Revenue—Offset	–27
Subtotal Other	60
TOTAL PROJECT CAPITAL	**845**
Sustaining Capital	170
Escalation	50
PROJECT BUDGET	**1065**
SUNK COSTS TO DATE	35
TOTAL PROJECT	**1100**

* Plant Equipment, Construction Equipment & Labor, Bulk Materials, Subcontractors.

FIGURE 11.6 Project budget cost elements

Subcontract items. All field-work scope items that are carried out by specialist subcontractors, including turnkey packages, are a component of the direct costs.

Construction equipment. The contractor's construction equipment required for the erection of the fixed plant and materials, even though it is not quantity based and thus definitely an indirect cost, is almost always shown as a direct cost, though generally shown as a separate item within the estimate (in part to ensure that it is not overlooked). This includes cranes for the major lifts, transportation equipment (for personnel and materials), excavation equipment, other mobile equipment, and scaffolding.

Contractor mobilization and demobilization. These are indirect costs always counted as direct costs.

Construction contractor overheads and profit. The contractor's overhead and profits (also known as contractor distributable costs or contractor markups) relate to the recovery of costs expended by the site construction contractors other than those directly related to the physical supply and erection of equipment and materials. The overhead and profit component is a necessary cost of the contractor in order to stay in business. Again, although these costs are definitely indirect (not based on quantity), virtually everyone includes these items in the direct cost category. The costs are usually broken into the separate categories of variable overhead, fixed overhead, and profit.

- **Variable overheads** relate directly to the execution of the construction contract and include the following:
    - Supervisory staff salaries, burdens, benefits, and allowances
    - Support and nonproductive labor on-site
    - Staff accommodation, food, and travel costs (including recruitment)
    - Temporary buildings and facilities on-site
    - Workshop equipment and supplies provided by the contractor on-site
    - Logistics vehicles and equipment used by staff during construction
    - Site office overheads (communications, lights, power, office consumables)
    - Janitorial, general site cleanup, site warehousing, site material handling
    - Contractor consumables
    - Security, safety, personal protective equipment, and first aid provided by the contractor on-site
- **Fixed overhead** represents the stay-in-business overhead costs of the contractor not directly related to the performance of the contract. These fixed overhead costs are influenced by size and location of the contractor organization, method of financing, and volume of business. They include the following:
    - Head office costs, including advertising and marketing
    - Tendering costs
    - Construction bonds and insurances
    - Financing charges
- **Profit** is cost to the mining company, but is not a cost to the contractor provider; rather, it is a projection of anticipated income. Setting the profit margin is a judgment call of the contractor determined by the contractor's corporate policy, the current economic climate and market conditions, project location, schedule compression, and the present workload of the individual contractor.

Contractor distributable costs are generally shown as a percentage of the cost of construction labor (but sometimes as a percentage of direct cost) and are calculated for the estimate from historical data for similar projects, up through the feasibility stage estimate. From that point on, they are derived from the actual site contractors. The project team needs to be alert for any double-counting of cost items within contractor markups, that is, items already covered elsewhere in the project estimate.

Direct duties and taxes. Identifiable duties (e.g., import duties) and taxes (e.g., sales tax, value-added tax) relating directly to the supply and delivery of construction materials and equipment should be included in the direct-cost section of the estimate but separated for transparency.

INDIRECT COSTS

Indirect costs are those that cannot be directly attributed to the construction of the physical facilities of the plant or associated infrastructure, but are required to support the construction effort. These costs may include the following:

Temporary facilities. The provision of those temporary facilities, shops, offices, lunch rooms, roads, power, water, effluent disposal, other utilities, and the like, not included in the constructor's direct costs but used by the constructors in carrying out their work.

Construction camp. The capital cost of the construction camp used by the constructors, site management (project management team and the EPCM), and the Owner. (Note: The camp operating costs [room, food, laundry, transportation, etc.] are normally included as a labor direct cost.)

Construction and project support services. Surveying (if not provided by the Owner or construction contractor) would be included here, as would site cleaning, all preoperational testing, and project investigations and studies. (Note: This item and all the following indirect costs are mostly classified as direct costs by Rio Tinto.)

Warehouse, stores, and handling facilities. These are the warehouse and stores items not included in the construction contractor's direct costs.

Commissioning and start-up. Items that are *not* provided by the Owner or constructors go into these costs, such as vendor commissioning engineers and staff.

Health, safety, environmental impact, social acceptance, sustainability, and community requirements. These are all indirect costs that must be considered.

Small tools and minor support equipment. If these items are not provided by the constructors, then they are generally considered indirect costs rather than direct costs.

EPCM COSTS

EPCM costs are significant enough to be in a stand-alone category. EPCM costs include the design and engineering of the project, procurement of all the physical items required, and management of the construction contractors. Some organizations, such as BHP Billiton, place EPCM costs with indirect costs, but the authors prefer to treat them collectively as a separate item, similar to the present practices of Rio Tinto, Newmont, and Bechtel.

The EPCM will, like the construction contractor, bill for overhead and charge a fee for profit. While the fee will always be negotiable up front, once it is included in the project budget, the Owner needs to understand that the EPCM profit (and overhead) built into resultant EPCM billing rates are not "cushions" in the budget for the Owner to draw on to absorb

TOTAL INSTALLED COST (TIC) - $millions	**$200** **Percentage of TIC**	**$1,000** **Percentage of TIC**
Home Office Staff		
Project Management	1.2	0.8
Engineering & Design (including Process)	6.0	4.7
Project Controls (including Scheduling & Estimating)	0.7	0.4
Procurement / Expediting	0.5	0.3
Contracts Administration	0.3	0.2
Administration (including Accounting & Human Resources)	0.1	0.1
Subtotal Home Office Staff	8.8	6.5
Office Expense	0.9	0.5
TOTAL HOME OFFICE	9.7	7.0
Construction Management Staff (Field Personnel)		
Management & Supervision	2.5	2.1
Project Controls (including Scheduling & Estimating)	0.7	0.5
Quality Assurance / Quality Control	0.1	0.1
Procurement / Expediting	0.2	0.2
Contracts Administration	0.2	0.2
Administration (including Accounting & Human Resources)	1.0	0.5
Local Hires	0.7	0.4
Subtotal Field Staff	5.4	4.0
Temporary Facilities	0.7	0.5
Office Expense	0.5	0.3
Miscellaneous (relocations, small tools, other)	1.7	1.2
TOTAL FIELD (Construction Management)	8.3	6.0
COMBINED TOTAL: HOME & FIELD - (Range)	18.0 (14 to 20%)	13.0 (10 to 16%)
FEE	3.0	2.0
TOTAL EPCM	**21.0**	**15.0**

FIGURE 11.7 Typical EPCM costs

overruns in project expenses. The EPCM profit belongs to the owners of the EPCM firm; it is not a client contingency fund.

EPCM overhead is a real expense. Without the activities within overhead, such as office and corporate administration, building rent and utilities, insurance, equipment, vehicles and taxes, the EPCM could not accomplish the project. Figure 11.7 shows the approximate distribution of internal EPCM costs for two different-sized international mining projects managed by an EPCM firm based in North America. As shown in the table, EPCM costs are usually estimated as a percentage of TIC.

OWNER COSTS

Owner costs encompass all those costs specifically attributable to the Owner that are not included elsewhere in the estimate. While most organizations elect to separate this cost category, some, such as BHP Billiton, place Owner's costs in with the indirect costs. Financing cost, capitalized interest, working capital, and capitalized spare parts, although Owner incurred, are not part of Owner costs within this book's tabulation. Costs relating to Owner personnel including salaries, benefits, burdens, travel and accommodation, recruitment, communications, office, and rentals are carried as a component of Owner costs.

Owner costs typically include the following.

Project Management

- The project management team
- The costs of establishing project procedures, the Project Execution Plan, and an operations readiness plan—all those elements that are not part of the EPCM scope

Owner's Project Support Staff

- Owner's project team personnel
- Owner's technical, finance, accounting, and administrative support staff
- Operations workforce travel, recruitment, relocation, and training costs

Owner's Project Expenses

- Permitting costs and fees
- Land purchase and mine leasing costs, right-of-way acquisitions
- Royalties and fees
- Legal fees and expenses
- Marketing and sales costs
- Information technology and other technology

Owner's technical and mine developmental contributions. These could include any or all of the following:

- Exploration support (infill drilling, condemnation drilling, and assays)
- Mine plans
- Mine prestrip and surface bench or underground development
- Metallurgical testing and pilot plant

Specialist Consultant Support

- Aerial photography and mapping
- Geotechnical
- Hydrology
- Mine planning
- Environmental impacts and social acceptance

Owner operations organization establishment. The recruiting, hiring, and training of the operations organization that takes over the facilities after project completion.

Plant precommissioning, commissioning, and start-up (Owner's portion). All preoperational testing support, commissioning, and start-up support provided by the Owner.

Insurances, guarantees and warranties. Those not assumed by the contractor (could include general and professional liability, builder's risk, vehicle, transit and umbrella).

Taxes and bonds. Costs not assumed by the contractor (e.g., use taxes).

CONTINGENCY

Contingency is always included with an estimate to provide for the unknown costs that are likely to occur by experience but are not identifiable. When using an estimate to set the budget, contingency is added to improve the probability that the funding will be adequate to complete the project. See Chapter 12 for details regarding contingency. More contingency is needed for early estimates due to the higher uncertainty of accuracy.

FINANCING COST

Projects cannot go forward without financing, be it external or internal. Financing comes with its own cost. This cost, including capitalized interest, is assessed separately from the project estimate, normally by the Owner's treasury department, and then added into the budget as a line item.

OTHER COST ELEMENTS OF THE PROJECT BUDGET

Certain costs do not properly or easily fall into any of the preceding categories, so they are generally shown as stand-alone items in the budget.

Study costs. The costs of future studies are needed as line items in the scoping and prefeasibility estimates but generally do not appear beyond the feasibility estimate. These study costs can include the costs of any support exploration, metallurgical testing, environmental reviews, transportation studies, and financial evaluations.

Working capital. This is required for the budget but is usually derived from the operating cost estimate by the financial analyst (not the estimator) and then added to the budget as a line item. Working capital covers items such as raw materials, stockpile, and in-pit inventories; warehouse inventory; insurance spares; delayed sales payments; and delayed accounts payable. Interestingly, BHP Billiton counts working capital as an indirect cost.

Capitalized spare parts. The initial spare parts purchased as capital items for operations start-up are:

- The routine maintenance and operational spares needed for the initial months of operation. Normally this is a 12-month supply, but it can vary from 6 to 24 months; and
- The long lead-time "insurance spares" crucial to operational start-up but separate from routine maintenance spares.

The monies allocated to this line item will substantially depend on the location of the facility. The suppliers provide most of the data needed to estimate this cost. Some Owners, such as BHP Billiton, lump these items in with direct costs, but most companies elect to keep them separate.

Escalation. The cost estimate figure is normally expressed as of a base date with no escalation included in any of the line items. The expected escalation during the project life, based on the general inflation, market conditions, project schedule, and expected cash flows is derived as part of the financial analysis, using data provided from the Owner's treasury department, then added as a line item to the budget.

Escalation needs to be allowed for annually within the project budget. For budgetary management purposes, the sum of these annual escalations is generally included in the contingency account. However, when a project is being executed in a location where the inflation rate is of a significant magnitude, a separate account for the control of escalation is recommended.

Capitalized operating costs. Operating costs incurred prior to commercial operation are normally capitalized as part of the project cost, though these costs will be credited with an offset for any product sales during this time interval. The Owner's operations, tax, and accounting departments usually derive this information for the budget.

Sunk costs. Costs incurred for completed studies, metallurgical testing, and the like have no place in the project budget and need to be excluded. However, some organizations want to keep track of these prior project costs. If so, they should be shown separately and below the budget total.

The reader is reminded that no monetary amounts belong in any line item for project-specific risk. Risk is calculated and shown separately. Systematic risk that stems from the type of project and the level of project completeness is portrayed in the estimate accuracy and covered by contingency. Project-specific risk, if recognized, is handled by a management reserve. See Chapter 12 for more discussion.

UNIT COST ESTIMATING—USE WITH CAUTION

Unit cost estimating is correctly associated with the more accurate levels of the cost estimate. In unit cost estimating, the cost is derived from the number of units of work performed, for example, cost per square foot, per drawing, or per length of pipe.

The first step in unit cost estimating is to know the costs of doing the work based on historic data and experience. The cost per drawing sheet, for example, may be determined by simply taking the total cost to accomplish a past project and dividing by the number of sheets in the project's drawing set. This estimating method is legitimately applicable to routine or repetitive projects for which the unit costs are well known. The greater the number of projects for which the data are collected, the more meaningful are the cost data.

But unit costs must be used with caution. On occasion, they have proved disastrous, particularly on complex projects. Unit cost estimating assumes that the proposed project is just like the previous ones from which the costs are drawn when, in fact, all projects have unique features. Unit costs do not reflect varying design development times, which can be significant where modeling tools are used. Also, the time factor is ignored in unit cost data. Things change—for example, inflation increases labor and material costs. Other costs may go down as a result of efficiency improvements and new technology. Data collected just a few years ago may not accurately reflect today's conditions. The old adage applies: Garbage in, garbage out.

Unit costs are frequently favored because of their simplicity, but they must be used wisely. Similar precautions need to be taken with indexing and cost tables; just because the costs can be found in a glossy manual does not mean that they apply to this project.

UNACCEPTABLE EPCM PROJECT BUDGETING METHODS

The reader needs to be aware that some less-than-stellar engineering companies use two other methods for creating project budgets, namely, downward budgeting and staff-level budgeting (Dudson et al. 2007). Both of these engineering estimation methods should be rejected.

Downward Budgeting

Downward budgeting begins with an agreed-on amount of money available from the Owner of the project, perhaps a lump sum or percentage of the construction cost that the Owner is willing to pay, neither of which is necessarily related to the cost of doing the work required to execute the project. Budgeting then proceeds backward from the Owner's figure, deducting the direct expenses and contingency to arrive at the dollars available to the engineer for the staff labor, overhead, and profit.

This method does not start with the unique requirements of the project. There is no relationship between the project scope required and the time and money made available to complete them. Consequently, the labor budgeted may not be sufficient to accomplish a complete project. Trying to squeeze a scope of work into a budget determined by the Owner's financial situation, rather than the scope that needs to be executed, generally leads to a disastrous, unprofitable end for all parties. It should never be used on any project.

Staff-Level Budgeting

Staff-level budgeting is based on assigning the available engineering staff to a project for specified time periods to accomplish the work. What the actual tasks will be is not entirely known at project award time, but from experience, the engineers believe they can predict the effort it will take to get the work done. A built-in problem with the method is that when a project falls behind schedule, the budget automatically overruns. This method may be appropriate on small, routine engineering projects, but it has no place in the mining world.

MANAGING THE PROJECT BUDGET

The following budgeting procedures apply to all projects.

1. The project manager is responsible for preparing the project budget. The budget has to be approved by the Owner and the EPCM project sponsor before work begins. It is the responsibility of the project manager to ensure that appropriate working practices are observed whenever an estimate is prepared, reviewed, or presented. Before being issued, all estimates should be reviewed by another person besides the originating estimator.
2. The task list of activities used for the budget must be the same as the task list used for the schedule. After the schedule and budget are developed, the two are combined to show how the costs will be spread over the life of the project. By charting the cost of each activity against the duration of the project, the cost in each calendar week or month of the project life can be determined. This establishes a basis for monitoring and controlling the project schedule and budget, and provides a basis for invoicing and preparation of project payment schedules to assist in Owner cash flow management.
3. The expenditures projection is made by taking the budget for each activity and spreading it over the period allocated for accomplishing that task. Unless knowledge or judgment dictates otherwise, most activity budgets can generally be assumed to be expended

uniformly over the activity duration. The total cost for each period of the project (week or month) can then be totaled, and the cumulative cost calculated for each period.

4. The budget has to cover the entire scope and life of the project. During project reviews, the actual progress to date and the projected progress through project life, based on the most recent data, are always presented (preferably graphically). The project manager has the task of explaining the reasons for variations between budget and actual progress.

PROJECT VALUE ANALYSIS

If the financial analysis derived from the project estimate shows an uneconomical project, that is, a project that fails to surmount the corporate financial hurdle, corporation management will want to know why. After all, corporate dollars and possibly some market exposure will have been spent by that time, but the result is not what was hoped for. Thus a succession of reviews—internal and external—will take place. This is entirely proper.

However, one particular review that some organizations employ comes with potential danger. It is the project value analysis (also known as the capital value analysis or the capital optimization review), wherein external experts descend on the project and perform a "capital scrubbing exercise" on the disobliging estimate. Success for these retained external visitors comes from changing the project's current negative financial outcome into a positive by removing, on paper, sufficient capital from the estimate.

This is fine as long as the fat that may have crept into the estimate is removed, or value engineering takes place to find a smarter, more cost-effective way to reach the same project goal. But all too easily the value analysis can turn into an exercise in reducing properly derived contingency, shortening sensibly forecast schedules, or installing lower-quality components, such that the resultant project has a much higher risk of failure and a far lower probability of success.

If the new lower confidence level of outcome is transparently displayed, then all is fine. The Owner can decide if the extra risk is worthwhile. But all too often the changes are finessed and the project outcome is politically characterized with the same success probability. The moral of the story: Use value analysis wisely. Do not let it turn a disappointing paper estimate into an unprofitable project in the field.

DISCLAIMER

The final format of an EPCM estimate will always include some kind of disclaimer such as "This cost estimate is approximate. Actual construction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes, or other factors beyond the control of the estimators." This does not mean that the Owner should not rely on the estimate; it just means that the EPCM is pointing out that the dollar figure estimate is purely an informed opinion of probable cost, and that the EPCM's legal department is trying to manage its liability risk.

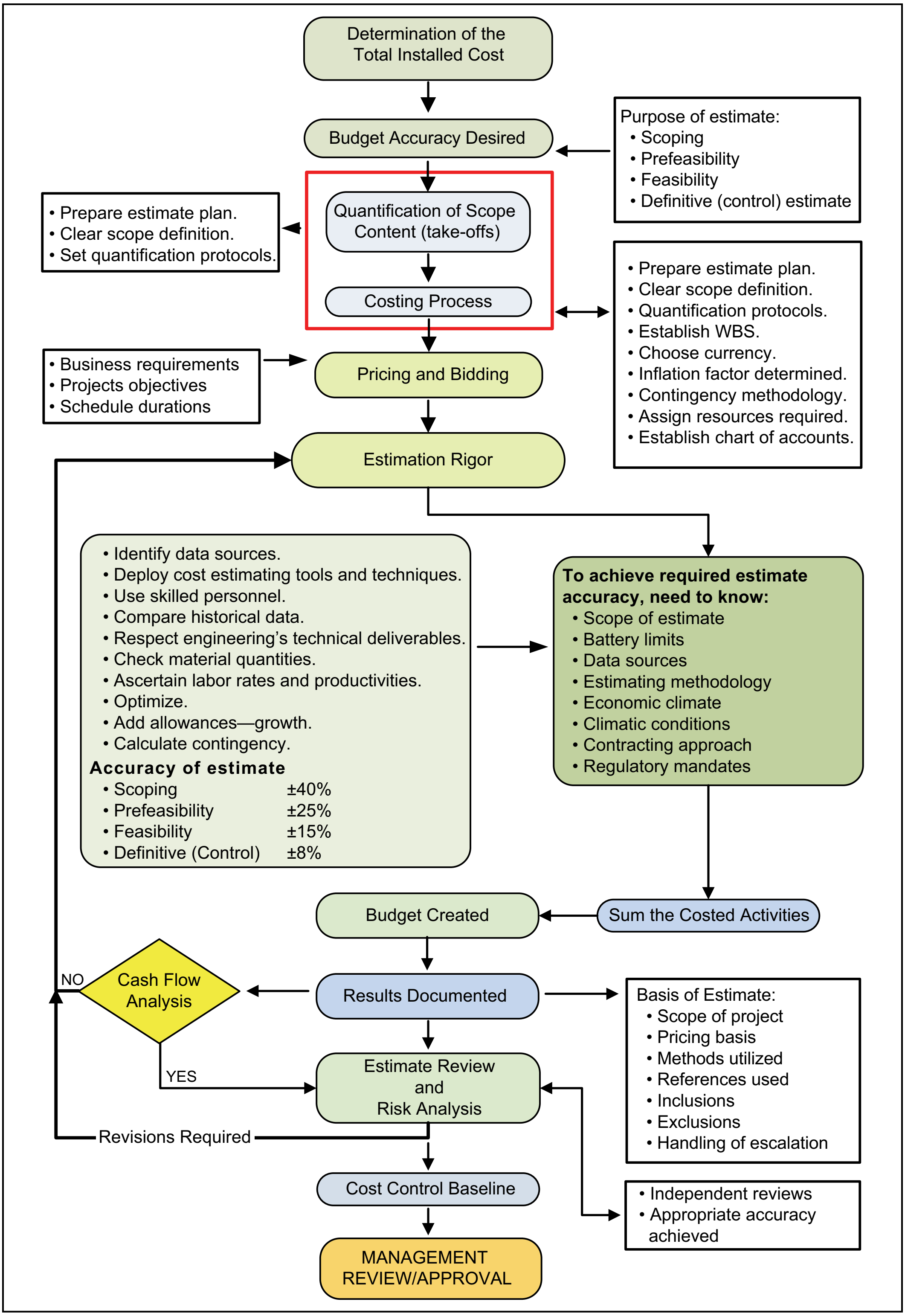
COMMON PITFALLS IN PROJECT BUDGETING

The common mistakes in budgeting are very similar to those that occur in scheduling:

1. Costs not broken down in a sufficiently detailed manner:
    - Difficult to recognize cost overruns as they materialize
    - Difficult to assess root cause of overruns or areas where action is needed
2. Assuming that all tasks are anticipated, leading to insufficient contingency when they are not
3. No allowances for the corrections that invariably result from each project review
4. Overlooking project activities that continue beyond plant construction
5. Neglecting to obtain contractor commitment to the budgets allocated to them
6. Omitting "soft," nontechnical tasks, for example, meetings and Owner management activities
7. Lack of transparency in reporting, which results in overruns not being timely addressed

CHECKLIST 11.1 BUDGET

No.	Item	Status	Date	Initials
1	Purpose and classification of estimate—determined			
	A. Scoping			
	B. Prefeasibility			
	C. Feasibility			
	D. Definitive			
2	Level of effort involved to achieve scope—understood			
3	Level of accuracy required for the estimate type—quantified			
	A. Maturity of input information—realistically assessed			
	B. Project definition—established			
	C. Estimate quality—set			
	D. Confidence level (e.g., 90%)—selected			
4	Prerequisite elements for estimate development:			
	A. Project scope—clearly defined			
	B. Battery limits—set			
	C. Valid data sources—available			
	D. Estimating methodology—selected			
	E. Economic climate—known			
	F. Climatic conditions at site—documented			
	G. Contracting approach—determined			
	H. Regulatory mandates—identified			
	I. Work breakdown structure (WBS)—in place			
	J. Tasks and activities—clearly identified			
	K. Currency or exchange rates—agreed to with Owner			
	L. Owner's accounting protocols—understood			
5	Costing process:			
	A. Estimate work plan—prepared			
	B. Strict quantification protocols—in place and followed			
	C. Pricing and bidding process—defined and followed			
	D. First principles base estimate (known knowns)—prepared			
	E. Growth allowances (known unknowns)—applied			
	F. Contingency allowance (unknown unknowns)—calculated			
	G. Basis of estimate (BOE)—produced			
	H. Estimation rigor—undertaken			
6	Draft estimate—summarized			
	A. Final estimate—peer reviewed			
7	Full budget—created			
	A. Budget cost elements—established with Owner			
	B. Working capital and financing costs—prepared			
	C. Escalation treatment—decided			
	D. Confirmation of requisite accuracy—determined			
8	Budget results—documented			
9	Risk analysis—prepared			
10	Cash flow analysis—undertaken			
11	Independent reviews—conducted			
12	Project baseline control budget—established			



FLOWCHART 11.1 Budget

CHAPTER 12

Contingency

All generalizations are false, including this one. —*Alexander Chase, 1966*

OBJECTIVE

An estimate of the costs to design, engineer, and construct a project facility is a necessity for the investment decision. By definition, an estimate is imprecise, and it carries financial risk. The cost implication of this imprecision and risk is reflected in the application of contingency to the estimate along with assigning an accuracy range.

This chapter explains what contingency is, to remove misconceptions about its composition and use. The differences between design development allowance, growth allowance, management reserve, escalation, and contingency are explained. The chapter also clarifies that contingency and estimate accuracy are not the same.

THE DEFINITION OF CONTINGENCY

Contingency can be defined as a specific provision added to a base estimate to cover indefinable items that have historically been required but cannot be specifically identified in advance. By this definition, contingency can apply to schedule as well as to budget.

From a budgetary viewpoint, contingency is a monetary allowance for items or considerations not defined at the time of estimate preparation, but that experience has demonstrated must be added to produce the total final cost.

Capital cost estimate contingency is defined by the Project Manage Institute (PMI 2008) in *A Guide to the Project Management Body of Knowledge* (*PMBOK Guide*) as “a provision in the project management plan to mitigate cost risk.”

The Association for Advancement of Cost Engineering International (AACE International) defines contingency as “an amount added to an estimate to allow for items, conditions or events for which the state, occurrence and/or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs” (AACE International 2005a).

A prior Project Management Manual publication by the authors (Hickson and Owen 1997) defined contingency as “a specific provision to cover variations which are expected to occur in the forecast cost.”

The authors currently favor the more precise but still simple definition of Swiss-based project management expert, Gordon R. Lawrence (formerly of Independent Project Analysis and of Jacobs Engineering), who states that “Project contingency is an amount of money for goods and services which at the current state of project definition cannot be accurately quantified, but which history and experience show will be necessary to achieve the given project scope" (Lawrence 2007). Whatever definition the reader favors, it can be agreed that budget contingency is a sum of money added to a capital cost estimate to cover uncertainties within the estimate. Contingency is thus expected to be spent to accomplish the project scope as defined.

Contingency is based on actual project experience *and is intended to cover* the following:

- As yet undefined items needed to complete the current project scope. This encompasses items expressly stated as *included* within the project scope, drawings, specifications, or estimate, but not clearly defined at the time of estimate preparation, for example, a building lighting component originally estimated from a square-footage criterion.
- Quantity variations (other than growth allowances) such as from a decision to improve the route of a pipeline or from better definition of feasibility study civil works.
- Additions that cannot be systematically assigned to a line item within the cost estimate.
- Estimating errors and omissions.
- Design evolution; those necessary changes to the written scope, drawings, or specifications of the approved feasibility study for the actual design facility.
- Budget-pricing variances for materials and equipment.
- Variability in market conditions, wage rates, labor head count, labor productivity, construction schedules, and project execution parameters.

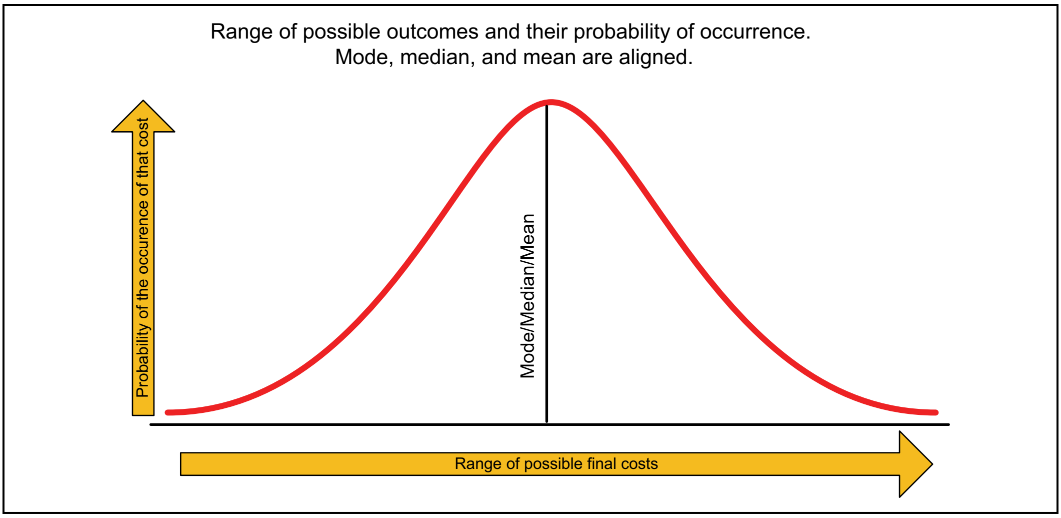
CONTINGENCY—WHAT IT IS NOT

As contingency is based purely on the specific project scope, *by definition it cannot cover out-of-scope items or changes or additional work, and it cannot be used to fund changes in quality.*

It is important to recognize what contingency is *not* intended to cover:

1. Design allowances, as these allowances can be included in the individual line items.
   - Design allowances are applied to defined scope items such as equipment and materials that have been quantified to a stated level of accuracy.
   - Estimators know from history that they need to intentionally add length to items such as pipe to allow for a predictable length cutting change during installation. Consequently, these design allowances are included as part of the estimator's base estimate (the most likely outcome value), not as a part of contingency.
2. Growth allowances, that is, items that we know that we do not know, such as expected increases in quantities and cost that will occur as the project progresses. All such expected increases can be allowed for within the present estimate (see Chapter 11).
3. Currency fluctuations (currency effects are captured in the financial model).
4. Escalation (escalation from base date to project completion is calculated separately).
5. Unexpected extraordinary economic situations, such as a community relocation, tailings storage facility redesigns in response to new permit requirements, and acute material shortages that render certain equipment impossible to obtain. These fall under the category of scope change. Scope changes are not covered by contingency.
6. Force majeure incidents such as natural disasters, strikes, work stoppages, and catastrophes.

The level of contingency assigned to a project cost estimate has to be aligned with the probability of overruns and underruns in the project cost. To arrive at an appropriate number requires a rudimentary understanding of statistics.



Source: Adapted from Lawrence 2007, with permission from *Pharmaceutical Engineering*.

FIGURE 12.1 Normal distribution curve of possible cost outcomes

COST ESTIMATE RANGE—MODE, MEDIAN, MEAN

A cost estimate is a prediction of the final cost at a time in the future when the project is actually executed. Because it is impossible to accurately predict the future, an estimate amount comes with some uncertainty. The range around the estimate reflects the uncertainty.

However, line-item budgets cannot be constructed with cost ranges; thus estimators assign a single-point, “most likely” value to the cost item that they are estimating. If the probability distribution curve of the range of cost outcomes (between the maximum and minimum possible) is normally distributed, then the range of possible outcomes would be as shown in Figure 12.1.

The mode is the most frequent occurrence (most likely outcome) of the possible costs.

If project management wanted a cost estimate with a 50/50 outcome value (where there is a 50% chance of overrunning or underrunning the estimate amount), then they would choose the median value. In statistical terms, there are an equal number of possible outcomes on either side of the median.

The median is the 50/50 outcome value of the possible costs.

Again, if the data set of possible cost outcomes for the cost estimate is normally distributed as shown in Figure 12.1, then the mode (the most likely value developed by the estimator) is the same as the median (the 50/50 outcome value). With a normal distribution, the mode and the median points on the curve are also the same as the mean.

The mean is the mathematical average of all possible cost outcomes.

ACCURACY RANGE

Cost estimates are generally presented with a plus or minus accuracy. Accuracy is the nearness (degree of closeness) of the estimated value to the true value. To be statistically valid,

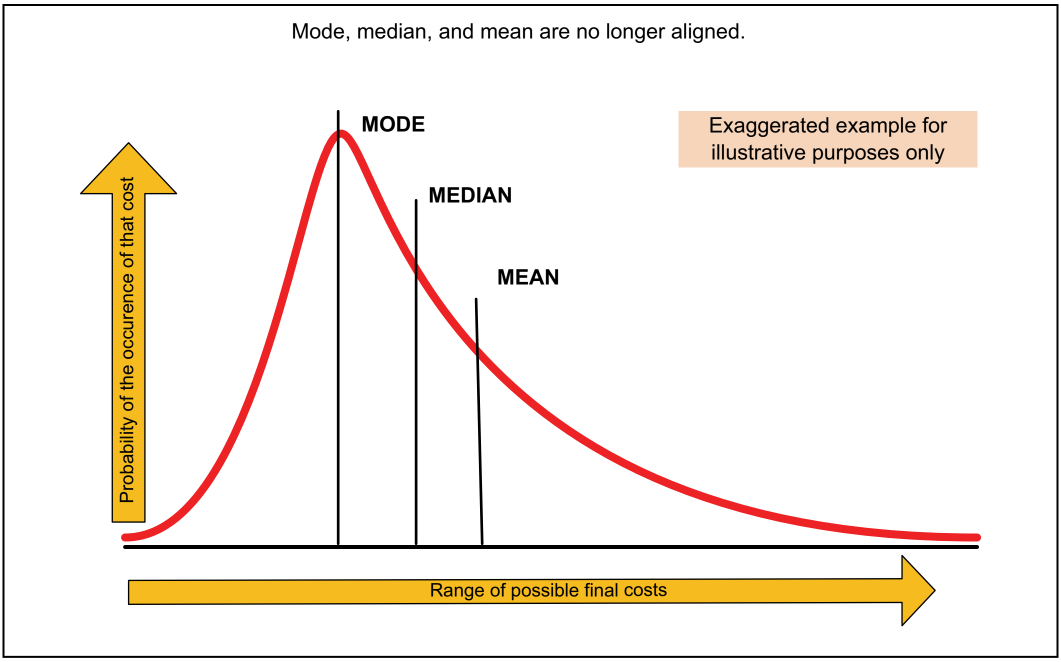


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FIGURE 12.2 Right-skewed distribution curve of possible outcomes

any statement of accuracy needs to be given with a specified confidence interval. See Chapter 11 for details on estimate accuracy. Thus, stating that there is a 90% confidence level that a $10 million project has a ±10% accuracy means that 90 times out of 100 the cost will fall between $9 million and $11 million. This also means it is expected that 10 times out of 100 the cost will be either greater than $11 million or less than $9 million.

A PROJECT COST ESTIMATE IS A RIGHT-SKEWED DISTRIBUTION

Because cost cannot be less than zero and the upper limit is not well defined, the range of possible outcomes is *not* symmetrical around the mode. The distribution is not normal; it is right skewed. Whenever this is the case, as it is for mine project cost estimates, the mode, median, and mean are not in alignment, as is seen in Figure 12.2. The median (the 50/50 outcome) for a right-skewed distribution is a higher cost outcome than the mode (the most frequent occurrence). The right-skewed nature of a mining project's distribution of possible cost outcomes explains why, when describing a project's estimate range, the plus and minus percentages are rarely the same.

Because all project cost estimates are fundamentally right skewed, the base estimate cost produced by the estimator (i.e., the mode) needs to be adjusted to at least fill the gap between that estimated cost and the 50/50 outcome cost (the median). There is an even bigger gap to fill if the Owner's attitude to risk demands more certainty than the 50/50 outcome, as shown in the right side of the two possibilities portrayed in Figure 12.3, that is, the gap between estimator's mode and Owner's selected level of predictability.

Project contingency monies bridge the gap between the base estimate calculation of the mode and the Owner's desired predictability outcome level. This desired outcome level is the

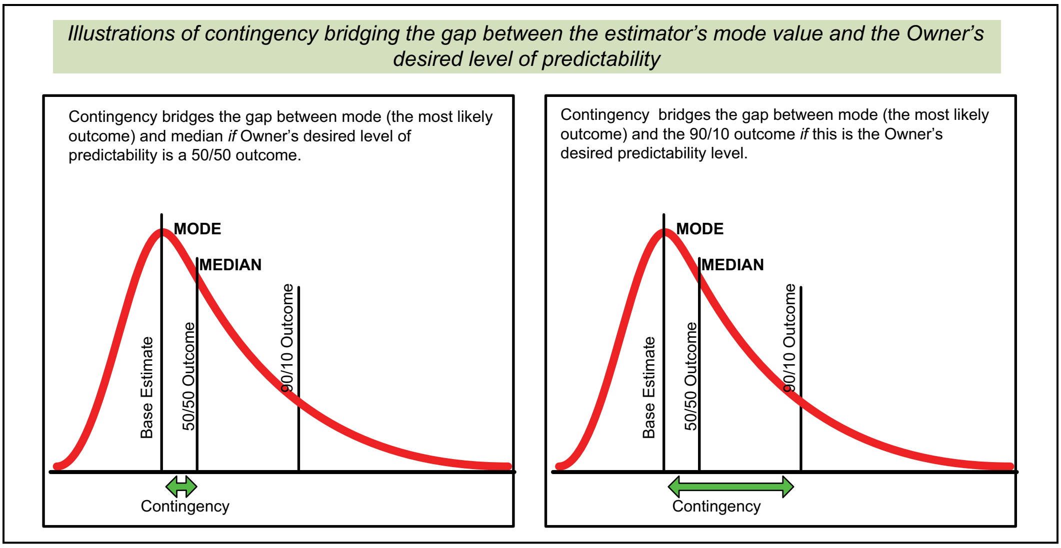

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FIGURE 12.3 Contingency: Bridging the gap

probability point to which the project team is being asked to control, that is, the confidence level that the project cost will come in at or below.

Contingency is calculated as one lump sum. It should remain as such in a consolidated, transparent amount and not be back-loaded (spread) into the individual line-item activities of the estimate.

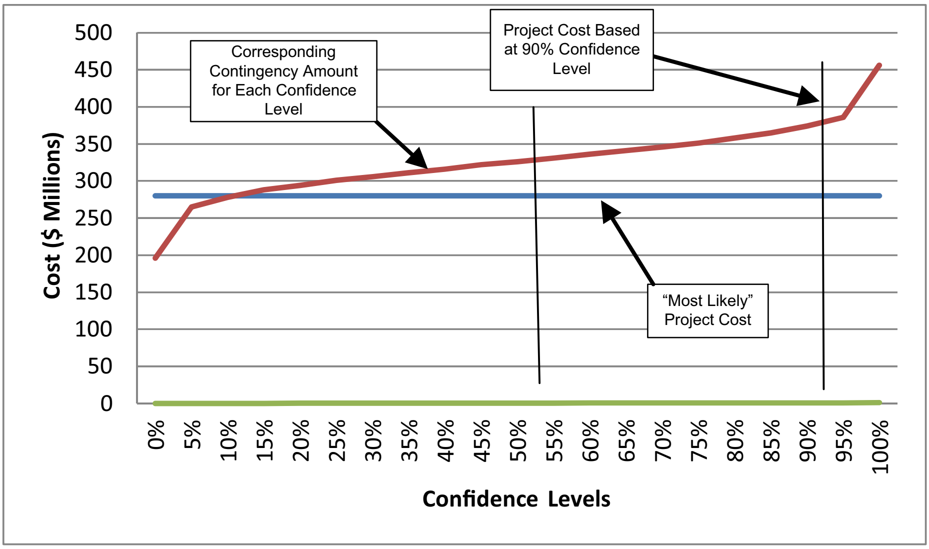
GOOD ESTIMATES REQUIRE CONTINGENCY

Contingency is added to ensure project outcome predictability. The distribution curve of possible project cost outcomes reflects the unique scope of the one specific project being evaluated. Consequently, the calculated contingency applies exclusively to this one project's defined scope. This is why contingency cannot be a fund to cover changes in scope or quality.

Because estimators enter the most likely cost (the mode value) into each line item on a base estimate, contingency is required to properly protect against the statistical likelihood of overrun. Contingency allows the Owner to attain the desired level of predictability, be it the 50/50 outcome, the 90/10 outcome, or whatever. Consequently, a *properly calculated contingency is expected to be consumed during the normal course of the project*. Thus, the act of including the correct amount of contingency is a sign of good, not poor, estimating. The proper assignment of contingency is not a padding of the estimate.

THE APPROPRIATE CONTINGENCY ALLOCATION FOR A BUDGET

Most corporate treasury departments and project organizations highly value cost predictability. As such, they want a much better than 50/50 chance of being within budget. Figure 12.4 shows the range of project outcomes for a project with a base estimate, modal cost of $284 million. The graph and table in Figure 12.4 show that this project requires a contingency of $42 million to come up to a 50/50 chance of finishing within budget, but it takes a $90 million (32%) contingency to achieve a 90% chance of coming within budget.



Base Estimate (Mostly Likely Cost)	$284 Million	
Confidence Level	**Value $ Millions**	**Contingency**
0%	$196	–30.8%
5%	$265	–6.5%
10%	$278	–1.9%
15%	$288	1.3%
20%	$294	3.7%
30%	$306	7.8%
40%	$316	11.5%
50%	$326	14.8%
60%	$336	18.3%
70%	$346	21.9%
80%	$358	26.0%
85%	$365	28.7%
90%	**$374**	**31.6%**
95%	$386	36.0%
100%	$456	60.5%

FIGURE 12.4 Project cost contingency analysis

Mining project history shows that the statistical 50/50 outcome rarely reflects project cost outcome reality. Thus, knowledgeable mining organizations mandate somewhere between an 80/20 and a 95/5 probable outcome for their project cost estimate rather than the 50/50 outcome value. Falconbridge (now Xstrata), for instance, mandated a 90/10 outcome when one of the authors worked with that organization. Even the U.S. Congress and the U.S. Army require an 80/20 probable outcome as a minimum (USACE 2009).

The authors' experience is that an 88/12 outcome provides the most appropriate contingency value for mining project budget estimates. While theoretically there is an 88% chance of being less than the specified cost using this outcome value, the authors have found (within their mining reality) that adoption of the 88/12 outcome contingency value will generally yield a final project cost essentially at project budget (Hickson 2002).

The evolution of the 88/12 percentage probable outcome is as follows. During the authors' project careers, the world's four leading mining engineering, procurement, and construction management (EPCM) firms were advocating either an 80% confidence interval (Fluor and Jacobs) or an 85% confidence interval (Bechtel and Kvaerner). However, several of their projects still came in over budget. Thus the authors used a slightly more risk-averse 90% confidence level for their projects at Freeport-McMoRan and Cyprus Amax, and the shareholders of these two organizations were rewarded with a resultant 1.4% total net cost *underrun* over a 14-year span from 1986 to 1999 (Hickson 2000c). Eleven major international projects were delivered in these two programs, with a total capital expenditure of almost $4 billion. The individual projects ranged from $125 million to $1.1 billion, and only two of the 11 suffered overruns: one an overrun of $2 million (1%), and the other an overrun of $31 million (23%). As a back-calculation, a selection of an 88/12 percentage probable outcome contingency value for the 11 projects would have produced a zero net underrun/overrun result. See Figure 34.1.

CONTINGENCY CALCULATION

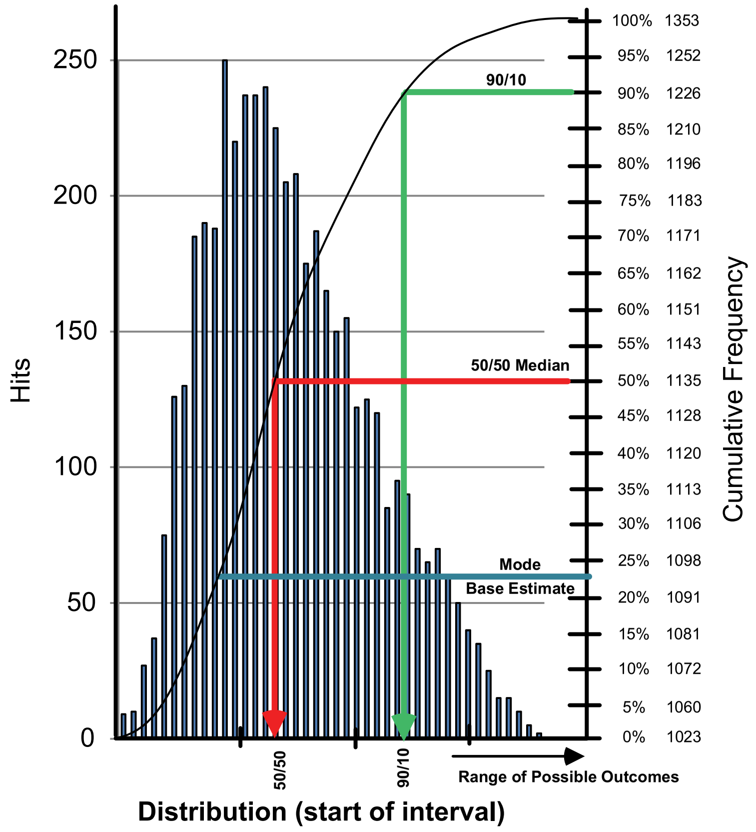
As shown earlier in this chapter, contingency and estimate accuracy can be graphically displayed within a distribution curve. Calculating the unique curve for a project, along with the probability ranges around the estimate, requires a statistical Monte Carlo simulation of the project's risk probabilities. The effect of each project risk and its likelihood of occurrence (the risk drivers described in the risk analysis section in Chapter 9) are coupled by the risk probability mechanisms of the Monte Carlo simulations to develop the range of possible outcomes for the project's risk distribution curve.

A Monte Carlo simulation of possible project outcomes can be performed for schedule as well as for cost. Figure 12.5 shows that for this particular grassroots Asian project for which one author was an advisor, the scheduler's base estimate of 3 years (1,096 days) to build the mine needed to add 130 days (4.3 months) and extend the schedule to 1,226 days to achieve a 90% confidence of completing the project within schedule.

Burroughs and Juntima's (2004) examination of past project results informs that as long as project scope definition is reasonably good, a probabilistic method for determining contingency allowance, such as a Monte Carlo simulation, yields a better project cost performance outcome prediction than the more common deterministic methods of predetermined percentage or expert judgment. *A predetermined percentage* is used when companies simply mandate a percentage of the base estimate (e.g., 15% for a feasibility-level estimate) as the contingency. *Expert judgment* is used when experienced estimators and project team members assign a level of contingency based on their combined experiences.

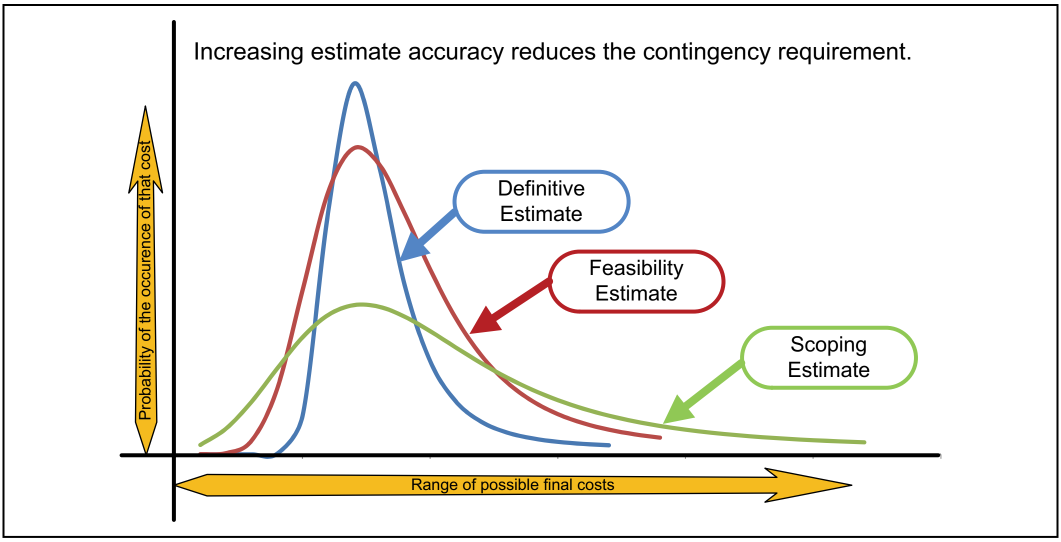
Although Burroughs and Juntima's (2004) work overall supports the authors' advocacy of the Monte Carlo analysis methodology for contingency assignment, where project scope definition is poor, the Monte Carlo simulation methodology does not perform particularly well. Risk analysis is only as good as the base data fed into it.

Further, Monte Carlo simulations often suffer from a lack of understanding of the mathematics behind the process along with optimistic assessments of extreme values, either of which can lead to inappropriate (generally lower) contingency allowances.



Data for Duration of Entire Project	
Analysis	
Iterations	5000
Statistics	
Minimum	1023 days
Maximum	1353 days
Mode (Base Estimate)	1096 days
Mean	1143 days
Bar width	One week
Highlights	
50%	**1135 days**
90%	1226 days

FIGURE 12.5 Monte Carlo simulation for a project schedule



Source: Adapted from Lawrence 2007, with permission from *Pharmaceutical Engineering*.

FIGURE 12.6 Increasing estimate accuracy

If a Monte Carlo simulation methodology is not undertaken and contingency is assigned by deterministic expert judgment, the contingency will be initially defined by project areas, typically down to individual work breakdown structure (WBS) budget line items to the best appropriate accuracy level using the best available data. For example, earthwork typically requires one of the higher contingency allowances; whereas a quoted piece of equipment typically requires a fairly low contingency allowance. Following agreement on all the line items that compose the full project budget, contingency is lumped into one account, the same as is done with the Monte Carlo simulation statistical analysis of risk probability and then managed as one item during the project execution, rising and falling as changes occur.

REDUCING CONTINGENCY

Knowing that project contingency is the difference between the mode and the desired level of outcome predictability (e.g., the 88/12 outcome), it follows that different levels of project contingency will be required for different shapes of risk distribution curves. The less risk and uncertainty there is around a project cost estimate, the more the range of probabilities can be reduced. The sharpness of the distribution curve will increase, and the gap between the chosen outcome level and the mode will decrease.

Figure 12.6 is an illustration of the concept that increasing the accuracy reduces the risk, and that reduced risk narrows the probability range, which in turn reduces the contingency requirement. The amount of contingency required to be added to a project estimate is thus a function of the risk and uncertainty emanating from the project characteristics and the level of scope definition (design, engineering, etc.) to that point in time.

PROJECT COST UNCERTAINTY

Project cost uncertainty and risk arise from several distinct elements, including systematic risks (risks that result from project characteristics) and project-specific risks.

Expected contingency amounts are shown for the different levels of estimate.

Estimate Type	Contingency as a Percentage of Project Cost
Order of Magnitude (Scoping)	+40% (Range +30% to +70%)
Prefeasibility Study	+22% (Range +15% to +30%)
Feasibility Study Budget	+15% (Range +12% to +18%)
Definitive (Control)	+8% (Range +5% to +10%)
Detailed (Final Check)	+5% or less

FIGURE 12.7 Expected contingency amounts

Systematic Risk

Two systematic risks are the paramount drivers of cost growth:

1. **The level of completeness of project definition prior to project start.**
    - Project front-end definition is clearly within the control of the project team.
    - Estimate accuracy ranges narrow as project design, engineering, and construction proceed. The more that is definitely known, the less risk and uncertainty there is in the estimate. This lessened risk reduces the estimate accuracy range, which in turn lessens the calculated contingency needed, as well as increasing the probability of achieving the predicted budget.
    - The estimator prepares the cost estimate on the work documents provided.
        - Items omitted from the work scope will not be picked up.
        - Omitted items are potential risks to the project cost outcome.
    - Ill-defined items carry greater risk than clearly defined items.
    - Projects that are not well-defined require greater levels of contingency.
2. **The type of project being undertaken.**
    - Project type risk is largely outside of the control of the project team.
    - Complex projects carry greater design and execution risk than simple projects.
    - A project using new technology carries greater design and execution risk than a facility that uses tried and proven processes and equipment.
    - A project in a remote location generally bears a greater execution risk than a facility in a better known location.
    - Complex projects, remote projects, and/or projects embracing new technologies will thus require greater levels of contingency.

Project-Specific Risk

Project-specific risks are those that are unique to a project's scope or strategy, for example, the weather or the labor market. These risk drivers are identified through risk analysis and are best mitigated by front-end planning (e.g., constructing in favorable weather cycles).

EXPECTED LEVELS OF CONTINGENCY

Figure 12.7 shows the different contingencies that could typically be expected at each level of estimate. These are strictly guidance numbers, inserted here only to allow the readers to compare their project's calculated contingency against them. The actual contingency for any particular project will solely depend on the specific factors governing that project, as this chapter has tried to make clear.

CONTINGENCY HANDLING

Every mining organization values cost predictability. This means that every mining organization should encourage the proper calculation of contingency. Contingency should never be removed (or reduced) to meet a front-end project cost target. If the estimate and contingency are correctly prepared, contingency removal immediately condemns the project to a worse than desired probability of overrun. Further, whenever contingency is arbitrarily removed or reduced, this sends a message to the project team that they are not trusted to estimate costs accurately. Any perception of loss of trust is bad for a project.

The mining company should not advertise or even insinuate that they will punish anyone for cost overruns. Punishment for overruns leads to hiding contingency monies within estimate line items. Hiding contingency has the following damaging effects:

- It sets the stage for a culture of weakened and less accurate estimating.
- It harms project control. The control budget no longer reflects the expected hours or cost. A degraded project control function adds risk.
- Human nature being what it is, monies hidden in the budget inevitably get spent, which leads to a less competitive project in the Owner's portfolio.

It is the project manager's job to thoroughly evaluate the contract requirements of the EPCM and construction contractors to ensure that the supplied project scope task activity list is truly complete. If not, the budget will fall short. On the other hand, the project manager and team must not overdo it by adding *too many* cushions to the cost estimate and work time for the activities in the task list and making generous allowances for problems that may never occur. Trying to cover the worst-case scenario of every conceivable problem will push the budget completely out of line.

Contingencies are intended for those circumstances not anticipated during project planning and budgeting. Contingencies are not a blank check to cover sloppy project planning or performance. Conversely, Owners should not act as if contingency monies do not exist and not allow their drawdown for proper situations.

Contingency rises and falls during project execution as changes occur. Contingency drawdown to cover negative cost variations, as well as savings from positive variations to the discrete elements within the WBS, is controlled by the project manager, and it flows in and out of the project contingency allowance as appropriate. Contingency movement against an established, predicted drawdown curve is like a thermometer of the project, showing how well the project is progressing. Figure 12.8 is a simple change management log that shows an actual project contingency drawdown over 25 months of a 30-month, $169 million project.

Contingency management software today uses potential deviation notices (PDNs) to capture potential changes. These PDNs are electronically fed into the change management log software, for such times as (if or when) they become actual accepted changes. A typical major project could easily have close to a thousand PDNs over its life and end up with more than one hundred accepted changes prior to completion.

	Project Commitments ($ Millions)				Contingency ($ Millions)			
					"Earned Status"		Current Forecast	
	Committed Amount to Date	Committed % to Date	Committed % Remaining	% of New to Go	% Remaining	Amount Remaining	Forecast Amount	% Remaining to Commit
YEAR 1								
May	$7.9	5.4	94.6	0.0	AFE Budget	$19.6	$17.7	12.9
June	$9.0	6.1	93.9	0.8	99.7	$19.5	$19.5	14.3
July	$10.1	6.9	93.1	1.6	99.5	$19.5	$18.8	13.9
August	$12.0	8.2	91.8	2.9	99.0	$19.4	$20.6	15.7
September	$28.8	19.6	80.4	31.2	83.2	$16.3	$17.3	14.7
October	$34.7	23.7	76.3	40.2	75.9	$14.9	$19.3	17.5
November	$43.5	29.7	70.3	25.7	87.1	$17.1	$17.3	16.8
December	$45.6	31.1	68.9	27.2	86.1	$16.9	$17.7	17.5
YEAR 2								
January	$49.4	33.7	66.3	29.9	84.1	$16.5	$17.5	18.0
February	$53.9	36.8	63.2	33.2	81.7	$16.0	$16.0	16.9
March	$56.9	38.8	61.2	35.3	80.0	$15.7	$15.7	17.0
April	$71.9	49.0	51.0	0.0	Def Estimate	$17.5	$17.5	23.4
May	$74.7	50.8	49.2	3.7	98.7	$17.3	$17.2	23.7
June	$77.9	53.0	47.0	7.9	97.0	$17.0	$17.2	24.8
July	$91.1	61.8	38.2	25.7	87.1	$15.2	$16.8	29.9
August	$95.9	64.3	35.7	32.1	82.5	$14.4	$15.0	28.2
September	$96.9	63.7	36.3	33.3	81.6	$14.3	$12.2	22.1
October	$101.5	66.5	33.5	39.6	76.4	$13.4	$11.5	22.4
November	$111.2	72.9	27.1	52.5	64.2	$11.2	$11.7	28.1
December	$110.0	72.1	27.9	50.9	65.8	$11.5	$11.7	27.3
YEAR 3								
January	$112.6	73.3	26.7	54.4	62.2	$10.9	$10.6	25.7
February	$118.0	76.6	23.4	61.6	54.2	$9.5	$10.1	28.0
March	$118.8	76.8	23.2	62.8	52.9	$9.3	$9.3	26.0
April	$122.8	79.4	20.6	68.0	46.6	$8.1	$9.6	30.0
May	$127.0	82.2	17.8	73.8	39.2	$6.9	$9.6	34.9

Note: Contingency is drawn down as project costs are committed. The planned rate of contingency drawdown in relation to the percentage committed is the "earned" amount. It is shown for comparison to the actual amount residing in the contingency account.

FIGURE 12.8 Project contingency status log

MANAGEMENT RESERVE

When the Owner requires an even greater certainty that the project budget will not be overrun, a management reserve fund is sometimes authorized, on top of project contingency, to cover Owner uncertainties relating to execution of the project. A management reserve fund is introduced where there are significant, identified project-specific risks that are outside of the approved project scope and quality.

One example is a possible but unbudgeted scope change from a permit authority's requirement to enclose a stockpile to mitigate visual impacts after the preliminary environmental impact study approval. Such a requirement would constitute a significant change in the project manager's mandate, the project scope, the cost, and the schedule. Another example is a legal reserve fund established for a grassroots mining project that could face a landowner lawsuit if the project goes forward.

Other reasons for the insertion of a management reserve sum could be to cover unusual economic situations, strikes, inclement weather conditions (beyond any stated allowance), certain project time extensions, prototype processes, possible currency fluctuations, and so forth. These are very specific events with an uncertain probability of occurrence, but their effect on the project if they come to fruition would be significant. Certainly, any "unknown unknown" (see Chapter 11) outside of the control of the project that the Owner's management wished to recognize would be carried within the management reserve, not in contingency.

The management reserve monetary allowance (sometimes known as a client reserve) is created solely at the Owner's discretion. A management reserve is part of the approved management- or board-authorized capital and thus part of any IRR or NPV (internal rate of return or net present value) calculations, and it is administered and controlled by the internal corporate sponsor from the mining company, not by the project manager. Management reserve funds are released by the Owner on an as-needed basis. No money is included in the project capital cost estimate for this reserve.

Management reserve funds are separate from the contingency because these funds are outside of the scope of the project manager. Funds for out-of-scope items do not belong in the project team's world. The project manager needs to steer the project according to the probability point that the team was asked to use at project authorization. A management reserve must never be allowed to be used as a slush fund by the project team. If a management reserve is used, its calculation would be based on the following:

- Project location
- Degree of definition of project scope
- Level of undefined project risks (the unknown unknowns)
- Potential for Owner scope changes to occur

This reserve is unusual; it is *not* present in most projects. If present, it may or may not be spent, depending on whether the envisaged uncertainty actually occurs.

Note: Some project pundits suggest that management reserve funds should also cover the difference between the 50/50 probability point and the outcome probability point chosen for the project (e.g., an 88/12 outcome point), and that the project manager should only have available the calculated contingency monies from the gap between the mode and the 50/50 outcome point. This is illogical and should be rejected by all. The gap between 50/50 and the Owner-desired outcome point is part of the project scope. The contingency monies need to encompass the entire gap between the mode and the probability point the Owner wants to control to. Splitting contingency monies into two funds, one controlled by the project manager and one controlled by an off-site Owner function, is counterproductive to achieving the desired project outcome.

CHAPTER 13

Comparison of Project Stage Work Efforts

There's nothing you can know that isn't known. —John Lennon, 1967

OBJECTIVE

This chapter presents a table comparing the escalating levels of effort required at the different study stages of a project life. The levels of effort are the minimums required to properly prepare the project for successful execution.

Figure 13.1 provides the reader with a quick guide to the activities required in each study stage. If the activities are undertaken to the degree listed, then approval for moving on to the next project stage will be facilitated.

PROJECT REPORTS HIGHLIGHTED IN THE COMPARISON TABLE

Here are the four phases of project life that are compared in Figure 13.1:

1. Scoping evaluation	(Chapter 4)
2. Prefeasibility study	(Chapter 6)
3. Feasibility study	(Chapter 7)
4. Definitive estimate	(Chapter 11)

The table comparatively lists the various work activities that should be undertaken in each of these preexecution stages of a project life. The work elements listed in the table under each study's name are separately described in more detail in the corresponding chapters of this book.

The tabulation mostly tries to list the typical *minimum* ingredients for each of the four document phases of a major greenfield project. There is divergent opinion within the mining profession as to exactly what these amounts should be, but what is listed in the table represents the commonly accepted minimums. Input to the table came not just from the authors' experiences, but also from key individuals from within the world's three largest international mining organizations and from eight of the globe's leading engineering, procurement, and construction management (EPCM) firms.

Not all of the elements shown will be needed on smaller projects; that is, the entries are guides—not hard-and-fast requirements for every project. While it is true that some elements listed in Figure 13.1 will not be needed on some projects, particularly small projects, the project manager cannot merely assume that items can be dispensed for a particular project. If the project manager *knows* that the item is unnecessary, then certainly it should be omitted, but the project manager then takes responsibility for the omission.

If the project manager is unsure whether an element is needed, the default path is to ask someone who knows.

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
PURPOSE			
Preliminary investigation to support the pursuit or rejection of an identified opportunity. Potential commercial viability assessed. Estimate accuracy is suitable for project rejection, but not adequate for board go-ahead of construction.	Study of alternative project configurations to demonstrate the technical and economic feasibility of the preferred conceptual installation (type and size) that could realistically be built. Yields the framework for a follow-up feasibility study.	Describes the complete, optimized project installations to be built. Sufficient scope definition for board approval, financing, budgeting, and control. Estimate accuracy suitable for nonrecourse external financing (i.e., a bankable document).	Final project control update. Further modifications should be unnecessary or minimal at most. Feasibility of project essentially ensured; no longer in doubt from this point onward.
PROJECT MANAGEMENT			
Mostly internal Owner personnel	Mix of engineers and specialists from outsource EPCM and Owner	Team mostly from EPCM, but support from external specialists and Owner	Team mostly EPCM, but bolstered by Owner staff from future site operations
Project leader is a person familiar with this minerals industry sector and experienced in project management.	Project team has relevant minerals industry knowledge and is familiar with Owner's objectives.	Leader is skilled in engineering management. Project team includes design engineers and estimators.	Professional design engineers, estimators, and construction managers are requisite within the project team.
SITE VISITS			
Single site visit by Owner's staff	2 or 3 visits by Owner specialists	Multiple on-site assessments	Permanent on-site presence
STUDY DOCUMENT			
Document produced by Owner staff or a single-sourced outside consultant	Document typically produced by outside engineering or EPCM firm	Document produced by EPCM firm; sufficient definition for project control	Document produced by EPCM firm, hired for detail engineering phase
Labor hours: 500 to 10,000	Labor hours: 5,000 to 120,000	Labor hours: 20,000 to 375,000	Labor hours: 1,000 to 5,000
Total cost: $50,000 to $2 million	Total cost: $400,000 to $20 million	Total cost: $1.5 million to $60 million	Total cost: $100,000 to $1 million

FIGURE 13.1 Comparison of project stage work efforts

(Continues)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
LOCATION/PROPERTY POSITION			
Site location map	Site location map and general topographical map	Site location map and detailed topographical map	
Regional climate data	Site-specific climate data	Site climate data over multiple years	
Property ownership/royalty status:	Property ownership/royalty status:	Property ownership/royalty status:	
Property lease desirable	Property under lease	Property title rights fully controlled	
	Claims list	Claims list and claims map	
	Mineral rights secured	Mineral rights secured	
	Encumbrances identified	Encumbrances identified	
CURRENT STATUS AND HISTORY			
	Historical chronology	Historical chronology	
	Past production, if any	Past production, if any	
EXPLORATION/GEOLOGY			
Data collection: From library review and preliminary site visit	Data collection: From library review and by on-site geologist(s)	Data collection: Virtually all on-site by geology team (Owner and outsource)	Data collection: On-site by Owner staff
Review existing maps. Preliminary geologic mapping.	Geologic maps and associated cross sections produced.	Geologic maps, sections, level plans, i.e., deposit defined in three dimensions.	Detailed geologic maps, cross sections, long sections, level plans.
Outcrop samples. Geophysics optional.	Geophysical and geotechnical sampling. Test pits.	Geophysical and geotechnical sampling. Test pits.	
Preliminary geologic assessment	Basic geological assessment/review	Detailed geologic assessment	Detailed geologic mapping
Limited assay data available	Preliminary mineralogical sampling	Detailed mineralogical mapping	
Preliminary mineralogical assessment	Preliminary mineralogical study	Detailed mineralogical support study	
Preliminary coal quality analysis	Preliminary coal quality/washability	Detailed coal quality/washability study	

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
DRILLING			
Drill-hole parameters: A few targeted holes (optional) Mostly RC holes; for initial resource	**Drill-hole parameters:** Initial fill-in of wide-spaced holes Sufficient holes for NI 43-101 PEA	**Drill-hole parameters:** Closely spaced holes, on a grid Sufficient holes for an NI 43-101, a JORC, or an SEC 10-K reserve	**Drill-hole parameters:** Closely spaced holes, on a grid Sufficient holes for an NI 43-101, a JORC, or an SEC 10-K reserve and model checks
Checks: Check on existing drill-hole data Drill-hole location map Confirmation assays (optional)	**Checks:** Verification of drill-hole data Drill-hole location map Check assays of existing core Twin holes (optional) Selected confirmation assays	**Checks:** Verification of drill-hole data Collar and downhole surveys Full re-assay of existing core Twin holes (preferably >5) Confirmation assays (1 in 20)	
MINERAL RESOURCE			
Geologic model: Physical limits Rudimentary statistics	**Geologic model:** Lithology/tonnage factors/code Basic statistics/variograms	**Geologic model:** Lithology/tonnage factors/code Basic statistics/variograms	**Geologic model:**
Resource: Inferred mostly; some indicated	**Resource:** Indicated mostly, some measured	**Resource:** 80% measured/indicated	**Resource:** 100% measured/indicated
RESERVES			
Assumed calculation parameters	Derived calculation parameters	Test-derived calculation parameters	Parameters from feasibility study
Preliminary (possible and probable)	Preliminary probable and proven tons and grade defined to meet NI 43-101 PEA	NI 43-101, JORC, or SEC 10-K quality (proven and probable) tons and grade	NI 43-101, JORC, or SEC 10-K quality (proven and probable) tons and grade
No reserve able to be classified	Mine plan mostly consists of probable reserve status material.	Mine plan contains a minimum of 80% proven reserves.	Mine plan contains a minimum of 80% proven reserves.
Manual calculation (typically cross-section or polygonal), i.e., conceptual estimate by the Owner.	Reserve delineated sufficiently for a reasonable estimate of tons and grade. Generally, a geostatistical block model, but can be cross-sectional.	Two reserve calculations: One has to be geostatistical, using a detailed block model. One must be by an external, recognized specialist.	Reserve calculation uses preferred method from feasibility study.

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
MINE PLAN			
Mining method: Assign surface or underground.	**Mining method:** Specific method established.	**Mining method and mine plan:** Method and mine plan configured.	**Mining method and mine plan:** As adopted in feasibility study.
Mining parameters: Minimal engineering basis	**Mining parameters:** Rudimentary geotechnical data Rudimentary hydrology data	**Mining parameters:** Site-specific geotechnical data Site-specific hydrology data	**Mining parameters:** From feasibility study
Pit slopes: Generic 40° to 45°	**Pit slopes:** Preliminary by rock type	**Pit slopes:** By cell mapping and oriented core	**Pit slopes:** From feasibility study
Economic parameters for mine plan: Order-of-magnitude ±200%	**Economic parameters for cones:** Preliminary ±40%	**Economic parameters for cones:** Improved estimate ±20%	**Economic parameters for cones:** Final operating criteria ±15%
Process recovery for mine plan: ±30%	**Process recovery for floating cones:** Preliminary ±10 to 15%	**Process recovery for floating cones:** Improved estimate ±5%	**Process recovery for floating cones:** Improved estimate ±3%
Cutoff grade (COG): Assumed	**Cutoff grade:** From floating cone parameters	**Cutoff grade:** Optimized using COG equations	**Cutoff grade:** From feasibility study
Surface pit design: 40° to 45° generic sketch Simple outline of final pit	**Surface pit design:** Floating cones with pushbacks Haul roads factored into design. Incremental and final pit outlines	**Surface pit design:** Detail optimized phase designs Haul roads included in design. Phase, annual, and final pit outlines	**Surface pit design:** Detail optimized phase designs Haul roads included in design. Phase, annual, and final pit outlines
Underground design: General outline of development Metal: Assumed stoping system Coal: Assumed longwall or room and pillar; assign a percentage extraction	**Underground design:** Simple outline of development Metal: Specific stoping system Coal: Design for ventilation, roof control, and secondary mining	**Underground design:** Detailed outline of development Metal: Specific stoping system Coal: Ventilation, roof control, utilities, haulage, mining details	**Underground design:** Detailed outline of development Metal: Specific stoping system Coal: Ventilation, roof control, utilities, haulage, mining details

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Production schedule: Paper schedule Mining rate from paper schedule	**Production schedule:** From pushbacks Mining rate from mine plan	**Production schedule:** Detailed annual schedules Mining rate from mine plan Optimized COG strategy	**Production schedule:** Detailed year-to-year schedule Mining rate from mine plan Optimized COG set
"Mine life" production tonnages (ore and waste) and "mine life" grade	Yearly and mine life tonnages, grade production, and strip ratios	Yearly and mine life tonnages, grade, production, and strip ratios	Yearly and mine life tonnages, grade, production, and strip ratios
Waste dumps/coal refuse storage: Block area Simple outline of final shapes	**Waste dumps/coal refuse storage:** Design to match total waste tons Incremental and final outlines	**Waste dumps/coal refuse storage:** Sites and heights selected Phase, annual, and final outlines	**Waste dumps/coal refuse storage:** As in feasibility study
Mine services: Assumed	**Mine services:** From sketch designs	**Mine services:** Fully outlined	**Mine services:** Firm design basis
Resource requirements: Assumed	**Resource requirements:** Generic equipment/consumables list Personnel list	**Resource requirements:** Detailed equipment/consumables list Personnel list	**Resource requirements:** Final equipment/consumables list Final personnel list
METALLURGY			
Ore sampling: Generally none; assumed values	**Ore sampling:** Metallurgical sampling of core	**Ore sampling:** Metallurgical sampling of core	
Metallurgical mapping: None	**Metallurgical mapping:** Sampling of ore body zones	**Metallurgical mapping:** Complete mapping of ore body	
Tests: Review and verification of existing metallurgical information	**Tests:** Advanced bench-scale testing to determine preliminary recoveries	**Tests:** Complete comprehensive suite of tests and pilot plant to confirm design and derive defendable recoveries	**Tests:** Confirmatory metallurgical tests to optimize feasibility study parameters
Recoveries: Estimated or assumed	**Recoveries:** Preliminary, based on actual metallurgical tests performed	**Recoveries:** Calculated from the suite of metallurgical tests performed	**Recoveries:** Calculated from the suite of metallurgical tests performed
Technology selection: Use the industry's typical practices	**Technology selection:** Compare project specific options	**Technology selection:** Identify optimum option	**Technology selection:** Selection finalized

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Coal washability and sink–float data: Estimate	**Coal washability and sink–float tests:** Preliminary	**Coal washability and sink–float tests:** Improved estimate	**Coal washability and sink–float tests:** Definitive marketing parameters
Production schedule: "Mine life" ore tons, grade, recoveries, and concentrate/metal output	**Production schedule:** Yearly ore tons, grade, recoveries, and concentrate/metal output	**Production schedule:** Yearly ore tons, grade, recoveries, and concentrate/metal output Ramp-up to full design by month	**Production schedule:** Yearly ore tons, grade, recoveries, and concentrate/metal output Ramp-up to full design by month
ENGINEERING AND PROCESS DESIGN			
Design basis: Preliminary; concepts extrapolated from similar plants First cut assumes estimated plant product(s) and throughput capacity.	**Design basis:** General; key drawings for initial definition of scope Preliminary mine and process rates, plant product(s), and capacity Preliminary engineering only	**Design basis:** Complete; all design drawings for full definition of scope Final mine and process throughput rates, plant product(s), and capacity Basic engineering optimized and essentially complete (>85%).	**Design basis:** Final; detail design fully agreed to by Owner and EPCM Final mine and process throughput rates, plant product(s), and capacity Detail engineering advanced. Minimum of 35% in each discipline; >55% overall.
Value engineering: None	**Value engineering:** The key trade-offs are complete. Best case configuration is selected.	**Value engineering:** Design trade-offs are complete. Final configuration is frozen.	**Value engineering:** Optimization trade-offs are complete. Final configuration is frozen.
Design concept: Criteria and specifications outline	**Design criteria:** Preliminary outline of facilities	**Design specifications:** General specifications complete	**Specifications:** Formal specifications finalized
Site plan: Sketch of approximate locations	**Site plan:** Likely facility locations postulated Preliminary plot plans	**Site plan:** All facility locations established Detail plot plans	**Site plan:** Final locations set Site and plot plans complete
Layout: Approximate geographic locations with site location map Sketch illustrations	**Layout:** Some optimization of initial facility locations with site location map Simple general arrangements 2D drawings of plant	**Layout:** Optimal facility locations on-site map; topographical and regulations respected Detail GAs for design development 3D model advanced	**Layout:** Exact location(s) for facilities on final site location map Final GA drawings 3D model complete

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Process flow diagrams: Minimal process parameters set from industry typical Potentially viable process flow diagram idea derived from known processes Generic assumptions of values Simple block diagram One process flow diagram	**Process flow diagrams:** Basic process parameters set from testwork Probable process flow diagram developed based on preliminary test work data Main elements of material balance Major equipment list only Major process flow diagrams	**Process flow diagrams:** Full suite of process parameters from testwork Detailed process flow diagram advanced based on comprehensive pilot testwork Optimal heat and mass balance Full, optimized equipment list All process flow diagrams optimized and complete	**Process flow diagrams:** Final detailed process parameters Process flow diagrams final and frozen Heat and mass balances frozen Final detailed equipment list Final process flow diagrams
Engineering flow diagram: None	**Engineering flow diagram:** Major instruments and valves	**Engineering flow diagram:** Optimized line sizes, instruments, and valves	**Engineering flow diagram:** Final line sizes, instruments, and valves
HAZOP: None	**HAZOP:** Optional fatal flaw analysis	**HAZOP:** First HAZOPs can be undertaken.	**HAZOP:** First HAZOP must be conducted.
Reagent and consumables usage: Industry typical	**Reagent and consumables usage:** Preliminary	**Reagent and consumables usage:** Complete and optimized	**Reagent and consumables usage:** Detailed final
Surge capacity and stockpiles: None	**Surge capacity and stockpiles:** Preliminary estimates	**Surge capacity and stockpiles:** Detail calculations	**Surge capacity and stockpiles:** Final design and sizing complete
Operating and control philosophy: None	**Operating and control philosophy:** Outline	**Operating and control philosophy:** Detailed for all systems	**Operating and control philosophy:** Complete and final
Resource requirements: Assumed	**Resource requirements:** Initial equipment and personnel lists	**Resource requirements:** Detailed equipment, consumables, and personnel lists	**Resource requirements:** Final equipment, consumables, and personnel lists

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Civil work:	**Civil work:**	**Civil work:**	**Civil work:**
Rough topographical maps	Rough topographical maps (e.g., 1:10,000 with 10-m ground contour intervals)	Semidetailed topographical maps (e.g., 1:2,000 with 2-m contour intervals)	Accurate detailed topographical maps (e.g., 1:1,000 with 1-m contour intervals)
	Draft soils report	Semicomplete soils tests report	Complete soils tests and report
Special features noted	Basic preliminary quantities	Detail loadings and quantities	Detail loadings and quantities
Sketches (optional)	Typical drawings	Typical drawings; some detailed	Detail drawings >70% complete
Equipment specifications:	**Equipment specifications:**	**Equipment specifications:**	**Equipment specifications:**
Major equipment list	Major equipment list, including brief description of main items	Complete equipment list with all major equipment priced FOB job site	Final list with all sizing refined and priced FOB job site
	Initial sizings (optional)	Detail sizing	
General concept outline	Outline of criteria	Detailed specifications	Complete specifications and data sheets
No specifications or data sheets	Preliminary specifications	Data sheets on major equipment	Formal supplier response in hand
Architectural:	**Architectural:**	**Architectural:**	**Architectural:**
None or sketches (optional)	Sketches	Exterior elevations only	Essentially complete
Structural/mechanical:	**Structural/mechanical:**	**Structural/mechanical:**	**Structural/mechanical:**
None	Minimal, outlines only	Preliminary, some detailed	Complete
Piping/HVAC/P&ID:	**Piping/HVAC/P&ID:**	**Piping/HVAC/P&ID:**	**Piping/HVAC/P&ID:**
None	Single line piping drawings; major P&IDs	Detail for major systems; general for rest; schematics and P&IDs complete	Piping complete; P&IDs optimized
	Preliminary list of all large-diameter piping needs	Detail list of all process piping requirements (>2-inch diameter)	Complete list of all process piping requirements (>2-inch diameter)
Tankage:	**Tankage:**	**Tankage:**	**Tankage:**
None	Preliminary list	Complete list and data sheets	Final detailed list and data sheets

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Electrical distribution: None	**Electrical distribution:** Basic one-line diagram Preliminary equipment list	**Electrical distribution:** Design one-line diagrams complete Detailed equipment list	**Electrical distribution:** Design advanced; partial drawings Complete, final equipment list
Motors: None	**Motors:** General description Preliminary sizing	**Motors:** Detail list of major items with hp Detailed sizing	**Motors:** Complete list of all items with hp Sizing complete
Instrumentation:	**Instrumentation:** General	**Instrumentation:** Preliminary, with supporting list	**Instrumentation:** Detailed, with supporting list Instrument diagrams complete
Information systems: None	**Information systems:** Preliminary	**Information systems:** Details on key systems	**Information systems:** Final; detailed using vendor data
Process description: General	**Process description:** Narrative	**Process description:** Detailed	**Process description:** Final
Level of definition: Percentage of engineering complete, expressed as a % of total engineering Recommend 1%; range <1% to 2%	**Level of definition:** Percentage of engineering complete, expressed as a % of total engineering Recommend >7%; range 5% to 12%	**Level of definition:** Percentage of engineering complete, expressed as a % of total engineering Recommend >20%; range 12% to 30%	**Level of definition:** Percentage of engineering complete, expressed as a % of total engineering Recommend >70%; range 60% to 80%
INFRASTRUCTURE			
Full site plan: No General overview provided	**Full site plan:** Likely facility locations postulated All critical facilities identified	**Full site plan:** All facility locations established All support facilities listed	**Full site plan:** Final facility locations set All support facilities detailed
HYDROLOGY			
Water source(s) estimated and discussed using regional data No hydrology study Plant water balance not addressed Mine dewatering issues identified	Water source(s) identified from existing data Preliminary hydrology study Preliminary plant water balance Mine dewatering needs estimated	Water availability confirmed by study Local groundwater regime defined Detailed plant water balance Dewatering strategy confirmed	Specific water source proven Finalized plant water balance Mine dewatering plan finalized

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
COMMUNICATIONS			
	Communications systems study undertaken Satellite usage investigated	Communications licensing and standards issues built into design Designed for Owner wide area network (WAN)	Owner communications system functioning on the construction site
POWER			
Industry typical data used	Preliminary requirements derived	Power requirements designed	Power requirements finalized
Overview of power availability	Power sources identified	Specific power source identified	Specific power source contracted
	Distribution to site addressed	Distribution to site engineered	Distribution to site established
Published regional power costs	Electrical loads estimated; unit costs from local area	Electrical loads derived; unit costs from detail study	Electrical loads finalized; unit costs from contract
PROCUREMENT			
Logistics: Review of existing logistics support systems Report highlighting significant obstacles to materials flow	**Logistics:** Preliminary logistics study made for construction and operations Highlight report of material flow impediments to and from site Identify customs issues	**Logistics:** Detailed logistics plans produced Shipping, transportation plan, and marshalling requirements established Customs issues ascertained	**Logistics:** Comprehensive logistics plan established Shipping and transport plan set; marshalling requirements established Customs issues ascertained
Materials procurement:	**Materials procurement:** Identification of appropriate parties to undertake materials purchasing, and expediting for the construction effort Identification of possible suppliers for major equipment	**Materials procurement:** Material and equipment sourcing plan outlined; plans identify the single point entity responsible for sourcing Short list of suppliers; identification of vendors for major equipment Long lead-time items identified	**Materials procurement:** Material and equipment sourcing plan detailed; purchasing and expediting personnel in place for construction Vendor selection complete All long lead-time items ordered

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Warehousing: None	**Warehousing:** Location and size of major warehouse facilities estimated	**Warehousing:** Facilities for construction and operations identified	**Warehousing:** Facilities for construction and operations identified Initial warehouses established
Percent procurement: Zero	**Percent procurement:** Zero	**Percent procurement:** Long lead-time equipment only	**Percent procurement:** Procurement >70% complete
WORKFORCE			
Project management staffing: Project manager selected by Owner to champion the opportunity	**Project management staffing:** Project management team defined Highly qualified project manager for project execution selected	**Project management staffing:** Owner's project management team roles listed; organization chart derived Proven successful project manager for project life span in place	**Project management staffing:** Project management team in place; organization chart set Owner project manager and cost engineer in place
Operations staffing levels: Factored estimate Local availability of operations personnel reviewed	**Operations staffing levels:** Preliminary estimate Conceptual organization structure Operations personnel requirements listed by department Potential labor source identified Conceptual recruitment plan	**Operations staffing levels:** Zero-based personnel budget Detailed organization structure Detailed operations personnel list by job function and annual pay rate Source of labor identified Labor buildup schedule set Training for start-up described	**Operations staffing levels:** Zero-based personnel budget Final organization structure set Known operations personnel list by job function and annual pay rate Source of labor identified Labor buildup schedule set Detailed training plan fully defined

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
ENVIRONMENTAL			
Data review/collection: Preliminary site visit desirable Evaluate project for environment and permit constraints Review of readily available data, e.g., country reports, library search	**Data review/collection:** Site visit(s) necessary Preliminary evaluation of impact on the environment Evaluate existing databases and country reports Long-duration field studies begun Initiate baseline data collecting	**Data review/collection:** Multiple site visits necessary Focused characterization of potential environmental impacts All environmental databases and country reports reviewed Long-duration field studies underway Baseline data gathering complete	**Data review/collection:** Site presence requisite Specific definition of potential impacts on the environment Update environmental database as needed
Data assessment and preparation: Identification of environmental red-flag issues Overview of major environmental and permit issues; characterize risks	**Data assessment and preparation:** Assess political/community issues Preliminary plans for handling environmental red-flag issues Summary of the environmental and permit issues; characterize risks	**Data assessment and preparation:** Assess political/community issues Full evaluation of environmental and permitting red-flag issues Comprehensive environmental and permit report; characterize risks	**Data assessment and preparation:** Public affairs strategy finalized Acceptable mitigation measures for all red-flag issues fully defined Update feasibility study results, e.g., permit conditions, mitigation, and design
Environmental management plan: Conceptual plans for managing any identified "red-flag" issues	**Environmental management plan:** Preliminary environmental management plan (scope of an ASTM Phase I Assessment) Preliminary impact mitigation study Monitoring program prepared Geotechnical stability review Sediment and erosion control plan Preliminary mine waste plan Tailings management plan	**Environmental management plan:** Comprehensive environmental management plan (scope of an ASTM Phase II Assessment) Impact mitigation plan Monitoring program finalized Geotechnical stability analysis Sediment and erosion control plan Mine waste management plan Detail tailings management plan	**Environmental management plan:** Environmental management plan is complete, and mitigation measures fully designed. Impact mitigation plan finalized Monitoring program functioning Sediment and erosion control plan Final mine waste management plan Final mine waste management plan

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Environmental management plan (Continued): Minimal detail closure plan	**Environmental management plan (Continued):** Conceptual reclamation plan Evaluation of acid rock drainage potential from waste rock dumps Hazardous material investigations Spill prevention strategy Draft EIS/EA preparation initiated, when applicable	**Environmental management plan (Continued):** Reclamation plan Acid rock drainage potential study Preliminary hazardous materials (HAZMAT) plan Spill prevention and response plan QA/QC parties responsible for environmental compliance identified Draft EIS/EA well defined; usually submitted to the regulators and issued Serious public objections identified	**Environmental management plan (Continued):** Site reclamation and closure plan Final acid rock drainage handling plan Final HAZMAT handling plan Spill prevention and response plan QA/QC persons responsible for environmental compliance identified Final EIS/EA approved No known objections to approval
PERMIT REQUIREMENTS			
Permit overview: General overview of environmental and/or other necessary permits, gathered from readily available information	**Permit overview:** Comprehensive overview, understanding, and listing of the necessary permits for this mine type and locality	**Permit overview:** Detailed evaluation of environmental and other permit requirements identified and highlighted in a legal constraints study	**Permit overview:** Detailed evaluation of environmental and other permit requirements identified; ability to satisfy regulations confirmed
Regulatory framework: Framework investigated	**Regulatory framework:** Framework understood Permit timetable created Regulatory requirements communicated to project manager and EPCM company Ensure engineering designs compatible with permit requirements	**Regulatory framework:** Framework understood Permit timetable in hand Selected governmental permit actions initiated, based on engineering completed Permit acquisition support identified Key permits applied for	**Regulatory framework:** Framework understood Permit timetable finalized Remaining permit applications submitted as detail engineering complete Permits to initiate operations in process Construction start permits in hand

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Reporting: Requirements researched	**Reporting:** Requirements understood	**Reporting:** Obligations documented	**Reporting:** Initiated
SCHEDULE			
Mine development plan: Development period assumed	**Mine development plan:** Development schedule estimated	**Mine development plan:** Schedule broken down in detail	**Mine development plan:** Firm schedule, with annual detail
Project master schedule: Level 1 schedule Estimate outline only, Gantt bar chart of major work elements	**Project master schedule:** Level 2 schedule Required; Gantt bar chart showing overall time frames Preliminary schedule calendar set Schedule outline for engineering	**Project master schedule:** Level 3 schedule Required; Gantt bar chart showing activity details and overall time frames Schedule calendar set with Owner Deliverables detailed in schedule Major milestones identified	**Project master schedule:** Level 3 and Level 4 schedules Required; Gantt bar chart showing activity details (including actuals to date) and overall time frames Final schedule calendar set Deliverables detailed in schedule Milestone list complete and set
Construction schedule: Not required	**Construction schedule:** Optional, but desirable	**Construction schedule:** Semicomplete is necessary. Critical path activities and schedule outlined and resourced	**Construction schedule:** Detailed and complete Critical path schedule fully resourced and complete
Commissioning and ramp-up: Not required	**Commissioning and ramp-up:** Outlined	**Commissioning and ramp-up:** Detailed critical path	**Commissioning and ramp-up:** Detailed and resourced critical path
PROJECT EXECUTION OUTLINE			
Project Execution Plan: PEP not required Resources to conduct next project phase identified	**Project Execution Plan:** PEP not required Operations personnel viewpoints solicited; buy-in obtained throughout Resources to conduct next project phase identified	**Project Execution Plan:** Required Execution approach defined Operations buy-in of design and critical concepts firmly established Resources for project execution phases identified	**Project Execution Plan:** PEP detailed and complete Execution approach agreed to by all parties Owner representatives in place in EPCM office as part of design team Resources for project execution phases in place

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Project framework:	**Project framework:**	**Project framework:**	**Project framework:**
Project scope—broad description	Project scope—preliminary outline	Project scope—defined	Project scope—firmly set
		Project procedures manual complete	Project procedures manual in use
			Mass excavation plan in place
		Project design basis agreed to	Project design basis document in use
		Change control procedure described	Change authority established
		Project controls system outlined	Project controls functioning
			Definitive cost estimate replaces feasibility study as basis of ongoing project cost control, but original feasibility study budget remains as baseline reference.
		Project reporting needs defined	Project reporting system in place
Monthly progress report published	Monthly progress report published	Monthly progress report published	Monthly progress report published
	QA/QC program outline	Workplace safety program outlined; QA/QC program final	Workplace safety and health program and QA/QC program final and in use
			Comprehensive plan covering precommissioning, commissioning, and start-up prepared using outside specialists, EPCM, and Owner staff
		Partnering philosophy statement	Partnering concept established
		Project audit philosophy established	Selected project audits underway

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Construction contract strategy: Not required	**Construction contract strategy:** Options outline discussion Geotechnical work initiated	**Construction contract strategy:** Decision as to whether lump sum, T&M, fee plus, GMP, etc. Philosophy stated and justified Critical geotechnical work and test pits complete in all areas; data in hand	**Construction contract strategy:** Methodology selected; either lump sum, T&M, fee plus, or GMP, etc. Detailed and implemented All major contractors mobilized
Percent constructed: Zero	**Percent constructed:** Zero	**Percent constructed:** Zero, unless fast-track project (Note: fast-track not recommended)	**Percent constructed:** Construction >25% complete
CAPITAL COST ESTIMATE			
Initial and mine-life-sustaining CAPEX: Top-down entirely Sustaining/replacement factored	**Initial and mine-life-sustaining CAPEX:** Mix of bottom-up and top-down Sustaining CAPEX factored	**Initial and mine-life-sustaining CAPEX:** Mostly bottom-up for the estimate Sustaining CAPEX calculated	**Initial and mine-life-sustaining CAPEX:** All bottom-up figures Sustaining CAPEX detailed
WBS: Outlined Project code of accounts—none	**WBS:** Preliminary Code of accounts—preliminary	**WBS:** Defined Code of accounts—defined	**WBS:** Established Code of accounts for Owner's property, plant, and equipment in use
Mine capital cost estimate basis: All factored (or assumed)	**Mine capital cost estimate basis:** Partly from preliminary equipment list; rest from manuals and in-house data	**Mine capital cost estimate basis:** Detailed list of initial and future fleet; quotes on all major equipment	**Mine capital cost estimate:** Equipment list for initial and future requirements; firm, accepted prices
Plant capital cost estimate basis: Estimate prepared by experience, factor, unit cost, shelter volume, etc. Estimate form—generally none Site visit by Owner's estimator	**Plant capital cost estimate basis:** Estimate prepared by probable unit cost or spread (including installation) Estimate form—often desirable Site visit by project estimator—one letter quote for each major equipment supplier	**Plant capital cost estimate basis:** Estimate from sound engineering criteria, equipment list, and takeoffs Estimate form—likely required Site visit by estimator and major equipment suppliers—two quotes	**Plant capital cost estimate basis:** Estimate by spread from design criteria, equipment list, and takeoffs Estimate form—required Site visit by project estimator and by all major vendors—three firm quotes

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Plant capital cost estimate basis (Continued):	**Plant capital cost estimate basis (Continued):**	**Plant capital cost estimate basis (Continued):**	**Plant capital cost estimate basis (Continued):**
Civil/structural—unit volumes from sketches	Civil/structural—takeoffs from sketches for major items	Civil/structural—partial takeoffs and quotes, benchmarked to real data	Civil/structural—contractor takeoffs; material takeoffs (MTOs) on completed drawings
Architectural—historic factors	Architectural—partial takeoffs	Architectural—mostly takeoffs	Architectural—complete takeoffs
Mechanical—% of machinery	Mechanical—preliminary takeoffs	Mechanical—mostly full takeoffs	Mechanical—contractor prices based on takeoffs
Piping/HVAC—% of machinery	Piping/HVAC—takeoffs on major items; factors on rest	Piping/HVAC—partial takeoffs and hours, benchmarked to real data	Piping/HVAC—contractor prices based on takeoffs
Electrical—historic factors; unit cost/hp, cost/kW, percentage of total cost	Electrical—area rates for most items; historical factors elsewhere	Electrical—present rates; takeoffs and hours for electrical runs	Electrical—detailed estimate from contractor tenders
Labor rates—historic factors	Labor rates—known, generic/union construction rates from region	Labor rates—actual construction rates and burdens for the area	Labor rates—rates and burdens for awarded contracts
Productivity—not evaluated	Labor productivity—assumed	Labor productivity—evaluated	Labor productivity—known
	Construction equipment usage—percent of labor	Construction equipment usage—percent of labor/crew	Construction equipment usage—contract agreement method specified
Material volumes—historic figures with a % factor for installation	Material volumes/amounts—takeoffs on major items only	Material volumes—partial takeoffs; rest by weight factor or past experience	Material volumes/amounts—complete takeoffs; firm contract prices
	Bulk commodities from initial GA drawings and sketches	Bulk commodities quantified from plot plans, GAs, and design drawings	Bulk commodities quantified from plot plans, GAs, and detail drawings
Material/equipment pricing—either from manuals or historical data bank	Material/equipment prices—from EPCM; a few single vendor quotes	Material/equipment pricing—detail list using quotes from multiple vendors	Firm vendor material/equipment prices; complete, itemized equipment list

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Plant capital cost estimate basis (Continued): IT/control systems—% of budget Assume prices FOB site, with tax	**Plant capital cost estimate basis (Continued):** Major long lead-time items known Spares list and initial fills factored IT/control systems—% of budget All prices FOB site, include tax	**Plant capital cost estimate basis (Continued):** All long lead-time items identified Spares list and initial fills estimated IT/control systems—calculated All prices FOB site, include tax	**Plant capital cost estimate basis (Continued):** Long lead-time items ordered Spares list and initial fills set IT/control systems—from bids All prices FOB site, include tax
Infrastructure: Facilities costed from historic factors	**Infrastructure:** Facilities costed from quotes or estimating manuals	**Infrastructure:** Costed from formal written quotes on all major facilities	**Infrastructure:** Costed from written firm prices on all major facilities
Contractors’ OH&P: Included in unit cost or set as percent of total cost	**Contractors’ OH&P:** Percent of direct cost with factors for indirect costs Subcontract pricing—historical	**Contractors’ OH&P:** Written quotes providing estimates Subcontracts—written quotes	**Contractors’ OH&P:** Written quotes with complete details Subcontracts—written quotes
EPCM: Percent of total budget	**EPCM:** Percent of direct cost	**EPCM:** Estimate from EPCM firm	**EPCM:** Detail from hired EPCM firm
Prefeasibility and Feasibility Study: Costs a percentage of total cost	**Feasibility Study:** Cost by firm quote		
Owner cost/preproduction expense: Generic top-down estimate or a percentage of total budget Corporate overheads excluded	**Owner cost/preproduction expense:** Mostly factoring of similar projects; bottom-up estimates for key items Sustaining capital shown Corporate overheads excluded	**Owner cost/preproduction expense:** Zero-based budget calculation Sustaining capital shown Corporate overheads excluded	**Owner cost/preproduction expense:** Zero-based budget update Sustaining capital shown Corporate overheads excluded
Escalation: Generally excluded	**Escalation:** Use Owner’s allocation	**Escalation:** Defined, by area and risk	**Escalation:** Detailed evaluation
Working capital: Factored from Owner methodology	**Working capital:** Estimate prepared by experience factor from similar project	**Working capital:** Estimate calculated from detail zero-based budgeting by Owner	**Working capital:** Same basis as feasibility study; updated for additional work complete
Exclusions: Not applicable	**Exclusions:** Broadly stated	**Exclusions:** List of items agreed to by Owner Needs to be kept to a minimum	**Exclusions:** List of items agreed to by Owner Kept to a minimum

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Contingency: Generic estimate. Either set as a single percentage, or heavy factors used to cover the unknowns. +40% overall; range 30% to 70% Equipment +15% to 25% Structures +20% to 50%	**Contingency:** Broad evaluation. Overall project contingency is still heavy. Many items are still estimates. +22% overall; range 15% to 30% Quoted equipment +10% to 15% Structures +15% to 20%	**Contingency:** Detail engineering and zero-based budgeting should reduce overall contingency calculation to <18%. +15% overall; range 12% to 18% Typically no single area >20% Equipment with firm quotes +5%	**Contingency:** Detailed evaluation results in a minimal contingency. +8% overall; range 5% to 10% No area has >10%.
Accuracy at 90% confidence level: Expect ±40%; Range +100% to −50% for overall PROJECT Accuracy judgmentally assessed	**Accuracy at 90% confidence level:** Expect ±5%; range +40% to −30% for overall project +30% to −20% for individual facility ±30% for site closure plan Accuracy statistically evaluated	**Accuracy at 90% confidence level:** Expect ±5%; range +25% to −20% for overall project +20% to −10% for individual facility +20% for site closure plan Monte Carlo simulation to yield <10% probability of overrun, i.e., 90% confidence project $ will be less than or equal to budget.	**Accuracy at 90% confidence level:** Expect ±8%; range +12% to −10% for overall project +15% to −10% for individual facility ±15% for site closure plan Monte Carlo simulation to yield <10% probability of overrun
OPERATING COST ESTIMATE			
Operating quantities: General, i.e., generic Workforce estimate	**Operating quantities:** Estimates (some factoring) Personnel list—by department	**Operating quantities:** Detailed Personnel list—by job function	**Operating quantities:** Detailed from mine plan takeoffs Personnel list—by job function
Mine operating costs: Generic order-of-magnitude	**Mine operating costs:** Preliminary estimate from manuals and benchmark of other properties	**Mine operating costs:** Zero-based budget; vendor input; breakdown by mining function and year	**Mine operating costs:** Zero-based budget; vendor input; breakdown by mining function and year

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Plant operating costs:	**Plant operating costs:**	**Plant operating costs:**	**Plant operating costs:**
Collection and usage of any existing cost data. Order-of-magnitude estimates are from manuals and data banks are used where no data exist.	Labor, supplies, fuel, power, reagents, liner costs, etc., are chosen by benchmark and factoring of similar projects, or from estimating manuals.	Detailed from zero-based budget	Detailed from zero-based budget
		Labor costs (rates and burdens) calculated from review of similar actual local area data and contracts	Update and optimization of labor, fuel, power, reagent, liner costs, consumables, etc., from feasibility study
		Letter quote from vendors for most supplies; minimal historical data	Firm letter quote from chosen vendor for actual equipment selected
		Formal quotes for major consumables	
		Written proposal from local utility	Actual contract with local utility
Overall unit costs	Costs broken out by work area	Costs by area and element	Costs by area and element
	Maintenance costs are estimated as a percentage		
Operating costs shown yearly in total dollars and per unit produced	Operating costs shown yearly in dollars, per ton and per unit produced	Operating costs shown yearly in dollars, per ton and per unit produced	Operating costs shown yearly in dollars, per ton and per unit produced
Freight, smelting, and refining costs:	**Freight, smelting, and refining costs:**	**Freight, smelting, and refining costs:**	**Freight, smelting, and refining costs:**
Generic from manuals	Estimate from preliminary quotes	Detailed from submitted bids	Detailed from contract agreement
Administrative costs:	**Administrative costs:**	**Administrative costs:**	**Administrative costs:**
Generic	Estimates (some factoring)	Detailed	Detailed by zero-based bottom-up
Insurance:	**Insurance:**	**Insurance:**	**Insurance:**
Order-of-magnitude factor	Historical factor	Budget quotes from Owner	Firm quotes from selected insurers

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
Accuracy: Likely to be no better than ±33%	**Accuracy:** Typically +25% to −10%	**Accuracy:** Typically +15% to −5%	**Accuracy:** Better than +10% to −5%
MARKET PLAN AND MARKET POTENTIAL			
Marketability of product discussed	Market size and demand estimated	Marketing plan derived by third party Identification of potential buyers	
ECONOMIC EVALUATION			
Financial analysis:	**Financial analysis:**	**Financial analysis:**	**Financial analysis:**
To demonstrate broad viability	Inputs OK for reliable results	Final economic decision tool	Confirmation of feasibility study
Preliminary economic assessment	Assess key economic parameters	Full assessment of all parameters	Full assessment of all parameters
Royalties and taxes—ignored	Royalties and taxes—estimated	Royalties and taxes—Owner derived	Royalties and taxes—from Owner
Mineral prices from trade journals	Mineral prices set	Mineral prices set	Mineral prices set
Simple spot cash flow analysis	Cash flow analysis by Owner	Sophisticated cash flow analysis	Sophisticated cash flow analysis
	Unit cash cost and full cost derived	Unit cash cost and full cost derived	Unit cash cost and full cost derived
Preliminary pretax IRR	Pretax IRR	Pretax IRR	
		Full investigation of tax regime	Full investigation of tax regime
	Post-tax IRR	Post-tax IRR, ROI, and payback	Post-tax IRR and ROI
Preliminary NPV at 10% discount	NPV at Owner discount rate	NPV at Owner discount rate	NPV at Owner discount rate
No sensitivity analyses	One or two sensitivity analyses	Multiple sensitivity analyses	
RISK ASSESSMENT			
Risk characterization: General overview of the high level risks, e.g., resource, location, political, social, permits	**Risk evaluation:** Narrative on the key risks, sometimes including a preliminary fatal-flaw analysis	**Risk evaluation:** Formal Monte Carlo analysis of the totality of the project risks	**Risk evaluation:** Narrative of remaining project risks; mitigation plan for each risk

FIGURE 13.1 (Continued)

SCOPING EVALUATION	PREFEASIBILITY STUDY	FEASIBILITY STUDY	DEFINITIVE ESTIMATE
	Risk issues: Mitigation options to key risks identified and preliminarily costed List potential barriers to project	**Risk issues:** Risk issues now fully understood and to the largest extent, controlled Few unknowns remain, if any Informal fatal-flaw analysis	**Risk issues:** Essentially, no unknowns Fatal-flaw analysis requisite
BUSINESS CONSIDERATIONS			
State the potential value to Owner	Highlight any competitive advantage List rewards that project brings Owner Reconciliation of the project's returns with corporate objectives	Highlight any competitive advantage List rewards that project brings Owner Reconciliation of the project's returns with corporate objectives	
FINANCING			
	Preliminary discussions to establish availability of funding/insurance Foreign exchange strategy—discussed Preliminary currency risk assessment	Scoping study reviewing availability of financing and insurance monies Foreign exchange strategy—defined Currency exposure to nearest $5 million determined Owner's treasury department determines financing and interest payments during construction	Detailed third-party analysis of the politics and economics of financing Foreign exchange strategy—set Currency exposure to nearest $5 million determined Parameters for financial completion

Notes: CAPEX = capital expenditure; EA = environmental assessment; EIS = environmental impact statement; EPCM = engineering, procurement, and construction management; FOB = free on board; GA = general arrangement; GMP = guaranteed maximum price; HAZMAT = hazardous materials; HAZOP = hazard and operability; hp = horsepower; HVAC = heating, ventilation, and air conditioning; IRR = internal rate of return; IT = information technology; JORC = Joint Ore Reserves Committee; NI = National Instrument; NPV = net present value; OH&P = overhead and profit; P&ID = piping and instrumentation diagram; PEA = Preliminary Economic Assessment; QA/QC = quality assurance and quality control; RC = reverse circulation; ROI = return on investment; SEC = Securities and Exchange Commission; and T&M = time and materials.

This table lists typical minimum ingredients for the four report phases of a major greenfield project. Not all elements are needed on small projects. This is a guide, not a list of mandatory items for every project.

FIGURE 13.1 (Continued)

CHAPTER 14

Authorization for Expenditure

When you cannot measure what you are speaking about, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.
— Lord Kelvin, 1824–1907

OBJECTIVE

This chapter provides guidance for preparing the documents necessary for executive approval of a project so it can progress to the execution stage.

Detailed, frank, and high-quality documentation is crucial to successfully advance a worthy project opportunity. Paramount is that the submittal process as well as the documents align with board strategy, corporate goals, and stakeholder positions, and are consistent throughout with company policy.

DOCUMENTATION

Projects requiring capital expenditure necessitate formal approval from the appropriate level of management. The right information has be gathered and presented in a standard format that minimizes the burden of review on the approving entity.

Project development submittals for major organizations require the following components:

- Authorization for Expenditure (AFE) form
- Feasibility study (Chapter 7)
- Preliminary Project Execution Plan (PEP; Chapter 16)
- Operations readiness plan synopsis (Chapter 33)

AUTHORIZATION FOR EXPENDITURE FORM

The AFE form provides a standard format in which to document the key factors and analysis needed for corporate investment decisions.

Typical requirements for completion of the AFE form are contained in Figure 5.2. The mining company's own AFE preparation guidelines will provide specific direction for the nature and scope of the economic and risk analyses required to justify this particular project expenditure. The guidelines ensure that adequate rigor will be applied to the process so that only the best value-adding projects will be selected for capital allocation.

Typically, a company AFE form contains three primary sections:

1. Front page summary:
    - General project information
    - Classification of expenditures
    - Summary of project benefits and risks
    - Authorizing signatures
2. Qualitative analysis:
    - Background and context of project
    - Project description
    - Project costs
    - Alternate options
    - Contribution to strategic goals
    - Implementation plan
    - Summary and conclusions
3. Quantitative (economic) analysis:
    - Total project cost and economic evaluation results
    - Economic sensitivities
    - Effects of currency rates and local taxes or royalties

The preceding information should be directly available for précised extraction from the feasibility study and the preliminary PEP.

Full and proper completion of this part of the viability stage informs the board that all necessary documentation has been developed, the goals and objectives are clearly understood, and buy-in has been obtained from all major stakeholders.

FEASIBILITY STUDY

The feasibility study is the primary supporting document for the submission of the project development or construction AFE. A feasibility study produced in accordance with the process described in Chapter 7 not only outlines and fixes the project scope, but it also captures the project's contribution to corporate goals, including the following:

- Project benefits and economic return
- Return on capital, net present value (NPV), payback, and other key performance indicators
- Likely cost and schedule ranges, using stochastic modeling simulations

To put the project and its benefits in proper perspective for board and executive management review, the feasibility study should also clearly provide the following:

- A list of the key assumptions (and their overall accuracy) that were used to arrive at the feasibility study conclusions, including engineering, geological, developmental, marketing, scheduling, environmental, permitting, and social acceptance assumptions

- A discussion of potentially significant risk factors associated with the project, including scope, engineering, construction, technological, operational, market, geological, environmental, social, currency, political, and country risk
- Justification that the amount of contingency allotted is appropriate for the level of technical uncertainties still remaining over the life of the project
- Proof of independent and constructive challenges within the cost and schedule development process

PRELIMINARY PROJECT EXECUTION PLAN

The preliminary PEP covers all aspects of what is required to successfully deliver the project from this point forward. The plan lays out the sequence of activities that will complete the project and attain project objectives. Note: The adjective "preliminary" is inserted here because the PEP does not normally become final until *after* the project kickoff meeting has been held.

The PEP, as outlined in Chapter 16, firmly establishes the scope of work, defines responsibilities, and sets out project strategy in regard to selection and usage of outsource resources.

The preliminary PEP describes how the project will be organized, executed, managed, controlled, and delivered. The PEP is thus the basis for directing the engineering and construction stages of the project, should the project obtain approval.

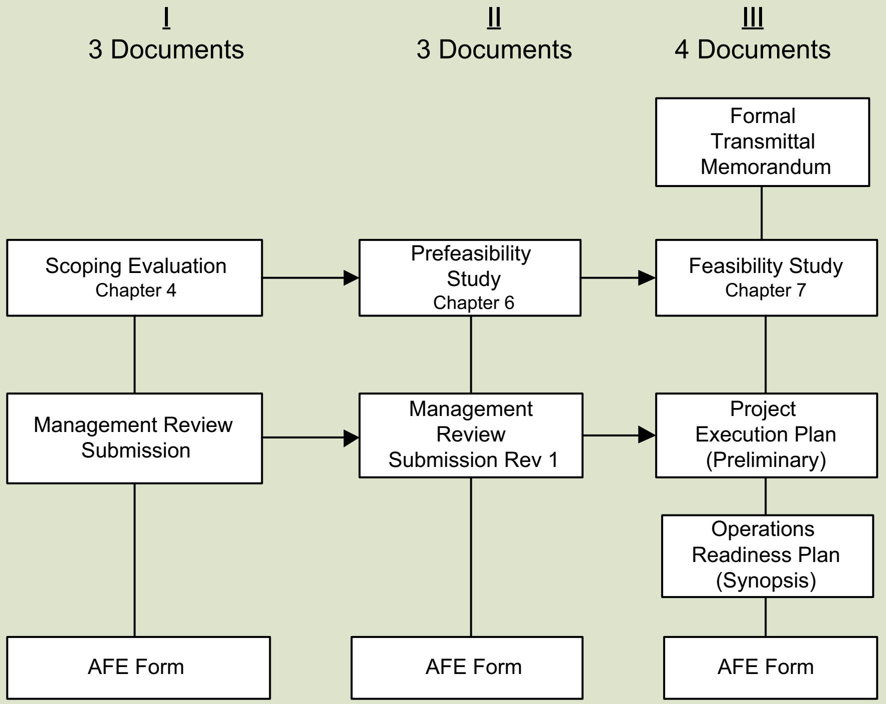
The preliminary PEP additionally includes all the pertinent analysis and information not included in the feasibility study yet necessary to back up the AFE.

OPERATIONS READINESS PLAN SYNOPSIS

An operations readiness plan (or a business readiness plan, in Newmont parlance) is a document that outlines the phasing of the project into the operating business, from the operations perspective. It describes for each operations department the project impact, including the general concepts behind what has to be done within the department to accommodate the project, how it will be done, in what sequence it will be done, and who will do it. The operations readiness plan synopsis, preliminary as it is at this early stage, is an excellent complement to a preliminary PEP for any grassroots project, but it is not always necessary for a brownfield situation.

The details of an operations readiness plan are provided in Chapter 33 as part of the project completion stage of this book.

Figure 14.1 illustrates how the Management Review Submission for the project AFE evolves over the stages following the scoping evaluation.



In following the project development process, there are several stages at which the appropriate level of management approval is required. If funds are required to further develop the project, an AFE form and the appropriate support documents must be prepared.

I. Management Review—Chapter 5

- Scoping study document
- Management Review Submission (preliminary project description)
- AFE form (specifically for the value of work in the next stage)

II. Management Review—Chapter 5

- Prefeasiblity study document
- Management Review Submission (a revision of the document prepared earlier with more definition)
- AFE form (specifically for the value of the work in the next stage)

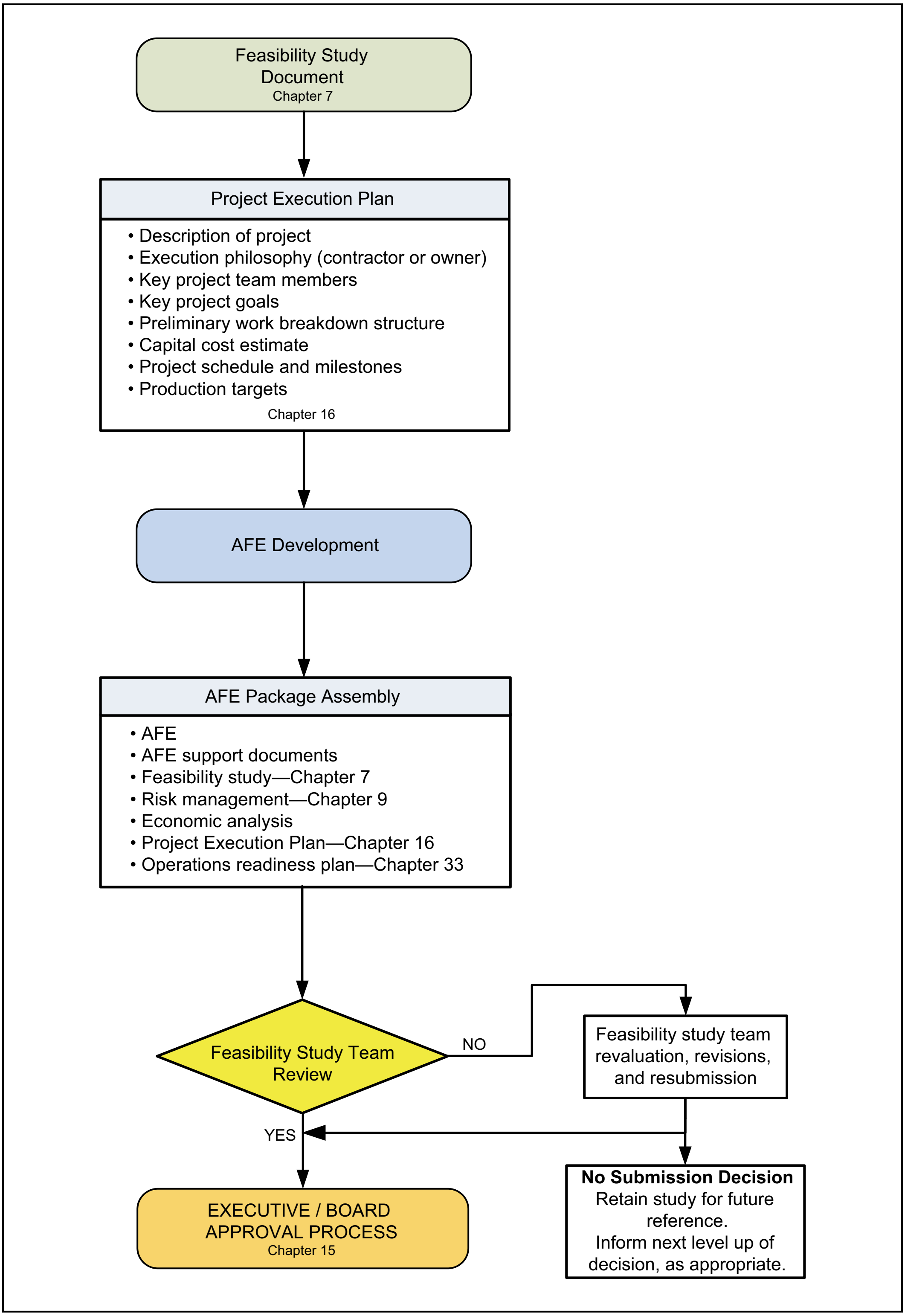
III. Executive / Board Decision—Chapter 15

- Formal Transmittal Memorandum as described in the AFE guidelines
- Feasibility study document
- Project Execution Plan (this document is an expansion of the management review submissions previously prepared and it explains the project and expectations in detail)
- Operations readiness plan (synopsis)
- AFE form (for the total project cost to bring the facility into operation)

FIGURE 14.1 AFE package documents

CHECKLIST 14.1 AUTHORIZATION FOR EXPENDITURE

No.	Item	Status	Date	Initials
1	Feasibility study—complete			
2	Preliminary PEP—completed			
3	Operations readiness plan synopsis—produced			
4	AFE guidelines—reviewed			
5	AFE backup material—prepared			
	A. General project background information—provided			
	B. Concise project description—completed			
	C. Project context and feasibility conclusions—documented			
	D. Level 3 development schedule—produced			
	E. Project capital expenditure—derived			
	F. Future operations production costs—prepared			
	G. Economic evaluations (pretax IRR and NPV)—completed			
	H. Alternatives analyzed			
	I. Value drivers identified			
	J. Key assumptions—documented			
	K. Benefits and risks—summarized			
	L. Contribution of project benefits and deliverables to Owner's strategic objectives—identified			
6	Project execution scope of work, going forward—documented			
7	Planned cash flow expenditures—presented			
8	Proof of independent review—submitted			
9	Recommendation for project execution—determined			
10	Recommendation for project management of next stage—resolved			
11	AFE package for project execution—prepared			
	A. AFE form—signed and submitted			



FLOWCHART 14.1 Authorization for Expenditure

CHAPTER 15

Executive and Board Decision

> *Never be diverted either by what you would wish to believe or by what you think would have beneficial effects if it were believed. Look only at facts.*
> *— Bertrand Russell, 1872–1970*

OBJECTIVE

As outlined in Chapters 5 and 14, all major capital expenditure projects require some level of management review and approval. The objective of this chapter is to provide insight into the approval process with an emphasis on those projects that require the approval of the corporate executive or Board of Directors.

APPROVAL LEVELS

The approval of company senior management and the board will typically be required at each major stage throughout a project's development life. These levels of approval are normally defined within a company's policies and procedures manual under either *delegation of responsibility* or *Authorization for Expenditure (AFE)* protocols.

Also, at each operations unit and within the company's pertinent business division, it is likely that supplemental approvals will be preliminarily required. The AFE and supporting documents (discussed in Chapter 14) are submitted for review and approval through the Owner's management chain up to the management level required by company policy.

For most corporations, the monetary value of the project determines the required level of management approval. All major projects with significant expenditures require approval by, at least, the company president or CEO. AFEs for outlays in excess of the signature authority of the CEO will require approval of the Board of Directors.

AFEs Requiring CEO or Board Approval

Project development AFEs requiring president, CEO, or board decision would customarily first be approved by the appropriate business division president and transmitted to the company president or CEO only after all analyses have been reviewed by the company's treasurer, controller, and CFO. The business division president is typically the person who would submit the AFE and supporting documentation to the president, CEO, or board.

The monetary threshold will likely dictate using a formal transmittal memorandum requesting action on the project. Details of the supporting documents to the AFE were previously provided in Chapter 14. The essential components of the AFE transmittal memorandum are described in the following paragraphs.

The **executive summary** highlights in a logical and concise manner the key considerations for recommending the action, that is, the costs, returns, merits, and notable risks, as well as schedule milestones and an outline of the preliminary Project Execution Plan. While the final rendition of this executive summary is generally drafted by the business division corporate staff, input and the initial draft normally have to come from the feasibility study project team.

The **capital expenditure plan** is a tabular outline of the expected significant expenditures over the life of the project from development through closure and reclamation.

The **project schedule** shows all the key aspects of the project timing (typically to a Level 1 detail; Level 2 would not be inappropriate). Critical components, such as initiation and completion of permitting, engineering, construction, commissioning, and operational ramp-up are requisite.

The **production schedule** shows the timing and level of new or expanded production from start-up through full production and generally extends to the end of mine life and property closure. All key milestones during the ramp-up of production are clearly shown, along with any critical construction dates that must be met to achieve the desired production dates.

Note: Whenever board approval is required, the board secretary's requisite notification period for inclusion on the board meeting agenda needs to be recognized.

YES OR NO DECISION

Following receipt of the formal written submittal, and generally after a verbal presentation by the project proponents, the CEO and/or Board of Directors will make a recorded decision of yes (go forward with the project) or no (which could mean either go back and reconstitute the project or abandon the project).

FILING AND SAFEKEEPING

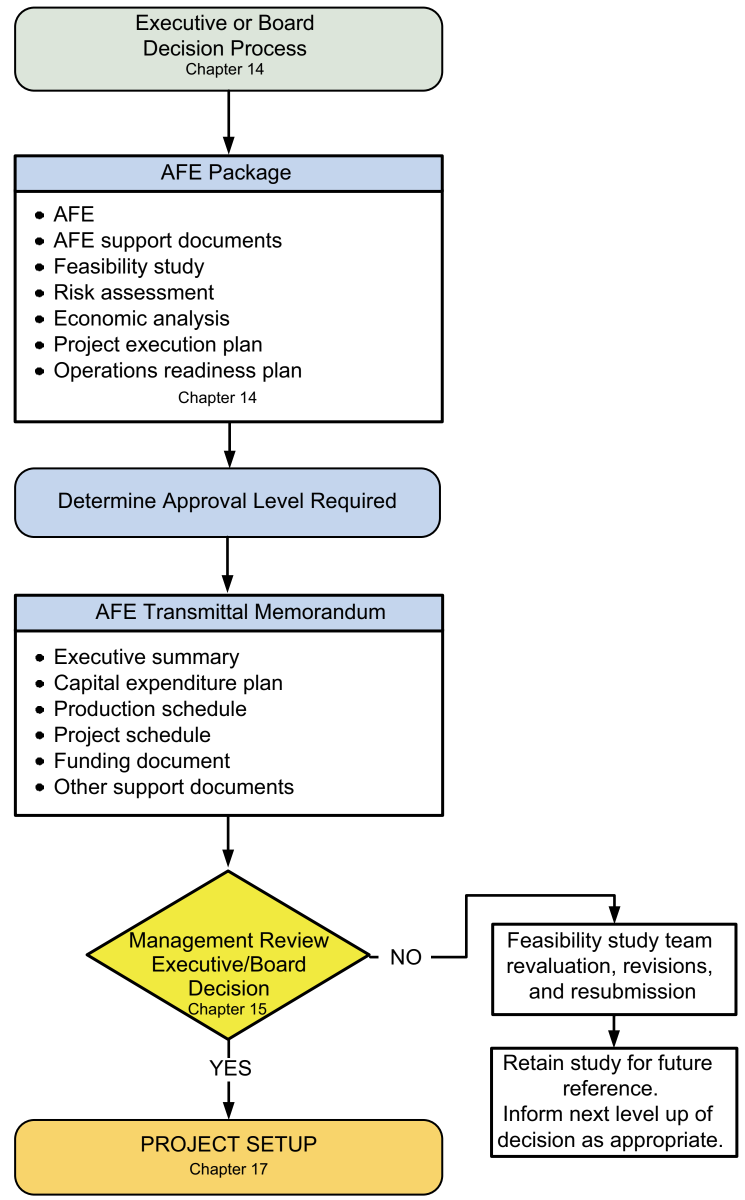
After board review, the AFE will be returned to the originating business division with the board action appropriately noted. An approved AFE needs to be kept in a secure place. The originating business division (usually the division controller or its designee) is responsible for maintaining appropriate records of approved AFEs and tracking project performance against the AFE.

AUDIT

The company controller and/or company auditors (possibly using representatives of a specialist project management group) will, as a rule, visit and audit the project at set times throughout the project life to ensure that it is adhering to the approved AFE and its conditions.

CHECKLIST 15.1 EXECUTIVE AND BOARD DECISION

No.	Item	Status	Date	Initials
1	AFE package—prepared			
	A. Feasibility study—complete			
	B. Preliminary Project Execution Plan—complete			
	C. Operations readiness plan synopsis—complete			
2	Owner's organization review level—determined			
3	Key project stakeholders—identified			
4	AFE package and supporting documents—submitted			
	A. Project memorandum—prepared			
	B. Executive summary—included			
	C. Capital budget expenditure summary—included			
	D. Project execution schedule—included			
	E. Future operations production schedule—included			
	F. Economic analysis —produced			
	G. Project assumptions, risks, and value drivers—documented			
	H. Key project benefits, deliverables, and goals—highlighted			
5	Originating team approval—submitted			
6	Owner's organization—initial senior management level review approval			
7	Owner's president and CEO—executive approval			
8	Owner's Board of Directors—final approval			
9	Original AFE and approvals—filed with controller and project team			



FLOWCHART 15.1 Executive and board decision

Planning Stage

CHAPTER 16

Project Execution Plan

> *If you don't know where you are going, you'll likely end up someplace else.*
> *— Yogi Berra, May 1947*

OBJECTIVE

This chapter provides guidance for preparation of the Project Execution Plan (PEP), the how-to companion document to the feasibility study. The feasibility study is necessary for obtaining management approval of a project before embarking on the execution stage. The PEP defines the approach for delivery of the project. It states the project objectives, delineates scope, evaluates each area for sufficiency, identifies key roles and responsibilities, and then outlines the course ahead for the project team to follow.

The document delivered for board review and approval must align with the goals of the board, company leadership, and project stakeholders. The aim is to provide clarity for the project team and direction for the way forward. It used to be that the PEP was not prepared until after board authorization. But today, mining organizations are correctly demanding to see a preliminary PEP before project approval. Thus, this chapter is placed ahead of the project setup chapter.

WHAT IS A PROJECT EXECUTION PLAN?

The PEP is defined by the authors as "the documented description of the logic network that coordinates the sequence of activities necessary to engineer and execute a project in the field as well as the responsibilities and strategy to timely meet project objectives relating to those activities." After establishing scope, the PEP prescribes project strategy, particularly with regard to selection and usage of internal and outsource resources.

The PEP is the means by which the project team sets the success criteria for the Owner for delivery and execution of the project. The PEP develops project-specific commitment goals, strategies, methodologies, and processes to achieve the fit-for-purpose project deliverables within the limitations imposed by the stakeholders, all based on the approved design criteria. The PEP is an organizational tool to identify the resources to achieve the desired outcome and to communicate all of this to the project stakeholders.

The PEP is one of three basic documents needed on any project that requires formal management approval of capital expenditure for development and/or construction. The other two documents are a bankable feasibility study (see Chapter 7) and an operations readiness plan (see Chapter 33).

SCOPE

Beyond providing a project description for management review, the PEP needs to outline the primary management and control parameters for the execution stages of engineering, construction, commissioning, start-up, and turnover of the proposed project. Specifically, the PEP needs to convey the following:

1. **Confidence** that there will be **no surprises** for the investors during project execution
2. **Clear direction** for the project team throughout project execution
3. **Full transparency** of project performance against budget and schedule progress
4. Establishment of an **early warning** system for risks
5. Installation of a robust project **control** system
6. Usage of project management **best practices**, calibrated with the latest pertinent experiences and innovation from throughout the mining project arena
7. Owner **management capacity augmentation** during the project undertakings
8. **Investment return maximization** via the application of project value optimization tools throughout the engineering and delivery phases

WHAT SUCCESS SHOULD LOOK LIKE

In setting the requirements for the PEP, we should again reflect on what success looks like. (See also Chapter 1.)

- Costs—both capital expenditures (CAPEX) and unit operating costs—are at or below feasibility study predictions.
- Project completion is on or ahead of schedule.
- The constructed facility is capable of sustaining design annual production and quality following operations startup.
- If a brownfield site, it has the least possible interference with ongoing operations.
- The board is comfortable with the plan and willing to approve the CAPEX.
- Everyone is clear on project team composition and in accord on a plan that creates requisite team strength.
- The engineering, procurement, and construction management (EPCM) partnership is without conflict, and it builds in-house Owner skills.
- No surprises occur during project execution.
- Engineering and construction are conducted safely with zero lost time accidents (LTAs) and citations.
- There is compliance with company and international environmental standards and regulations.
- Social acceptance has been obtained from stakeholders and neighborhood communities.
- The completed project invokes admiration and pride in and outside the company.

While all the elements listed here are valid for most projects, *the three accepted core success criteria* for every project are the first three items in the previous list: achievement of the cost, scheduling, and operability requirements. These core components act as a three-legged stool underpinning project success. The project manager must be vigilant to not trade off one facet to accommodate the other two. Success requires all three legs to be in place.

To put the preceding in a comparative quantitative context, the authors offer five "threshold of failure" factors that a project should not exceed in order to be successful. These factors are rated in terms of actual project outcome judged against industry averages.

Factors	Failure Threshold
Cost deviation ratio: Final project cost* versus funds authorized	>25%
Cost competiveness ratio: Total spend† versus similar scope project	>25%
Execution schedule slip: Engineering start‡ to mechanically complete	>25%
Schedule competitiveness ratio: Duration versus similar scope project	>50%
Production operability: Actual versus planned output at end of Year 1	<75%

* Escalated dollars; † constant dollars; ‡ detail engineering.

PRELIMINARY PROJECT EXECUTION PLAN OUTLINE

The purpose of a PEP is to document the sequence of activities necessary to meet project objectives. It defines responsibilities and sets out the project strategy for the selection and usage of resources. The PEP is the formal interface and integration management plan for coordinating, controlling, executing, and delivering the complete project scope, including the following:

- The Owner's self-perform scope
- Any scope being performed by an EPCM firm
- Any scope being performed by governmental entities, specialists, and/or consultants
- The scope being assigned for execution to construction contractors
- The scope being assigned to commissioning experts

The Owner's self-perform scope, the EPCM firm's scope, and on occasion the construction contractor's scope are often presented to the project management team prior to project execution in "mini" execution plans for each entity. This is good from an informational gathering viewpoint, but these documents cannot be allowed to serve the project going forward as separate stand-alone documents. Existing separately they will cause mayhem during the execution stage. It is the project manager's task to combine any such documents into one over-arching project execution plan (i.e., the PEP), and then to obtain commitment from each of the contributing entities (Owner, EPCM firm, and construction contractor) that they have each bought into this one PEP (be it preliminary at this juncture or final at project kickoff), and that they each will follow its path, *not* their previously submitted individual execution plans.

The preliminary PEP document accompanies the Authorization for Expenditure (AFE) submittal to the board. The documents prepared earlier for management review of the project in the scoping evaluation and the prefeasibility study phases are expanded and refined with the additional information developed during the feasibility study. These expanded documents are combined to become the preliminary PEP, which in turn becomes the basis for the final PEP that is used to control the engineering and construction stages of the project should the project obtain approval. (See Chapter 17.) Figure 14.1 illustrates how the Management Review Submission for the project development or construction AFE evolves through the project stages after the scoping evaluation.

If not already established within the feasibility study, the engineering and construction contracting strategy is set within the preliminary PEP, specifically,

- Selection of an appropriate delivery model (e.g., design-build; owner integrated; engineering, procurement, and construction [EPC]; or EPCM), taking into consideration Owner capability and project complexity;
- Decision on which project value steps should be done internally and which externally;
- Resolution of who is the natural owner of the various project risks (are there mechanisms to transfer or share risk?); and
- Determination on how best to align objectives between Owner and contractor.

The preliminary PEP contains all the elements that describe how the project is to be organized, managed, controlled, and delivered going forward, after approval. The PEP lays out in written form how the Owner's objectives for the project are going to be met. Here are the necessary elements.

- Project description: Summary description of the project
- Definitive scope of work: Remaining project scope, going forward
- Project goals: Key cost, schedule and performance goals, with corporate objectives
- Project governance: Control framework and authority levels to instill board support
- Method of project delivery: Owner, EPC, EPCM, or a combination
- Project manager: Identification of the person to lead the project
- Project team organization: Description of the project organization structure
- Project controls: Control processes, systems, and metrics
- Contracts management: Contract types to be employed and their management
- Quality management: Establishment of quality assurance and quality control (QA/QC) protocols
- Project criteria: Documentation of all crucial project criteria
- Work breakdown structure (WBS): A hierarchical decomposition of the project work to be executed
- Owner's technical and development support: Outline of Owner's project contribution
- Engineering and design requirements: Specifications, standards, and procedures
- Procurement: Procurement strategy and control
- Construction management: How the facilities will actually be built
- Commissioning and start-up: Project completion overlap with operations start-up
- Project closeout: Turnover process to operations, including the specified deliverables
- Health and safety: Program to ensure zero harm for all project individuals
- Environmental impact, social acceptance, and sustainability plan: Community protection programs
- Security: Strategy for the protection of project people and assets
- Risk management: Assessment and planned mitigation of the project risks
- Human resources (HR): Strategy for identifying and obtaining the requisite skills
- Training: Summary of key dates and training needs for operations readiness
- Administrative procedures: Support functions for project management
- Deliverables verification plan: Deliverables list, Owner approval times, checks, etc.
- Information technology: Provision of data and voice access to the project
- Communications plan: Procedures for interfacing with all stakeholders
- Reporting requirements: Timing and contents of the formal reports
- Project reviews: Assurance that the project business case remains robust

The preceding list of elements is similar to those for the Management Review Submission in Chapter 5. The differences reflect the different purposes served. The PEP captures the sequence of activities required to engineer and execute a project in the field as well as the responsibilities and strategy relating to those activities.

The PEP has to be tagged as preliminary at the time of project approval because several key features cannot be decided until after approval is granted (e.g., selection of project deliverer or award of construction contract). As such, the project team should expect to update the PEP periodically as the project progresses. The features within each key element of the PEP are highlighted in the sections that follow.

Project Description

The project description is a concise summary of the project, its location, type, size, process flow diagram, plant capacity, and so forth. The pertinent background that led to the creation of the project is included here. A synopsis of the status of any prior studies is provided.

Definitive Scope of Work

The project manager's understanding of the remaining project scope going forward, based on the Owner's latest directives, is precisely documented to ensure that all parties are in agreement on the exact scope of the work ahead. Battery limits are meticulously stated. The necessity for any mine development, the process plant, infrastructure, delivery of support services, installation of utilities, land acquisitions, community development, and/or resettlement programs all have to be addressed and either included within the scope or excluded as being beyond the battery limits. There must be no doubt as to scope.

The project scope needs to include a high-level summary of the project's capital budget. Staying on budget will be the board's focus; capital cost is thus a key component of scope. The included facilities are each identified by the WBS. Operations readiness activities are mostly excluded from the PEP (except for some cross-over items such as Owner's development support and operations personnel training) as the operations readiness activities are covered in the separate operations readiness plan (see Chapter 33 for details).

Project Goals

The business case that justifies the project purpose is conveyed here within the PEP. The key goals and how they align with corporate objectives are set down:

- The one-sentence, comprehensive, official project goal statement (see Chapter 17)
- Safety goal—zero incidents
- Production output (e.g., ounces of gold per year)
- Unit operating costs
- Capital cost
- Key milestone dates
- Environmental goal—zero on-site pollution incidents
- Social and sustainability goal—zero harm

These critical success factors have to be clearly communicated. Priorities, if there are any between the projects key goals, need to be stated.

Additional items that should be provided within the PEP include

- The schedule for operations start-up, showing ramp-up time to achieve full production;
- Summary economic analysis; and
- Cost estimate for the project management function.

The PEP is the first step in determining how best to align these goals and objectives for the Owner and the contractor, for example, through partnering, compensation, incentives or penalty clauses, and warranties.

Project Governance

Establishment of a project governance framework creates confidence for the board on the status of the project regarding the functional criteria of technical appropriateness, execution readiness, market health, political realities, and social impacts, as well as the project's maturity criteria of design definition, design optimization, organizational readiness, risk identification, risk mitigation planning, and resourcing.

Project governance sets the timing of key decisions for company executives and the board and helps accomplish project buy-in by the key stakeholders. With the establishment of project governance comes the setting of the levels of authority. The monetary limits for the levels of authority need to be documented and published in chart form within the PEP along with the individuals' names and titles so there is no question as to who can approve what.

Method of Project Delivery

Selection of the appropriate project delivery model (e.g., design-build, owner integrated, EPC, EPCM, or hybrid) is a key component of the PEP. The delivery model must take into consideration the company's internal capability, leadership preferences, market conditions, and project complexity.

- If the project deliverer is to be an outsourced entity, (EPC, EPCM, or a combination), then the PEP should establish the process for determining the specific deliverer.
- The PEP should also state which project value chain steps should be done internally and which ones are better executed by external contractor(s).
- The PEP should outline the contracting strategy and specify the drivers for prime contractor selection.

For most junior mining companies with limited internal resources, a sole-source EPCM arrangement with the engineer of the feasibility study taking on both engineering and construction management of contractors, but with a separate specialist subcontractor for the commissioning phase, is generally the most sensible arrangement. If the project delivery is to be an EPCM (or an EPC) firm, how the interface of this contractor is to be handled with project management and the Owner needs to be addressed within the PEP. There has to be an agreed framework that works for all parties. The role of the Owner needs to be understood by all.

Project Manager

The person who will lead the project execution effort has to be identified, along with the position's responsibilities and accountabilities. The person to whom the project manager reports should be stated, along with who reports to the project manager.

Project Team Organization

The PEP defines the structure, size, roles, and responsibilities of the project team for the project phases from end of the feasibility study through commissioning. It provides charts and a description of the project organization structure. A RASCI (responsible, accountable, supportive, consulted, informed) chart, such as in Figure 18.5, should be included, as much for the discipline of creating it as for the chart being a useful tool during actual project execution.

Items to be addressed within the PEP when defining the team organization include the following:

- Determination of the project management composition, for example, Owner in-house, Owner-outsourced, EPCM outsourced, or a combination
- Definition of the size, roles, and responsibilities of the Owner's team
- Identification of the responsible project management entity (team and leader) for each of the upcoming stages, including the selection process for any outside assistance
- Names and titles of key project personnel
- Identification of all third-party consultants, their roles, and persons to whom they report
- Project team organization chart (or matrix function chart) showing relationships
- Owner's organizational chart along with the EPCM and prime construction contractor(s) organization charts, when they become available
- Project organizational chart showing relationships between project stakeholders, along with roles and responsibilities
- Personnel list headcount of the project team (along with a labor-hour estimate)
- Job descriptions for the key team members, including qualification requirements
- The delegation of authority for decisions and approvals for differing levels of expenditure
- Outline of the up-skill mechanisms to be used to rapidly bring new hires up to speed
- Summary of employee incentive systems installed to attract and retain key positions

Project Controls

Installation of the project control processes, systems, and metrics ensures transparency of critical information and enables focus on the areas needing action and intervention. The project controls team is responsible for the accurate and timely reporting of the cost and schedule status of the project, and for the management of change.

Project control components to be addressed within the PEP include the following:

- Progress and performance measurement. This requires selection of an appropriate work measurement and cost and schedule reporting methodology, that is, earned value management (EVM).
- Project scope control policy
- Cost management and control
  - Estimating process
  - Cost reporting
  - Budget allocation and maintenance
- Schedule control
  - Basis of schedule
  - Planning, scheduling, and duration measurement

    - Project master schedule
      - Milestones
      - Critical path
- Change management system and plan
  - Trend identification and forecasting
  - Change notification process (potential deviation notices [PDNs])
  - Change order control
  - Major scope change control and approval procedure
  - Contingency drawdown management
  - Escalation management process
  - Handling of management reserve (if appropriate)
- Accounting control
- Invoicing and payment
- Interface with company accounting and auditing departments

Contracts Management

The procedures for managing contracts has to be addressed within the PEP, along with an outline of the type of contracts that the project expects to employ for project execution, and for which parties the different contract types will be used. The contracts management plan has to address these issues:

- How contract terms are to be enforced (who is handling contracts administration?)
- Process for handling contract changes
- Subcontracting approach
- Management of third parties
- Warranty and guarantee criteria

Quality Management

The key components of the quality management plan are laid out within the PEP. The quality management plan addresses all phases of the project from basic design engineering through to turnover of the project to operations. Quality management is not only the process to check the engineering, but it is also used to guide every supplier and contractor engaged to work on the project. The PEP establishes the QA strategy and QC procedures for each phase of the project. The constructors and vendors will be required to adhere to this set of standards.

Project Criteria

A list of crucial project criteria is included within the PEP. The specific project assumptions that establish the scope and the battery limits, as well as the quality and operational requirements, need to be documented. Any project constraints need to be identified and highlighted. The PEP identifies and incorporates all Owner project-specific obligations; it adheres to the Owner's policies and standards as well as to all statutory and regulatory requirements. Product specifications and/or product quality standards requirements need to be stated. A list of the project's approved definitions and acronyms should also be included here.

Work Breakdown Structure

The project WBS is the primary mechanism for organizing the management of project data and work. It is important enough to warrant its own section within the PEP. A WBS is needed at this early stage to establish and fit the major cost elements with the system that will be used by accounting control in future variance analysis reconciliations. A preliminary WBS is OK, but a final one is better. The same WBS needs to be maintained throughout project life, to allow meaningful assessment of differences to the control budget. (See Chapter 11.)

Owner's Technical and Developmental Support

The components of the Owner's expected technical and mine development support need to be outlined. These would likely include items such as

- Geology support work to the mine development;
- Resource and reserve quantifications;
- Mine engineering provision;
- Mine development (prestrip, shaft sinking, etc.);
- Geometallurgy support and metallurgical test work;
- Process development;
- Operating facility cost input;
- Sustaining capital requirements;
- Project energy strategy; and
- Water supply and water rights: site groundwater and surface water flow management.

Engineering and Design Requirements

The PEP states the level of basic engineering already completed, along with the expected date for transition from basic to detail engineering. An outline of the engineering management plan going forward is included in the PEP that describes the engineering protocols and design procedures, and designates the applicable codes, standards, and technical specifications that will be used throughout project execution. This plan describes the design basis document (criteria and assumptions), technology packages to be used, quality control procedures to be employed, and design reviews to be conducted. It must also state the timing for hazard and operability (HAZOP) reviews.

Engineering policies with respect to standardization, substitution of materials, and the like, have to be stated within the PEP. A decision needs to be made regarding any requirement for ISO 9001 and/or ISO 14001 certification requirements. If an EPCM is to be contracted, then identification of the engineering office location(s) and any facility or space requirements (home and field), including privacy space allowances for visitors, should be stated. The expected field-engineering role of the engineer should be specifically spelled out.

Note: Generally, when working with an EPCM contractor, the engineering and construction procedures adopted for the project will be those of the EPCM, modified to complement and satisfy the project procedures outlined previously. Existing company standards must be honored when project procedures are being prepared, though it is acceptable to modify a standard to suit the specific project needs, as long as the underlying premise behind the company standard is not violated.

Procurement

The strategy and control measures to be used for procurement in the execution phase of the project are laid down within the PEP. A high-level procurement road map is created, providing major package-definition and procurement timing that embraces these items:

- Provision of purchasing procedures
- Contracts administration (if not covered elsewhere)
- Sourcing methods (bidding process)
- Identification of long lead-time and critical items
- Expediting and inspection methods
- Supplier quality surveillance
- Logistics plan
- Materials management plan, including site control services
- Spare parts policy

Additional procurement issues to be covered by the PEP need to include the following:

- The level of involvement of the Owner's procurement group
- Decision on the number of contracts that the work scope should be split into for execution of the project
- Summary of the content for the construction contract work packages
- Determination of the optimal split of scope between the available contractors
- Description of the procurement approach to be used, for example, purchase order awards to be driven by the total value basis to the Owner (lowest cost to the Owner over the life of the goods) rather than the lowest transaction cost (least amount of money paid out when goods are purchased)
- Determination of which suppliers should be invited.
- Criteria for evaluating suppliers
- Methods for obtaining the active involvement of key suppliers
- Identification of any pertinent supplier alliance agreements
- Site contractor(s) procurement role
- Bulk materials procurement strategy

Construction Management

The PEP has to include a high-level description of the construction contractor management approach. This will depend somewhat on the delivery decision: EPCM, single-source EPC, design-build, or other. The following are issues that need to be covered within the PEP:

- The construction strategy, and any phase sequencing that will underpin the work plan
- Construction contractor selection strategy; how many and who should be invited
- Criteria for contractor evaluation
- Outline of the contractor selection approach, that is, description of the due diligence process, performance assessment, and compliance assessment approach
- Construction roles and responsibilities
- Labor resources availability. A realistic assessment of the likely sources for labor, along with the transportation and any training strategies possibly needed to ensure that the

requisite skills will be on-site. Any labor "pinch points" need to be identified (trades? supervisors?).
- Subcontracting approach
- Roles and responsibilities
- Field construction control
- Labor relations and industrial relations (including open shop vs. union shop impacts)
- Constructor's site safety plan
- Outline of the level of security needed on-site and how it will be achieved

The interface of the prime contractor with project management, Owner, and EPCM needs to be addressed within the PEP. It will evolve somewhat over time, but there should be an agreed-on starting strategy.

Commissioning and Start-Up

One of the key items to capture in the PEP is the initial operations production schedule showing the timing and overlap of precommissioning, commissioning, and production start-up with construction completion. Critical construction dates need to mesh with the precommissioning, start-up, and ramp-up schedules to facilitate a successful facility handover to operations. To achieve an efficient transition from project to operations requires detailed planning and organization. Planning needs to begin early in the detail engineering phase, as the commissioning activities influence the overall engineering.

The necessary tasks of precommissioning and commissioning have to be documented within the PEP, as do all of the project's requisite performance tests. The expected date for initiation of precommissioning has to be stated, but the facility handover is the date to be highlighted; that is, the transfer of care, custody, and control to the Owner, which is the date that triggers the official commissioning phase. The expected roles and responsibilities for project management, Owner, constructors, and EPCM as they interface with the specialist commissioning team need to be portrayed.

The pertinent definitions of *completion* (e.g., mechanical completion, practical completion, substantial completion, or whatever terms the project elects to use) need to be defined within the PEP, without ambiguity, so that everyone knows what constitutes project completion. The accounting rules that will govern the trigger of the commercial production decision need to be obtained from the Owner's treasury department and summarized in the PEP.

Project Closeout

The turnover requirements at project closeout have to be documented within the PEP. The process for addressing deficiencies, punch list items, and the like, also have to be captured. Project closeout is essentially a mini-project in itself. It needs a plan, a schedule, and its own responsibility matrix. All relevant documents that are to be delivered to the Owner have to be specified in the PEP.

Health and Safety

The project-specific site safety plan and contractor safety requirements are part of the PEP. The standards to be followed have to be cited, for example, all mandated Owner safety rules and policies. Minimum requirements include

- Site-specific safety program,
- Safety induction content,
- Worker health management,
- Drug and alcohol screening,
- Incident management, and
- Emergency response plan and/or crisis management plan.

Environmental Impact, Social Acceptance, and Sustainability Plan

In order to have a credible construction plan, the PEP should include the following:

- Environmental management plan
  - List of required permits, licenses, and statutory approvals
  - Checklist for adherence to permit conditions and permit dates
  - Permit support requirements, including analysis of the regulatory state of affairs
  - Site hazardous waste issues and management
  - Site interface meetings protocol for the appointed project environmental liaison, project management, and the site contractors
- Social acceptance and sustainability constraints management
  - Social responsibility and community engagement plan
- How indigenous peoples' issues are to be handled
- Government and regulatory agency relations management

Security

Regarding security, the PEP needs to address the strategy and plans for protecting workers and assets on-site, the control of entry to and from the site, and the procedures for loss prevention.

Risk Management

The PEP needs to ascertain that a risk register exists and that a risk assessment has been conducted. Resolution of who is the natural owner of the various project cost, performance, and schedule risks, and whether mechanisms exist to transfer or share risk can await selection of the project deliverer and the major site construction contractor(s). There needs to be a mitigation response for each of the top identified risks. Any gaps that exist in the risk management plan must be identified and a path specified for how they will be addressed.

A necessary component of a risk management plan is the exit strategy in case the risk tolerance threshold is exceeded. For legitimate political reasons, the Owner may not wish the exit strategy to be recorded within the pages of the PEP, but the risk-tolerance levels need to be set, and the project manager and the key project staff must be aware of those limits. An often overlooked item is the counterpart to the risk management plan, that is, an opportunities development plan. Many of the world's top project managers assign resources at the front end of the execution stage to seek out, capture, and exploit opportunities that are available or materialize within a project. This is a smart strategy and worth copying.

Human Resources

The strategy for obtaining the requisite skills to execute the project needs to be addressed within the PEP. The level of reliance on external contractors, hiring, training of locals, and so forth, needs to be stated and justified as to practicality. The project cannot get built without people, and not just any people—it requires qualified people. The results of labor-availability surveys and skills-assessment investigations need to be included to support the HR strategy. Depending on location, there may need to be a salary and wage survey. These surveys are usually undertaken by third parties.

Training

Any need for training of project workers has to be stated in the PEP, particularly if commitments have been made regarding the percentages of local hires and/or indigenous peoples. Expectations of any training by on-site contractors should be stated. While the details of training future operations employees is captured within the operations readiness plan rather than the PEP, the expected timing for the new employee training and orientation needs to be shown within the PEP, because this affects construction completion and turnover. (Key operations personnel will be a required component of the precommissioning, commissioning, and start-up activities.)

Administrative Procedures

Detailed project procedures have to be established to ensure that the project is executed and controlled to meet the stated objectives. All of these administrative procedures need to be in place and functioning by the end of the kickoff stage:

- Project procedures manual (PPM) outline and list of key components
- Compilation of project policies with respect to business ethics, employment, purchasing, contracting, safety, environment, and so forth
- Establishment of sufficient office space, along with equipment and support services
- List of office equipment, hardware, and software
- Document management and document control procedures
- Project accounting procedures (invoice submittal requirements and payment policies)
- Expenditure authorization and monetary approval protocols
- Owner's cost administration
- Travel and general office spending protocols
- Tax guidance protocols
- Banking plan (cash management and banking policies)
- Insurance requirements for the work, including a trigger mechanism to ensure that all aspects of the project are adequately insured from Day 1
- Financing proposal and/or options (if appropriate)
- Identification of legal support resources

Deliverables Verification Plan

The project deliverables must be clearly stated within the PEP:

- Drawings, models, value engineering trade-off studies and reports
- Physical project facilities to be constructed
- Certifications, warranties, and the like

Regarding the engineering documents, the deliverables verification plan specifies the approval times for Owners, the checks required before deliverable transmittal, the items that need professional engineer (PE) stamps, and so on.

Information Technology

The PEP needs to contain an outline of the project information technology and data systems. The focus within the PEP is how to provide and maintain data and voice access on-site. Technical support should be addressed. The major hardware and software requirements should be listed, as well as the key knowledge management and information systems.

Communications Plan

The project communications plan, an important component of the PEP, should contain all the necessary procedures for interfacing with stakeholder parties affected by the project. The communications plan should include the following:

- The communications matrix distribution list contains all of the project participants and stakeholders, including the Owner, engineer, contractors, subcontractors, consultants, regulatory authorities, utility providers, medical support, and local law enforcement (see Figure 17.4).
- The coordination procedure identifies each party's role and contact information (telephone numbers, fax, e-mail, address, etc.) and outlines each party's involvement relative to the project.
- Project meetings protocols list the expected substance of the formal communication sessions and project review meetings that need to take place at regularly scheduled times, for example:
  - Daily line-up meetings,
  - Weekly look-ahead meetings,
  - Monthly project review meetings, and
  - Senior management updates (typically every 3 to 6 months).
- Owner meetings expectations lay out the Owner's communication needs:
  - When will meetings occur?
  - What are the critical milestone dates when the Owner needs information?
  - When and how will issues between the Owner and contractors be dealt with?
  - In a crisis, how will the project manager communicate with the Owner?
  - How will communications be documented?
- The communications filing system is designated.
- Site requirements for bulletin board postings must be in accord with local, state, and federal laws, union obligations, and any licensing conditions.

Reporting Requirements

A key element for a successful project management effort is the early establishment of an effective, timely project-reporting system. From a control viewpoint, this is the information feedback system loop. Reports serve as cornerstones in the control, communication, and review processes. The frequency, format, and contents of the project reports are established by the end of the kickoff stage, along with the distribution list. The reports inform stakeholders on project status and progress:

- Weekly activity "flash" reports
- Monthly status and progress reports
- Periodic project reviews (every 6 to 12 months)

Project Reviews

The PEP sets a timeline of when and how cost and schedule reviews and audits are conducted and presented to senior management. Methods are set to establish their levels of accuracy. A calendar of reviews is developed. Review presentations provide assurance to management that the project business case remains robust (or not, as the case may be). Beyond the management review, there are a multitude of other project reviews that need to be addressed:

- Design reviews
- Estimate reviews
- Schedule reviews
- Constructability reviews
- Operability and maintenance reviews
- HAZOP reviews
- Risk reviews
- Health, safety, environmental impact, and sustainability reviews
- Quality audits
- Project audits
- Dashboards

The timing of the engineering design reviews is particularly important to set, generally at around 25% complete initially, and again at about 70% complete. The subject matters of any third party reviews are specified, along with a justification of need.

A project management dashboard to collect, analyze, and report on key data can be set up as a component of the PEP review and reporting process. The dashboard can also be set to interface with the risk register and thus be a risk assessment tool tracking risk mitigation activity. That said, the Owner must guard against the dashboard's provision of real-time project information leading to excessive executive interference or second guessing of project management actions, behaviors that are never helpful.

Some major mining firms use a formal investment readiness assessment matrix and/or a formal external value assurance review to bolster the review process, but the authors are unconvinced that these tools add much beyond rigor to the exercise. Certainly, senior management gets an added layer of comfort from these assessments and reviews, and they do help to expose project shortcomings, but they add little to a properly run project beyond more work for the project management team.

PROJECT PLANNER

A fairly new tool that the authors *do* recommend is the undertaking of an interactive project planner session as a step toward ensuring that the PEP covers all the elements. The key players of the project management team and the Owner are gathered together for a day, with the principal drafter of the PEP acting as a facilitator. A series of questions relating to project execution are posed to the gathered ensemble, and their responses are summarized by the facilitator on an overhead screen as consensus is reached on each issue.

A pertinent set of questions for use in such a project planner session might include the following:

1. Why is the project being undertaken? Why is the Owner committing resources?
    - What are the strategic and business goals that must be met?
    - Are there other projects that impact or are impacted by this one?
    - What role do marketing goals or economic sensitivities play?
    - Are there tax-related strategies that impact the project?
    - What project driver has the greatest impact? Cost? Schedule? Quality?
    - Are there cash flow constraints?
2. What must be built to meet the Owner's business objectives?
    - What are the functional, technical, and physical scopes for the planned facilities?
    - Are any desirable features or activities being excluded from the scope?
3. What factors must be understood to select the method of project delivery?
    - How well defined is the scope? What is the project complexity?
    - What is the skill competency of the Owner?
    - What resources are available in the project location?
4. How will the project manage its risks?
    - What are the internal (controllable) risks?
    - What are the significant external (uncontrollable) risks?
    - Are risk mitigation strategies in place? If not, can they be timely put in place?
5. Is the project team effectively organized?
    - Are names, roles, and responsibilities of key project management defined?
    - What functional groups of the Owner should be involved? For what tasks?
    - Will an EPCM firm be involved? To handle what roles?
    - What subcontractors and/or specialist consultants need to be brought in?
6. Are the key project phases, activities, and milestones set?
    - If not, what needs to be done to get these in place?
    - How realistic are the milestone dates?
7. Is the contracting plan in place?
    - What type(s) of contract make the most sense for the different activities?
    - Are there special terms that will be required of the contractor(s)?
    - Will alignment partnering be employed? If not, why?
8. How will a safe and secure project be best assured?
    - Are there specific objectives that need to be set? Are incentives to be used?
    - What will be the Owner's involvement in delivering the safety performance?
9. How will the quality requirements be assured?
10. How will project cost and schedule be maintained?
    - Who is responsible for preparing the project estimates?
    - Is an Owner-approved control budget in place?
    - Are the project WBS and Owner accounting systems in sync?
    - Is a Level 3 schedule in place? Has a critical path been established?
11. How will value be maximized within the project?
    - Are there value engineering tasks unfinished from the feasibility phase?
    - Can a constructability analysis add value at this juncture?
12. How will the engineering design be managed?
    - Are all the necessary criteria, standards, methods, and systems established?
    - Are the reviews and checks all set? Are there one or two HAZOP reviews planned?

13. How will the necessary equipment and materials be obtained in a timely way?
    - How are the procurement activities to be split among EPCM, contractor, and Owner?
    - Are the transportation logistics hurdles identified? Who is handling them?
    - Who is responsible for materials management and for warehousing on-site?
14. Is the plan for managing construction established?
    - Is an adequate supply of labor skills available? If not, how will this be rectified?
    - Are there union issues?
    - Who is providing the temporary facilities and/or the common services?
15. Is a plan for a successful start-up in place?
    - Are the precommissioning and commissioning roles allocated?
    - Have arrangements been made for a specialist commissioning team?
16. How will environmental integrity be assured?
    - Are all of the permit requirements known?
    - What will be the Owner's role in environmental management of the project?
17. Are there sufficiently robust document management and document control systems in place?
18. Are the information technology needs of the project site truly understood?
19. Is a viable information management system in place?
    - What reporting requirements are being mandated by project management?
    - Will the Owner receive the progress status reports in an acceptable time frame?
    - Are review and audit processes and timings set?
    - Will a dashboard be used? Are the key performance indicators established?
20. Does the project have any special factors, such as new technologies, that require attention?

In each of the three interactive project planner sessions attended by the authors to date, the neutral nature of the questions led to gap issues being unearthed and a number of project shortfalls being exposed, but without any of the participants being assigned blame. The outcome of the sessions was thus a more robust PEP, which was the objective going in. Each session allowed the attendees to be comfortable using their skills to bolster the PEP, without feeling a need to defend their previous contributions.

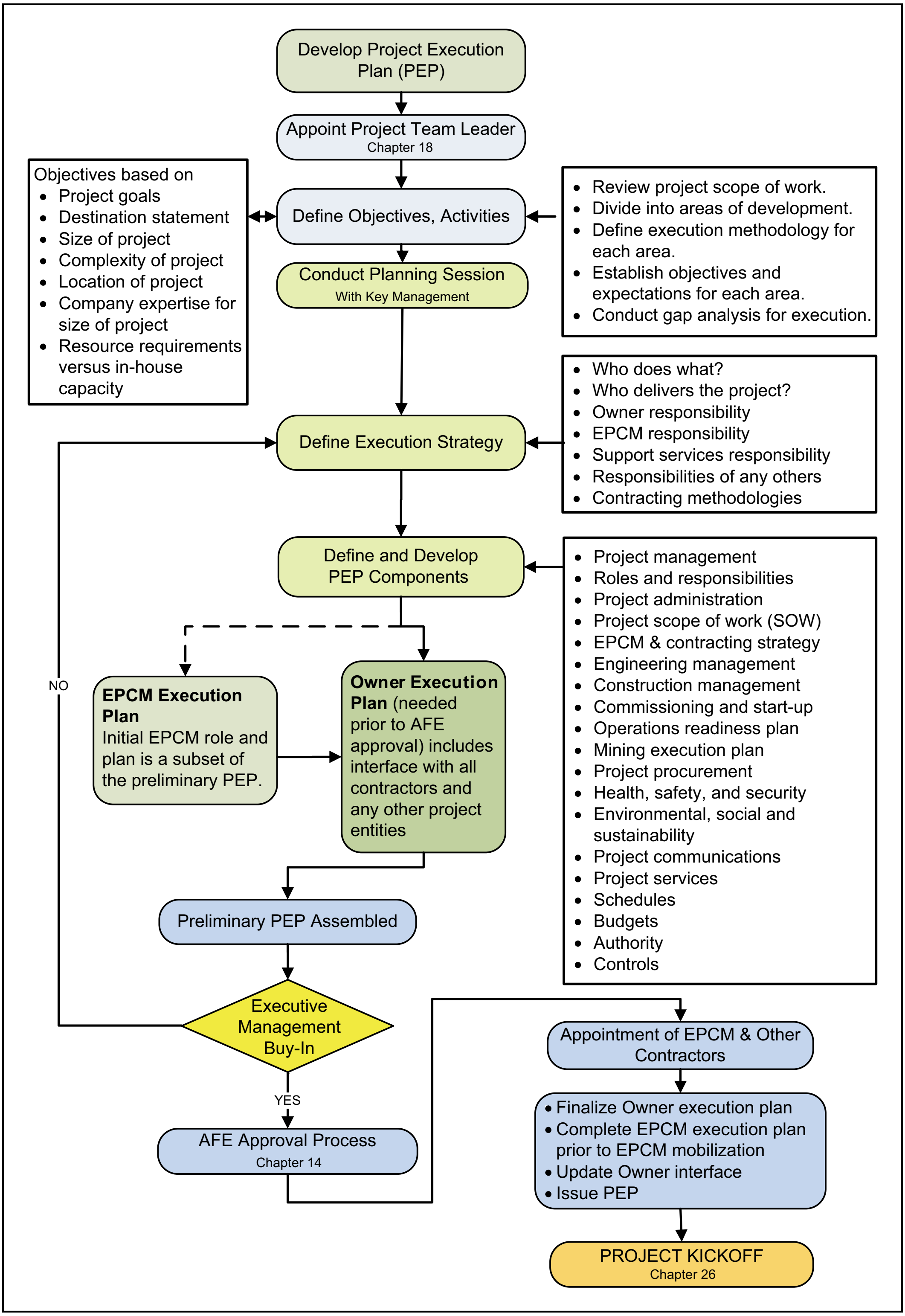
CHECKLIST 16.1 PROJECT EXECUTION PLAN

No.	Item	Status	Date	Initials
1	Feasibility study complete			
2	Success criteria—established with Owner			
3	Project delivery method (EPC, EPCM, and/or Owner)—determined			
4	Preliminary Project Execution Plan (PEP)—updated and expanded to final			
	A. Project description (synopsis of prior work)—documented			
	B. Definitive scope of work going forward—set			
	C. Key project goals—identified			
	D. Project criteria, battery limits, and constraints—identified			
	E. Gap analysis—complete			
	F. Owner's execution plan and EPC or EPCM execution plan coordinated into a single PEP—complete			
	G. Interactive project planner session—undertaken			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
	H. Project procedures manual (PPM)—assembled			
	I. Deliverables verification plan—prepared			
	J. Owner's executive management buy-in—obtained			
5	Project governance—established			
	A. Levels of authority documentation—in place			
6	Resources selection strategy (internal and external)—set			
	A. Project leader—appointed			
	B. Core project management team personnel—identified			
	C. Project team organization RASCI chart—produced			
	D. Owner's technical support resources—assigned			
	E. Labor force availability, skills assessment, and hiring strategy—outlined with Owner's HR department			
7	Quality management plan—outlined			
8	Risk management plan—in place			
9	Project master schedule—published			
	A. All key milestones—established			
	B. Critical path—determined			
10	Capital cost management—outlined			
	A. Work breakdown structure (WBS)—in place			
	B. Budget allocation and cost reporting—set			
11	Project controls—established			
	A. EVM progress and performance measurement—in place			
	B. Cost and schedule control processes—defined			
	C. Change management system—set			
	D. Contingency control process—outlined			
12	Major accounting controls—in place			
13	Project administrative procedures—established			
14	Reporting requirements—defined			
15	Communications plan—established			
16	Project reviews—identified			
	A. Project dashboard—functioning			
17	Engineering and design requirements—established			
18	Procurement procedures—established			
19	Construction management approach—issued			
	A. Contract management plan—prepared			
	B. Project breakdown into areas of development—outlined			
	C. Support services—identified			
	D. Health and safety requirements—identified			
	E. Site security needs—outlined			
20	Environmental impact, social acceptance, sustainability, and closure plans—produced			
21	Commissioning and start-up plan—prepared			
	A. Operations workforce hiring and training program—defined			
22	Turnover to operations process—outlined			
23	Project financing plan—identified, if appropriate			



FLOWCHART 16.1 Project Execution Plan

CHAPTER 17

Project Setup

By failing to prepare, you are preparing to fail. — Benjamin Franklin, 1727

OBJECTIVE

This chapter provides the methodology for the project manager to take the Project Execution Plan (PEP) and set up the project in accordance with project management best practices. The project execution "clock started ticking" when the official "green light" (the Authorization for Expenditure [AFE]) was issued. This chapter captures the planning steps that will give execution a strong start.

The discipline coverages required of the project team are outlined here. The chapter presents the project philosophy with respect to engineering, procurement, and construction. The documents and resources needed to initiate the project execution procedures are described, along with the informational reports and meetings that key stakeholders will be expecting.

PROJECT GOAL

Every successful project starts with a one-sentence goal that can be systematically divided into smaller, manageable, and easily understood objectives. This one sentence becomes the official goal statement for the project.

A project goal could be to *efficiently construct a 150,000-metric-ton-per-day copper-processing facility and infrastructure on the El Abra mine site in Chile that is technically sound and capable of producing 250,000 metric tons per year of London Metal Exchange (LME) grade A quality copper cathodes by August 1, 1996, for a cost not to exceed $1 billion, without incurring any lost time injuries or environmental harm.*

After the project goal is determined, objectives will be established to provide details within the PEP. Each functional group or person associated with the project has to have an objective. The objectives describe the specific responsibilities of the group or person, and they help everyone understand how their contribution relates to the overall project goal. Objectives must be measurable, written, and agreed on by all.

A good starting point of the goal-setting exercise for an individual is the publication of a destination statement for the project team as a whole. A destination statement, as seen in Figure 17.1, lays out what the project should look like 1 year after operations start-up.

Expectation of what the project looks like in the year following start-up

Relationships	**Organization and Culture**
We are a valued partner in the life of the community.	We embrace a safety-first culture.
We treat all stakeholders fairly and with respect.	Our employees are highly skilled and trained in core capabilities.
We make decisions based on facts.	We value sustainability and strive for zero environmental incidents.
We are respected by our suppliers for being knowledgeable and fair.	Our highly developed leadership, team skills, communication, and change management capabilities allow us to respond timely to the project's changing requirements.
Our product is preferred by customers; we deliver customer requirements.	We actively search for innovative solutions.
We work in a one-plan, one-team, and one-goal environment.	Our reputation in the community and industry retains and attracts high-performing individuals. We are the region's employer of choice.
Financial	**Activities and Processes**
We have the highest labor productivity in the industry.	We systematically review and improve our internal processes.
Our cost per ton/pound/ounce is in the bottom quartile of producers.	We use key performance indicators to measure and drive process improvement in costs, productivity, quality.
We consistently meet concentrate production and cash cost targets.	We optimize the utilization of your assets.
The project was delivered on time and in budget.	We utilize technology to analyze problems, define opportunities, improve management decisions, and keep our stakeholders informed.

FIGURE 17.1 Destination statement

STARTING CORRECTLY

A project succeeds when the desired results are delivered by the project team. To get the right outcome at the end, the project manager must take appropriate action steps at the very beginning. The manager must ensure that the following are accomplished:

- Project stakeholder expectations are clear and realistic.
- The vested interests of stakeholders are aligned.
- An effective team is in place; the right people are in right roles, with no changing of key players.
- Management is enrolled in the project goals and actively supports the project team.
- A comprehensive PEP is established.
- A project vision statement and project charter are in place and referenced regularly.
- Project leadership is empowered with sufficient authority to execute the project.
- Good communication protocols are established and practiced routinely.
- Accountabilities are defined and understood by all stakeholders and team members.
- The project basis is a proven technology, and if not, sound testwork has been done.
- Risk assessment is complete, and a comprehensive risk mitigation plan is in place.
- A change control system with a management protocol is in place.

- Effective monitoring, reporting, and communications systems are functioning.
- The Owner's leadership and key stakeholders are kept informed without impeding progress.

While preparation and planning are paramount up-front, practical risk management and skilled problem solving are equal key elements to project success. Major projects are a constant flow of planning, execution, issues identification, and mitigation, all within an environment of shifting priorities and changing personnel. It is the project manager's job to make sure that the project does not become another bad statistic.

Do not start too early. Projects are frequently 10 years or more in the making; the project manager must judiciously manage and temper the Owner's sense of urgency to get into the field right after project approval. Once started, a project has a momentum of its own. Adequate time must be spent to set up the project for a successful journey. All the necessary personnel, procedures, and resources must be installed for proper management and sufficient monitoring so that course corrections (when needed) can be effected in a timely way (Hickson 1996).

Do not ignore problems. Underperformance and negative issues only get worse the longer they are ignored. Early detection will result in a manageable recovery. The earlier that the project manager meets with the Owner and key stakeholders regarding any significant project obstacle, the sooner the parties can agree on a corrective direction and initiate a viable recovery plan (Owen 1997).

Know the Owner's risk threshold. A necessary component for project management when beginning a project is knowing the risk tolerance threshold that will shut it down. Key project leadership must be cognizant of the exit strategy if such a risk threshold is ever met. While most Owners do not wish to have their exit strategy publicized, the risk tolerance levels need to be set, and the project manager and key project staff must be aware of those limits.

Similarly, if the project goes over budget, the Owner's treasury group needs a plan in place for financing (beyond firing the project manager) if the Owner wants to continue the project.

Know the plan. Successful projects do not happen by accident. Success in project management requires that project teams understand and interact well with the complexities of the project and the existing Owner's organization. Successful teams effectively plan their path forward, cope proactively with change, and deal with the project risks to deliver the specific objectives established with the Owner at project start-up (Guzman 2012b).

Know when and where to get help. When the Owner feels that outside guidance would help the project setup process but does not yet want to commit to an engineering, procurement, and construction management (EPCM) organization, there are unaligned consultants that can fill that role, either independent project management experts or organizations (Ottley 1996).

Senior management consultancy firms like the Boston Group or PricewaterhouseCoopers can provide top-down guidance for getting all the right project pieces in place. Companies like PSMJ Resources are more bottom-up oriented, focusing on providing practical how-to procedures to follow, with forms and templates to use.

OWNER'S CORPORATE LEADERSHIP ROLE AND INVOLVEMENT

The role that the Owner's corporate leadership, that is, the board and senior management, choose to play as the project enters into the execution phase will make or break the project.

There is no way to temper this for the reader, so best to address the issues early in the project execution setup process.

First, the Owner leadership must understand that with board approval for execution, the paradigm has shifted. The project now needs a different focus and a different approach (Owen 2011). Senior leadership may have been significantly involved in the iterative process that led to feasibility study publication and approval. If this was so (and it should have been), then this was predominately good, as the collective and varied wisdoms within the Owner's corporate executive ranks helped make sure the project was correctly challenged and evaluated prior to approval.

But with approval in hand, the corporate leaders need to change their role from involvement to supportive. If they are not able to do this, the project will not succeed. This does not mean that the corporate leaders have to abandon their responsibilities. They are still accountable to the board and shareholders. The corporate leaders have to do the following:

1. Appoint a project leader that they trust, and then let that individual run the project.
2. Make sure that all the elements of proper governance are in place (see Chapter 3).
3. Put a destination statement in place that aligns the project team with corporate leadership.
4. Have a clear line of authority from the project leader to corporate executive leadership.

It is vital that all of corporate leadership be aligned and supportive of the project and the project team. One uncommitted member will undermine the process.

The corporate departments, in their support roles to the project, need to enable the project team, not attempt to be drivers of the process or seek to be power players. Meddling is not the same as supporting. Attempts to control the project process from the corporate office will impede progress and divide the organization. Project decisions in the execution stage must flow from the chosen project leader, not the corporate body.

If the Owner's corporate leaders are not committed to their support role to the project team, good project people will leave, and the corporation will end up with mediocrity and failure.

APPOINT A PROJECT TEAM THAT FITS THE PROJECT

With the project about to enter into the execution stage, one of the decisions to be made is the appropriate source and makeup of the project team to manage and control the project's further development. A formal project management assessment procedure, as outlined in the following sections, can be helpful in the appointment of an appropriately qualified project management team.

The project management role and the project responsibilities escalate along with project size, complexity, and cost as the execution stage gets underway. It is advocated herein that project management responsibility be chiefly assigned on the basis of project cost, since cost is generally a decent proxy for both complexity and size.

Projects can be characterized by cost to fall into one of three categories: major, intermediate (medium-sized), or small (as shown in Figure 17.2). The project management leadership needs be appointed in accordance with which one of the three categories that the project falls within.

No matter what the size of the project or the origins of the other team members, the project manager always needs to be on the Owner's payroll for the project life cycle, even if brought

Project Size	Major	Intermediate	Small
Example	New greenfield mine	Plant expansion	Ongoing mine development
Project manager	Full time	Full time	Full time for critical stages
Controls manager	Full time	Can be part time	Part time

FIGURE 17.2 Project management determination

in from outside solely to lead the project on a one-off assignment. This makes it clear to all entities as to whose interest the project manager is spearheading.

Major Projects

Major projects are defined as costing more than $200 million in 2015. The complexity, risks, and high capital cost of defined major projects, particularly greenfield projects, require that these projects be managed by a specialist project management team (either from inside the company or from external, hired entities).

The project team is assigned by mining company senior management in collaboration with the company's internal specialist project management group (if such a specialist group exists). The chosen team is charged with ensuring that project execution is properly managed in accordance with the approved PEP and for making the client, that is, the Owner, a satisfied customer.

One of the team's responsibilities is deciding when to bring in the additional expertise that can provide specialist skills and/or knowledge. In this regard, the project management team should proactively allow operations to retain meaningful involvement throughout the project life by

- Integrating operations staff experts into the basic engineering team during the period when the project parameters are being defined, and
- Assigning certain specialist technical areas (e.g., mine design) for in-house execution by operations personnel.

Intermediate Projects

Intermediate projects are defined as costing $20 to $200 million in 2015. Best practice typically assigns responsibility for more complex, midsized projects to a specialist project management group (i.e., similar to what is required for a major project), but routine intermediate projects can generally be satisfactorily handled by the individual operating unit management (i.e., similar to what is required for a small project).

Even if the project is assigned to operations to correctly characterize, manage, control, and execute the project, the operations project team will likely require additional outside specialists to bolster overall team competency.

The PEP for any intermediate project should always be reviewed by independent project management experts before funds approval, particularly when the project is managed by an operations project management team.

Independent project audits are needed for all operations-managed intermediate projects. Frequency of auditing will depend on project cost.

Small Projects

Small projects are defined as costing less than $20 million in 2015. For small projects, such as a modest underground mine development extension, the project team would typically be selected by the general manager of the site operating unit, with only oversight guidance from the relevant corporate departments.

The minimal risk and the lower capital requirements of defined small projects means that these projects can typically be managed by the mining company's local operations unit, simply by following the procedures within this book, including the submittal of a stand-alone PEP.

No role for an imported project management group is normally envisioned for these projects, though site operations managers should be encouraged to call on specialist project management expertise (internal or external) wherever they see a need, or if there is a lack of project resources at the operating site.

This decision process for assignment of primary responsibility for a project is illustrated in Figure 17.3.

THE PROJECT TEAM

The appointment of the appropriate project management team and leadership is critical to project success. The makeup of this management team is laid out in detail in Chapter 18.

For most major projects, an EPCM firm will need to be a component of the team, and with good reason. A significant portion of the skills needed for the project execution phases reside within the professional ranks of the EPCMs. For decades EPCMs have provided leadership in engineering design, field implementation, procurement, follow-up engineering (to improve design), commissioning prowess, project control, and contracts management.

But unfortunately the EPCM cost cutting of the past 20 years has meant that any team being offered today will lack some elements of the requisite depth. Thus one can no longer completely turn the project over to an EPCM firm. The EPCMs simply do not have all the skills necessary to deliver the project.

Further, today's EPCMs generally only have one solid A-team. Allowing the project work to be undertaken by lower-skilled practitioners is not a course to be followed; it can translate into untimely completions and/or poor quality workmanship if not countered.

The answer is for the Owner's selected project leader to fill in the team gaps and insert the requisite expertise from individual specialists and/or smaller engineering groups willing to be subordinate to the EPCM or to the Owner (whichever is deemed best by the parties). Thus, the Owner needs to be certain that the appointed project leader has an extensive network of qualified people that can be brought in.

Particular issues likely to be encountered when hiring an EPCM firm today are an absence of knowledgeable controls people and a lack of experienced contracts management staff. Even more disconcerting is the reluctance of EPCM engineers to leave the friendly confines of their offices to go out and work in the field. Their reluctance means that the EPCM home offices are not being apprised of their engineering errors. Field fixes do not get translated back into better future designs.

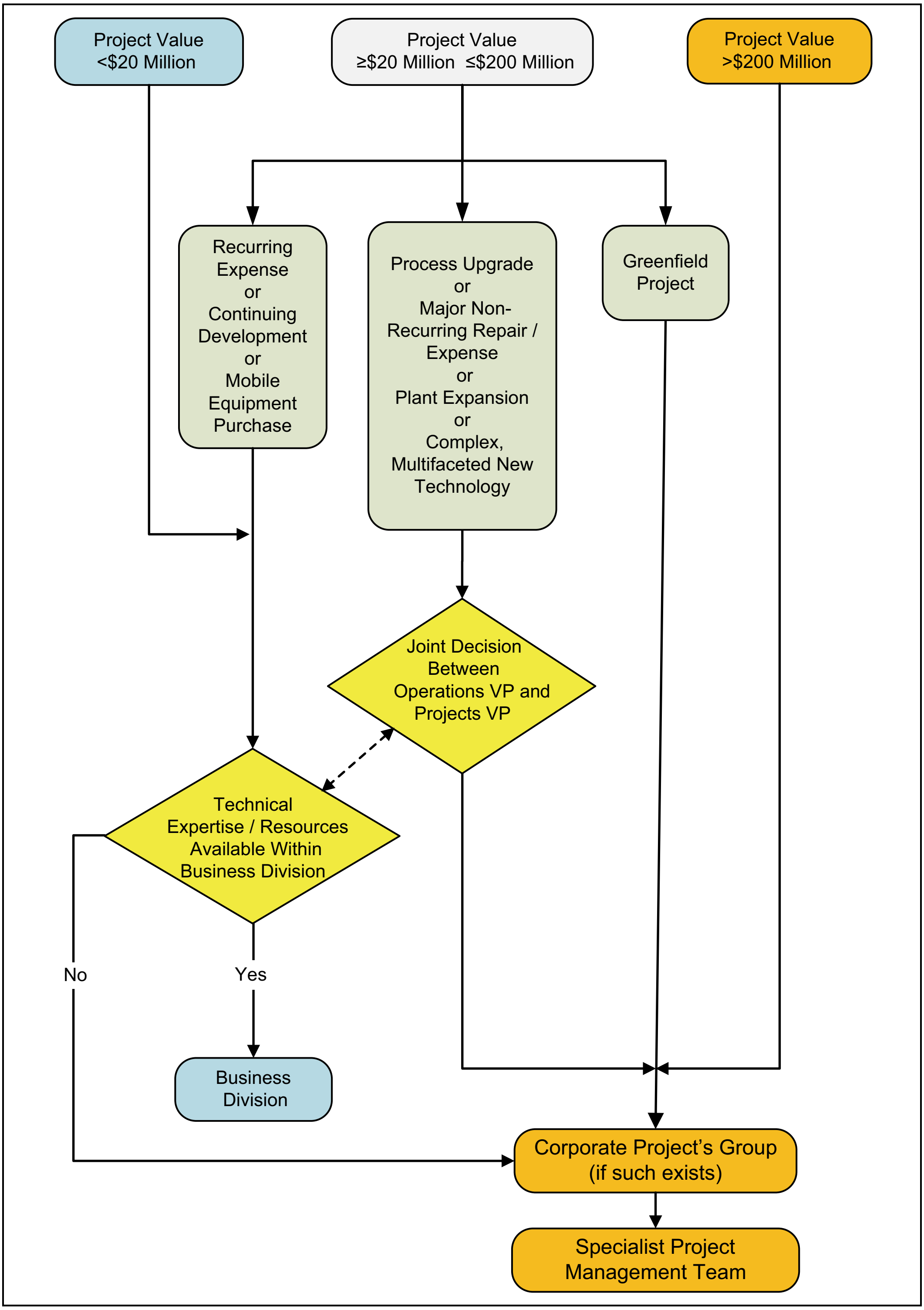


FIGURE 17.3 Decision tree—who manages the project?

Success in assembling the project team entails staying nimble and keeping the lines of authority simple. People are the key. The project needs an environment that makes good people want to be part of the process. Then the project manager and Owner have to maintain the process and embrace and reward the people. That is what attracts good employees.

A core team of key players working together with leadership to steer the process from one end to the other, from feasibility (or before) through ramp-up, is the best answer for today's complex projects. For a project to truly succeed, all participants must see themselves as part of the team. To this end, neither the project team nor the Owner can distance themselves from the contractor or from any other hired entity. A successful project team is created when all participants have equal stature, including the hired contractors, specialist engineering subcontractors, and major vendor suppliers. Different players will have various responsibility levels, but success stems from elimination of the "us" versus "them" syndrome.

With the right team leadership, it is possible to have a mixed, dedicated project team to properly manage the project and judiciously look out for the Owner's money. The project management team becomes the driving force to keep the process on track, bringing all the stakeholders along and keeping everyone in agreement.

Successful project teams do the following:

- Equally embrace and respect the necessary skillsets, no matter whether they are contractor, specialist engineer, vendor, consultant, or Owner-assigned personnel
- Do not skimp on the complement of personnel skills requisite during project life
- Clearly define project responsibilities
- Unambiguously identify reporting relationships
- Bring in their project controls manager early in project life

It is also the project manager's duty to remove people from the management mix who are detrimental—those who are either well-meaning but do not have the expertise or unwilling to work in a team approach.

As Kent Billing, director of Information Management and Systems for Xstrata sagely observed on October 31, 2008, when he rephrased one of quality expert W. Edwards Deming's more famous tenets, "Good people with bad processes and systems will get a better project result than bad people with good processes and systems." Moral of the story: Put the best people that you can in place. Again, people are the key.

FUNCTIONAL DISCIPLINES NEEDED WITHIN THE PROJECT TEAM

So, we have established that Job One is to assemble the project team. Beyond the project leader, the team requires specialized project management expertise, functional discipline competencies, administrative staff, and representation from key stakeholders from within the Owner organization.

The exploration and/or operations people who discovered a new resource or the corporate business staff who acquired a new property might have originally known the most about the opportunity's prospects, but they are not the people who should lead the project execution (or the feasibility evaluation). The discoverer of an opportunity can seldom view the outcome of developing that opportunity with wholly unbiased beliefs. While these exploration, operations, and business personnel can (and should) have input roles in the early scoping evaluation, beyond that point, the project team is more suited to this task, with its members of multidisciplinary backgrounds who can cover all the following requisite fields:

- Project leadership
- Project management
- Project controls (including cost estimation, schedule, and quality control)
- Accounting (including financial analysts)
- Engineering
- Procurement (including sourcing, expediting, logistics, material handling, receiving, storage, and preservation)
- Contracts administration
- Construction (including construction trades management)
- Quality management (and surveillance)
- Risk management
- Administration (including document control and management)
- Operations
- Maintenance
- Information management
- Environmental impact, permits, social acceptance, and sustainability compliance
- Government liaison
- Human resources
- Health and safety
- Security

Not all of these areas will need full-time project representation, and one person may be able to cover two or more positions, but all listed disciplines need to be present for meaningful participation in decisions affecting their area.

PROJECT RESPONSIBILITIES

The project manager, once selected, is tasked to define each project team member's responsibilities and the areas that each will be accountable for. Authorization levels assigned to team members must comply with the existing Owner's company delegation of responsibility policy.

INCENTIVES FOR PROJECT TEAM PERSONNEL

For critical projects, it is beneficial for the Owner's senior personnel who are assigned to the project (i.e., those who can make a difference to the project's success) to be aligned with an incentive scheme for the achievement of major milestones (e.g., first metal production, meeting of financial completion terms, project completion on schedule and under budget).

PROJECT PHILOSOPHY AND STRATEGIES

After defining the scope and responsibilities, the project team further delineates the project strategies, identifying the critical risk areas and all pertinent permit considerations. At this same time, the selection criteria for the appointment of the contractor (or contractors) to assist in the execution of the engineering and construction of the project are outlined (see Chapter 19), and the project procedures are set.

Part of the project strategy development will be determination of the type of contract(s) to be entered into with the engineering, procurement, and construction contractor(s). See discussion of the advantages and disadvantages of the differing types of contract in Chapter 20.

FINAL PROJECT EXECUTION PLAN

The first major activity of the project team, once the project is approved, is to modify and transform the preliminary PEP (see Chapter 16) into the control document for the project, in accordance with changes requested by the board. In other words, finalize the PEP.

The PEP encapsulates the four pillars that are the foundational basis for management of all projects: scope, time (schedule), cost (budget), and quality.

If the feasibility study (see Chapter 7) is the only comprehensive reference document in existence for the project and there is no preliminary PEP, then the feasibility study will need to be significantly abridged and indexed to create a practical, working PEP document. A feasibility study is not designed to serve as the control document for project execution. It is too lengthy; it contains volumes of data that are not relevant to project execution or to the project management functions.

Final, Revised Project Scope

If revisions to the preliminary PEP (see Chapter 16) are required, they normally emanate from senior management during review and approval. Most of the time, such revisions are minor.

Once the revisions have been made, the PEP document is finalized and becomes the primary control document for the project. Remember, the PEP is the documented description of the sequence of activities necessary to meet project objectives. This final PEP thus firmly establishes the scope of work (SOW), defines responsibilities, and sets out project strategy with regard to selection and use of outsource resources (e.g., EPCM contractors, specialists). It is the responsibility of the project team to ensure that the project follows the SOW as described in the project control document.

If significant changes to the SOW have been made since the feasibility study was presented to the board, the project team must ensure that the appropriate level of authorization has been obtained before such changes are implemented.

Execution Road Map

The final PEP takes the execution path that was laid out in the preliminary PEP document, evaluates each area for sufficiency, and then charts the path forward for the project team to follow. The following are functional areas to be examined within the preliminary PEP and questions to be resolved to set the path forward:

- Technical—What is the engineering definition level that the project is inheriting?
- Execution—What level of schedule and what class of budget are in place? Are the project's major phases and packages broken out? What key performance indicators serve the project best?
- Procurement—What sources are set, and which ones have to be developed? Any local content?
- Infrastructure—What facilities are in place, and what utilities have yet to be secured?

- Contracting—What contract strategy makes the most sense, and what does the Owner favor?
- Environmental—What are the permit timings for reaching completion?
- Political and social—What local engagement programs need to take place?
- Owner—What are the Owner's capabilities, and what governance exists?
- Organizational—Does a RASCI (responsible, accountable, supportive, consulted, informed) chart have to be created? What is the labor strategy?
- Risk—Are the risks known? Is the risk mitigation plan adequately developed?
- Resources—What resources have been secured, and which ones are still needed?

The final PEP resolves these and similar questions, removes the gaps and ambiguities, and lays out the plan for successful project execution.

PROJECT PROCEDURES MANUAL

Detailed procedures are required to ensure that the project is executed and controlled to meet the stated objectives. The project manager is charged with ensuring that all the necessary procedures are established, including the complete suite of project control procedures as outlined in Chapter 21.

These procedures are normally captured within the project procedures manual (PPM), sometimes referred to as the project manual. This manual becomes one of the two prime reference documents for executing the project, after the completion of the feasibility study (the PEP being the other).

A focus when establishing the project procedures and assembling the PPM is to use the assembly process to facilitate the interfaces between those stakeholders who have input into the project.

As key project procedures are prepared, existing company standards must be honored. It is acceptable, however, to modify company standards to suit specific project needs, as long as the underlying premise behind each standard is not violated.

The PPM is the reference data repository for the project. It houses the project's goals (SOW), design data, policies, and individual procedures, along with organization charts for all the personnel directly concerned with the project.

A comprehensive, generic list of the items that should be contained within the PPM is provided here. All of these items need assembling at this organizational stage to be fully implemented by the time of the kickoff event.

- Reference to location of the PEP (Chapters 16 and 17)
  - Project scope
  - Work breakdown structure (WBS)
  - Procurement and construction package breakdown (after it is established)
  - Organization chart for the project management team (Chapter 18); team responsibilities
- Contract agreements
  - Contracts control and contracts management
  - Warranty and guarantee criteria
- Project control system: tools and procedures (Chapter 21)
  - Reference to location of each project control document; list of the documents
  - Project schedule control: scheduling and work measurement procedure
  - Project cost control

  - Project quality control: reference to location of quality plan
  - Project scope control: reference to project scope control policy
  - Change control: major scope change control and approval procedure
  - Contingency control
- Engineering design systems: protocols and control procedures (Chapter 27)
  - Reference to location of project design basis document and the design criteria
  - Reference to location of engineering plan and schedule; schedule broken down by labor hours for each engineering discipline
  - Review and approval procedures for final design; design functionality statement(s)
  - Engineering deliverables
    - List of (any) requisite value engineering trade-off studies
    - Drawing list (with breakouts of procurement and construction packages)
    - Specifications list
  - Constructability reviews protocol
  - Fatal-flaw analysis methodology
  - Manuals—listing of requisite documents, for example:
    - Operations
    - Maintenance
    - Commissioning and start-up
    - Training
- Procurement procedures (Chapter 28)
  - Sourcing, logistics, and materials management protocols and procedures
    - Reference to location of data sheets and specifications
    - Equipment lists
    - Purchase requisition forms
    - Material control registers
  - All potentially pertinent supplier alliance agreements identified by the mining company sourcing personnel
  - Procurement control procedure
- Construction management procedures (Chapter 29)
  - Reference to location of construction management plan
  - Field construction control protocols, productivity monitoring methodology
  - Safety program
  - Field quality control protocols
  - Site material management control methodology
  - Spare parts verification procedure
  - Subcontracts management procedure
  - Subcontractor plans
  - Document control procedures
- Reference to location of commissioning and start-up plan
- Environmental impact and permit management plan (Chapter 8)
- Social acceptance and sustainability programs (Chapter 8)
- Project document-handling procedures
  - Project management procedures
  - Record-keeping procedures

- Project control procedures
- Project correspondence control methodology
- Project finance and accounting procedures
  - Accounting control
  - Invoicing and payment procedures
  - Monetary control
    - Cash management policies
    - Banking plan
  - Owner's cost administration protocols
  - Interface mechanism with company accounting and audit departments
- Project administration procedures
  - Reference to location of project's administrative procedures; list of key items
  - Governance framework outline (Chapter 3)
  - Delegations of authority and expenditure approval protocols
  - Travel and general office spending protocols
- Insurance mandates from the corporate insurance department (Chapter 20)
- Communications coordination plan (later in this chapter)
  - Interface procedure (with other company personnel and stakeholders)
  - Identification of all parties, their roles, and their contact numbers (telephone, fax, e-mail, etc.) outlining each party's involvement relative to the project
  - Reporting requirements and their frequency and content (Chapter 22)
- Project audit protocol (Chapter 21)

The manual must be updated and revised as the project progresses.

Each project is unique; thus, each project will have its own project-specific contents within its PPM. The previous list is merely a generic starter list for the reader.

While convenient, it is not necessary that the project procedures all be captured in a single PPM. The important point is that the procedures are in place by the time the project kickoff is initiated.

The project's delegation of authorities for the various levels of expenditures would be clearly defined at this stage. For guidance see Chapter 3 and Figure 5.2.

Generally, whenever an EPCM contractor is appointed, the engineering, procurement, and construction procedures will be those of the contractor, modified to complement and satisfy the requirements of the particular project.

The detail procedures for establishing the project for execution will be covered in Chapters 18 through 24 and Chapter 26. The narratives within engineering (Chapter 27), procurement (Chapter 28), and construction (Chapter 29) include additional specific procedural information.

ENVIRONMENTAL AND PERMIT MANAGEMENT

In most cases, the permitting considerations will have been ongoing before the project organization stage. The project manager, however, now assumes responsibility for ensuring that the necessary permits for project completion are obtained in a timely way.

Long-term, continuing environmental management is still likely the responsibility of parties outside of the project team. Typically, this environmental management is provided by the Owner's corporate environmental affairs group. Going forward, the project manager must work closely with those already involved in handling environmental issues, to both understand and proactively assist in the permitting process.

For environmental control, checklists are required for adherence to environmental permit conditions and dates. Site activity interface meetings must take place regularly among the Owner's appointed project environmental liaison, project management, and site contractors. Permit compliance needs to be routinely checked.

SOCIAL ACCEPTANCE AND SUSTAINABILITY CONSIDERATIONS

As with environmental impact and permitting, the social acceptance efforts will also have been ongoing before the project organization stage. The project manager, however, now assumes the responsibility for maintaining those stakeholder relationship-building endeavors that earn social acceptance. The project manager should strive to enhance these efforts throughout the project life. This will go a long way to preventing delays during the project execution stages.

Local community activists, along with international nongovernmental organizations (NGOs), may try to use the project to correct real and imaginary social ills. The project manager has to deal with these issues while keeping the project on track.

In the long term, gaining of stakeholder social acceptance is mostly the responsibility of parties outside of the project team. Typically, they are the Owner's corporate social affairs department and local operations community affairs department. The project manager must provide practical assistance to those already handling the social issues.

To maintain social acceptance, site meetings must take place regularly among the appointed community liaisons, project management, and site contractors.

Sustainability issues would mostly have been already incorporated into the feasibility study, and thus, as long as the project follows the approved project scope, there are not likely to be sustainability matters for the project team to deal with during the project execution stage.

COMMUNICATIONS COORDINATION

The key elements of the communications plan have already been laid out in the preliminary PEP (see Chapter 16). The plan going forward must include the ability for identified participants to receive and/or recall documents from the project database quickly and reliably. Because the plan caters to internal and external stakeholders (Figure 17.4), it needs to incorporate security measures to protect sensitive and/or proprietary information.

Project managers will almost always need to commission a Web site for the project, to allow information, that is, drawings, specifications, schedules, budgets, photographs, meeting notes, correspondence, and so forth, to be immediately available to every member of the project team, no matter how far removed they are from the site.

The explosion of social media and their capacity for participation has ushered in a new era of information exchange and/or technological interaction (Mullard and van Zyl 2011). In particular, social media are changing the very nature (and expectations) of project–community communications. Social media give users the ability to generate data, which is resulting in more and more stakeholders wanting to contribute to an online dialogue of how the project should be conducted. Social media cannot be ignored; they are a reality. Thus the project should use them proactively to raise awareness about issues and to garner support. The danger with these tools is that misinformation moves just as rapidly, with no ability for recall. If this happens, all that project management can do is provide corrected information and evidence as

Project Name & Number	Ruff Terrain Mine														
Project Manager															
Category Directory	**Organization**	**Name**	**Job Title**	**Address**	**Phone**	**E-mail**	**Contact Method**	**Stakeholder Mapping Matrix**			**Notes**	**Kick-off Meetings**	**Progress Reviews**	**Owner Meetings**	**Community Meetings**
								Support	**Neutral**	**Opposed**					
Project Management Team	We Build Em	Big Sam	President	USA	1-222	sam@net	E-Mail	?				?	?	?	?
Owner															
EPCM															
Construction Contractors															
Consultants															
Vendors															
Site Security															
Emergency															
Medical															
Utilities															
Local Government															
Regulatory Agencies															
Elected Officials															
Native Groups															
Media															
Service Organizations															
NGOs															
Mining Industry															
Business															
Community Citizens															
Other															

FIGURE 17.4 Communications plan

rapidly as possible through the same channels. While social media are no replacement for face-to-face interactions, they are useful listening platforms. They increase transparency and need to be embraced to enhance the overall communication process.

Just remember that *communication* is defined as a "two-way process to build a common understanding" (Bourne 2010). Sending an e-mail, having a virtual meeting, and posting on a Web site are not true communication. At some point humans need face-to-face conversation to recognize if communication is breaking down. If project management is trying to get a message across, the old rule still applies: If the communication fails, it is mostly the fault of the communicator (for not determining whether the message was received and understood).

REPORTS

A key element in a successful project management effort is the early establishment of an effective, timely information feedback system loop, that is, the reporting system. Weekly activity, monthly status, and periodic review reports are always required, as are certain key field reports and forecast updates, as summarized in the next sections. Chapter 22 contains the details.

Weekly Activity Report

The project manager must submit a weekly, single-page flash report on the major activities and issues to keep project stakeholders informed regarding project progress.

Monthly Progress and Status Report

A formal written report is required monthly. When an EPCM contractor is appointed, the Owner has to decide whether a joint contractor–Owner report will be produced or if separate independent reports will suffice. The authors favor one joint report.

Periodic Project Review Report

A periodic project review report covering an in-depth examination of the project measured against the base control document and the project objectives is produced every 6 to 12 months.

Field Reports

Field reports provide real-time information to project management. They need to be timely, short, and to the point. Reports should separately cover project scope issues, schedule changes and impacts, personnel requirements, cost trends, and forecasts.

Forecast Updates

On large projects that extend beyond a calendar year, it is sometimes necessary to update the project budget and/or schedule to reflect changes to the project environment. These updates are called forecasts, and the project's progress is tracked against both the original approved budget and the new forecast.

MEETINGS

Formal communication sessions and project review meetings need to take place at regularly scheduled times:

- Daily line-up meetings
- Weekly look-ahead meetings

- Monthly progress review meetings
- Senior management update meetings (every 3 to 6 months)

Monthly project progress review meetings, by themselves, are not enough. During the kickoff, the type and frequency of the additional meetings necessary for effective project management will need to be established by the project team, for example, technical reviews and contract negotiations.

Meetings are an important management tool, and their value should not be underestimated. The best meetings start on time, have an itemized agenda, close at a preset time, and have published minutes with named individuals for each required follow-up action.

A meeting is useless, however, if it does not produce results. It is estimated that some 20% of project management time is consumed in meetings; thus, meetings need to be conducted efficiently. Every meeting needs a chairperson responsible for attendance, conduct, and follow-up.

Do not step onto the treadmill of pointless activity (Schumpeter 2013). The biggest negative in the project (and business) world is too much busy-ness—too many things done for the sake of form. As the savvy old saying goes, “If we’re meeting, we’re not doing.” An excess of meetings will devour time. Avoid *vergaderziekte* (Dutch for “meeting sickness”).

INFORMATIONAL TECHNOLOGY RESOURCES

A necessary resource behind any project procedure is the information and data management system, namely, the project management computer hardware and software. Site information technology (IT) requirements have to be aligned with local Internet and communications providers before constructor mobilization to ensure that all project needs can be fully met in a timely way. Resources needed on-site include the following:

- Data and voice access, with technical support for the duration of the project
  - All contractors, subcontractors, EPCM, and Owner personnel must be able to access this system.
  - Fiber-optic lines will probably be needed to obtain the requisite quality and volume.
- Videoconferencing capabilities (on some projects)
- Basic necessities, besides electricity (with uninterrupted power source and/or generators)
  - Routers, firewalls, core switches, circuits
  - Desktop telephones, monitors, printers, and plotters
  - Mobile phones and/or radios for all key personnel

The project site will likely need its own dedicated server(s). The bandwidth of the main communications line and server size has to be selected and set, along with the hardware, cabling, and switches. Licenses have to be acquired for all propriety software.

The software systems selected must be real-time-linked to allow the project management team, Owner, EPCM, constructors, and key consultants to communicate seamlessly.

Software components of a linked and fully integrated project management information and control system will need to include the following:

- Cost and progress software that uses control accounts to plan, budget, track, forecast, and report on the cost, progress, performance, and productivity of all project phases using earned value measurement and control methodology. An example is PRISM software by Ares.

- Schedule interface software that can hold and flow all the schedule information in a time-phased manner into the cost and progress module. Schedule dates need links to engineering deliverables, equipment tags, and procurement and expediting activities. Oracle's Primavera P6 is suitable software for all projects in all stages; Microsoft's MS Project is fine for small, noncomplex projects and for the project viability stage.
- Budget module software that can manage any and all levels of budget estimate
- Engineering management and progress package(s)
- Document management and document control software, for example, EMC's Documentum
- Procurement, contracts, and purchase order administration software
- Capital equipment listing software
- Materials management and inventory management software
- Risk management software

The actual individual specialty project management software is ultimately selected based on the individual project needs, user skills, and software compatibility. Not all modules are needed on all projects. Companies such as Ares (PRISM), Oracle (Primavera Enterprise), and Meridian Systems (Prolog) offer full project-cycle, integrated project management systems that can link to the Owner's enterprise resource planning (ERP) and accounting systems of software providers such as SAP, Oracle, and NetSuite.

Training will need to be provided to members of the project management staff who are unfamiliar with the requisite software.

The importance of a functioning IT system on the project site cannot be understated, *but* having endured a multitude of underperforming systems on too many projects over too many years, the authors offer these guidelines:

1. Never allow the Owner organization to introduce a new ERP or accounting system into the project. Save the introduction for *after* project closeout.
2. Appoint a non-IT person to be in charge of establishing the field IT system.
3. Triple whatever time estimate the IT group gives for IT installation.

CHARACTERISTICS OF A SUPERIOR PROJECT SETUP

It takes time for superior projects to be set up for success. Superior projects turn into successful projects. Successful projects are set up with the following (Hickson 2001b):

- A full-time, experienced, and competent leader as the project manager
- A knowledgeable project management team that stays in place for the project's duration
- A project that was fully challenged and evaluated during the feasibility stage
- External, pragmatic reality checks confirming project feasibility prior to approval
- Definitive SOW with clear goals and consistent priorities
- A comprehensive, rigorous PEP in place before kickoff
- Project governance established that is consistently applied

- Clear accountability and authority
- A single project leader who is trusted and supported by Owner's entire corporate leadership
- Decisions made in the field by the project leader, not by a committee in the corporate office.
- The ability to make critical decisions quickly once the project is in the field
- An Owner who understands that the project needs to have *two* teams quickly in place at the right time: the project execution team of several thousand people *and* the operations team of several hundred people to run the new facility. This requires a single vision of purpose.
- Aggressive recruitment of appropriate personnel and disciplines
- A strong results-oriented project management team aligned with the Owner leadership
- A project leader who is willing to quickly remove and replace people on the team who do not fit
- Ample supply of capable people and resources
- Enough seasoned operators embedded in the engineering and commissioning teams that have previously worked in a similar size and type of plant to the facility that is being built
- Construction input to project design
- Well-defined, proven technology
- Engineering that is frozen early and stays frozen
- The proper amount of engineering in hand before mobilizing construction forces
- A project management team focused on staying in front of potential harmful issues
- Meaningful data on the availability of contractor and workforce skills at the project locale
- Sincere mandate for safety and zero harm from Owner and project leadership
- Rigorous quality focus throughout engineering, construction, and start-up operations
- Capital value analysis wisely used at critical points (postfeasibility, in engineering)
- Sufficient procedures and process in place to manage and control, but not stifle, the project
- Strict project controls established that use effective earned value methodology
- Focused risk management with a comprehensive risk mitigation plan that is followed
- Real-time information flow among key players (to tap the right talents)
- A project team that is capable and at ease in dealing with a constantly changing environment
- Close integration of engineering and construction, genuine respect among entities
- Reliable suppliers—materials, fabrication, and subcontracts
- Manageable work packages awarded, with a sensible balance of vertical and horizontal
- Genuine third-party reviews at set intervals, transparently distributed to key players
- Management exception reporting being practiced
- Proactive management of external and internal stakeholders
- An Owner who is actively engaged and represented throughout the project life

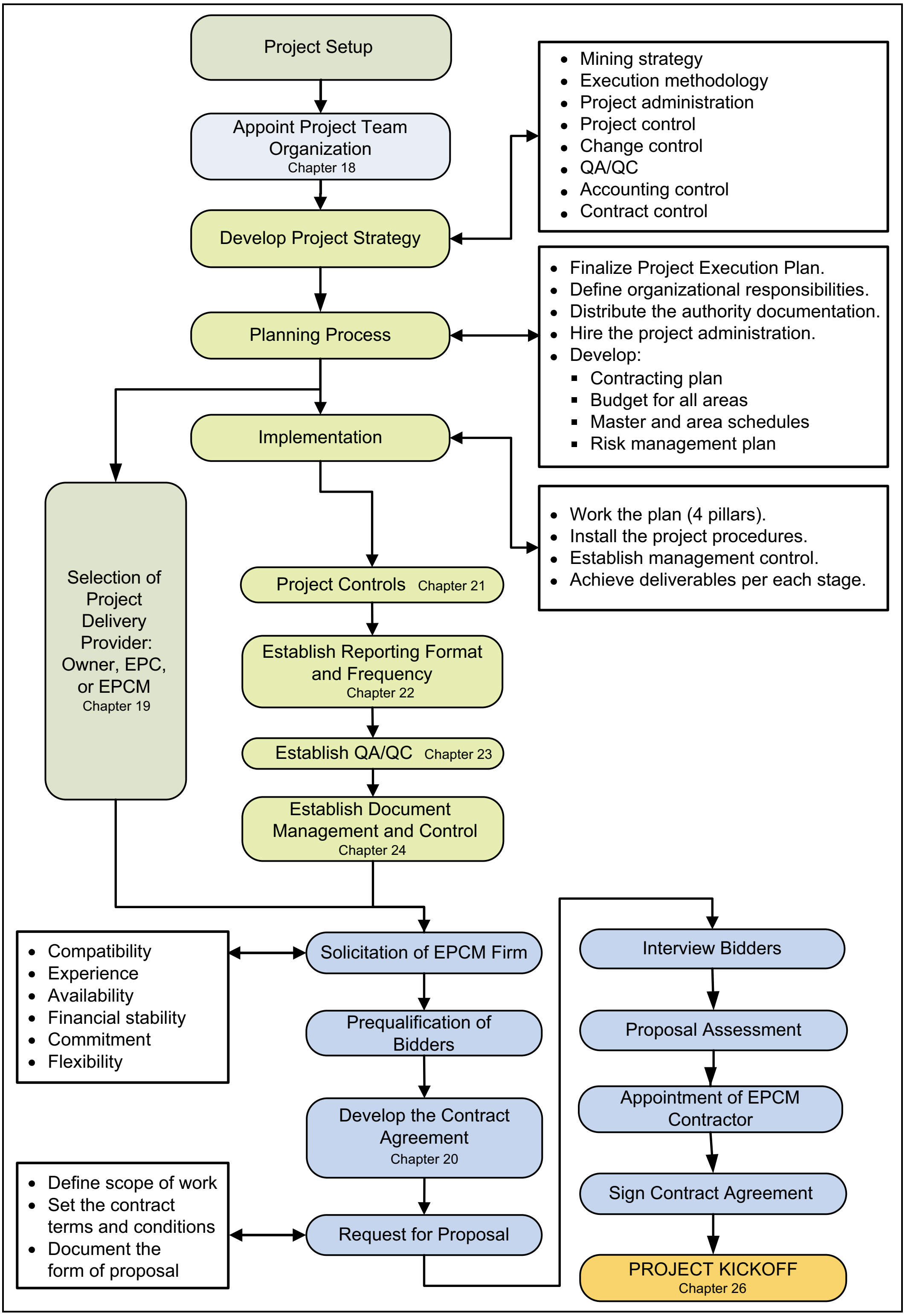
- Owner's leadership that provides the project team with support, guidance, coaching, and auditing during the entire project process without fault finding or meddling
- Owner executives and board with sufficient access and reports to be kept in the loop
- An aligned team with aligned objectives
- A constant bottom-line focus on the Owner's goals until the project successfully ramps up
- Extensive early training for commissioning and operations
- Engagement of a specialized team for commissioning, bolstered by early hires of key operations personnel and holdovers of knowledgeable construction craftspeople
- Early establishment of operational readiness

Taking the time to properly set up the project cannot be overemphasized. Human beings generally get the things right that they take an effort to properly address.

With whatever wisdom comes from reviewing close to 100 unsuccessful projects over the years, the authors have come to the realization that it is rarely the things that you think about and plan for up-front that cause a project to fail; rather, it is the things that were overlooked, finessed, not thought about, or omitted (either deliberately or in ignorance).

CHECKLIST 17.1 PROJECT SETUP

No.	Item	Status	Date	Initials
1	Owner's management approval for project execution—obtained			
2	Project goals—identified			
	A. Destination statement—published			
	B. Stakeholder expectations—understood and aligned			
	C. Deliverables—documented			
3	Project governance—established			
	A. Corporate leadership role—clarified			
4	Project manager (PM)—appointed			
	A. PM empowered with the authority to execute the project—OK			
	B. Clear line of authority from PM to corporate leadership—set			
5	Project team—identified			
	A. Appropriate team for project type and size—selected			
	B. Team responsibilities—assigned			
	C. Administration support staff—assembled			
6	Project strategies and philosophy—delineated			
	A. Owner's risk threshold—understood			
	B. Contracting approach—established			
7	Risk assessment—undertaken			
	A. Comprehensive risk mitigation plan—in place			
8	Project Execution Plan (PEP) modified to reflect approval terms—complete			
	A. Final PEP—in place			
	B. Scope of work—refined and frozen			
	C. Work breakdown structure (WBS)—established			
	D. Project delivery provider selection process—determined			
9	Project procedures—set			
	A. Project procedures manual (PPM)—assembled			
	B. Document management and document control—established			
	C. Change control system and procedures—in place			
	D. Quality management plan—functioning			
	E. Communications plan—implemented (internal and external)			
	F. Insurance requirements—satisfied			
	G. Environmental and permitting adherence checklists—prepared			
	H. Social acceptance program requirements—understood			
10	Informational technology resources—in place			
11	Reporting and information feedback system—established			
	A. Weekly flash timing—fixed			
	B. Monthly progress report contents—set			
	C. Dashboard—functioning			
	D. Third-party external reviews—established			



FLOWCHART 17.1 Project setup

CHAPTER 18

Team Organization

> *The best executive has sense enough to pick good men to do what he wants done, and the self-restraint to keep from meddling with them while they do it.*
> — *Theodore Roosevelt, 1858–1919*

OBJECTIVE

This chapter presents the project team organization for the project execution stage. The crucial requirement of leadership from the project manager is underscored. The approach for project team selection is outlined, the key personnel are identified, and the responsibilities and accountabilities of the project organization are defined.

The functions and authority that need to be established with respect to the engineering, procurement, and construction team members are explained. The evolution of the project team over time, the disciplines of the team members, and their relationships with each other (including the Owner; contractors; and engineering, procurement, and construction management [EPCM]) are all described.

The related objective for the selection of necessary outside assistance for project delivery such as EPCM firms and/or contractors is covered in Chapters 19 and 29.

HOW DO YOU MAKE AN EFFECTIVE PROJECT MANAGEMENT TEAM?

The reader could, and probably should, ask, "With all that is written about how a project should be organized, how come project leadership rarely delivers?" Apolinar (Pol) Guzman addressed this issue in one of his seminal presentations (Guzman 2012b). His observations still resonate, and they are intertwined here with the authors' experiences:

1. Modern society has great capacity to design and debate, but much less so for execution.
2. Business schools teach corporate management; project management is a side issue.
    - Corporations are in business to stay in business; projects are in business to go out of business.
    - Many corporate management techniques do not apply to project management.
    - Some techniques not only do not apply, but they also cause project dysfunction if used.
3. Firms like to set organizations on Day 1, then make the project fit the organization. This is backward; the organization has to change to accommodate the project. As every

cobbler knows, "The foot cannot be shaped to the shoe; the shoe needs to change as the foot changes in size."

4. There is no such thing as the "ideal" project management organization. Identify the project's unique facets, then fit the organization to the project.
5. Projects function best with a strong, centralized approach during the early developmental phases, followed by a shift to a more decentralized approach after the governance, goals, authority levels, project criteria, design parameters, budgets, schedules, and stringent control systems have been established and implemented.
6. As the project moves beyond engineering, the velocity and complexity create a need for the relatively independent functions of procurement, transportation, warehousing, contracts, infrastructure development, and field construction to each have significant authority, which in turn makes a decentralized organization essential. It is critical to make this bold move from centralized to decentralized in a timely way.
7. Projects require the project manager to be a strong leader.
   - Business schools downplay leadership; they stress managerial skills.
   - The project manager needs full authority for project implementation.
8. Projects need flat organizations with the key managers reporting directly to the project manager.
   - Fewer layers and people enhance communication and understanding.
   - Place the key people in a flexible group in the organization's two top tiers.
   - It is these 7 to 15 key managers who make the difference for project success.
   - Give each key manager individual responsibility for a specific project element.
9. Hold each key manager accountable for cost or schedule performance in his or her area.
   - Establish bottom-line goals for each individual that fit with the project goals.
   - Do not split responsibilities among individuals; this creates organizational fuzziness, with nobody taking responsibility or being accountable.
10. Ideally, each key manager's area is made into a manageable, individual cost center.
    - Give each manager the authority to take the necessary actions to achieve the goals.
    - To the extent possible, each manager should participate in setting the goals.
11. The key senior personnel need to be involved in the project from beginning to end. The 7 to 15 core personnel need to be highly qualified, experienced managers and planners with a business approach for a bottom-line outcome.
12. Projects are not operations.
    - Project managers have to instill an esprit de corps in those working under them.
    - Successful projects are differentiated from failures by their vibrancy, their crispness of conduct, and the pulse of excitement that permeates the whole team.
13. The velocity of change in a project will not accommodate involved management debate. Small problems can become fiascos before top management can be located.
14. Frequent and often brutal change is essential to the success of the project.
    - Large numbers of people are engaged for short periods in intense activity.
    - Changing the organizational numbers at the proper times is vital.
15. A project needs a balanced team of interdisciplinary skills and bottom-line focus. Specialists generally do not belong in leadership roles in the project team.
16. The formal organization structure is less important than achieving a committed team.
    - Building a team that accepts its role and truly participates takes leadership.

  - Holding the team together requires two-way trust and open communication.
  - It is the informal organization that enables a project to function.
17. Good project leaders get that way through training and experiences learned and relearned.
    - Few individuals are willing to endure repetitive learning in the field.
    - Would-be project managers fail to realize that one field assignment is insufficient learning.
    - Thus there are very few project managers with adequate project management knowledge.
18. No project should start without a comprehensive front-end plan—the Project Execution Plan (PEP).
    - Scrub the plan for all elements that impact schedule maintenance.
    - A project manager must anticipate rather than respond.
    - Projects fall short because planning and follow-up fall short.
19. Good project managers know that planning and setting objectives leads to goal attainment. People are goal-oriented beings.
20. Management by objectives and by exception is what is needed on a project. If the focus is on neutralizing the things that can go wrong, then things will go right.
21. Project management is a behavioral science, not a technical science.
22. Project management requires decisions to be made with imperfect knowledge.
    - Frequently, the path forward has no precedence and no defined procedures.
    - Projects require project managers to be risk takers.
23. The project manager needs to relish and be comfortable in guiding highly dynamic change.

INSTALL A DEDICATED TEAM

The best-run projects assign full-time, dedicated project leadership. Expecting key project members to handle other duties outside of the project is the first misstep to an unsatisfactory project outcome. It is normal to add team members as the project progresses and grows, and then remove members as the project winds down. However, it is a best practice to select and assign the project leaders, that is, the project manager and core team, up-front as soon as the project scope is understood and to keep that same leadership group through project closure.

Ideally, the team supporting the project manager should be geographically located together throughout the project life, be it initially in the mining company office, in the EPCM office during engineering, or on-site during construction.

At various stages during the project life, personnel from the EPCM, along with contractors, specialist consultants, and engineers from the major vendors, will serve as project team members. And most certainly, Owner representatives should always be brought in as active team members of any project.

INSTALL THE RIGHT-SIZED TEAM

A thorny issue that needs to be raised is the constant underestimation of the number of personnel it takes to create an effective project management team and the perennial lateness in installing them. Owners rarely fully grasp the myriad tasks involved in executing a project, and as such, they are generally skeptical about the numbers of people it takes or the urgency in hiring them. Thus, in far too many projects recruitment starts too late, hiring becomes a constant catch-up game, and the project stumbles along with too few people trying to corral too many issues. Typical results are late purchase-order placements, an absence of controls, improper installations, unaddressed risks, untimely reports, and incomplete training.

The answer is straightforward. Figure out the right size of the team needed when setting up the project for execution, then bring the people in before their work scope gets underway. Catch-up is a sure path to an unsuccessful result.

STRATEGIES FOR HIGH PERFORMANCE

To establish a high-performing organization that can successfully deliver the project, the right structure, tools, and processes that encourage people to excel must be set:

- Take the time and effort to create an aligned organization. Invest in partnering.
- Ensure that all key functional roles are in place prior to project kickoff. The assigned functional heads must be able to act authoritatively and not be compelled to check with a higher functional level before making decisions.
- Create a team with members who know and like each other; remove barriers between functional silos.
- Pay the core team handsomely. To get the well-qualified, highly experienced cadre of people that make a difference, incentives in addition to an excellent salary are effective.
- It is a huge advantage if key leaders can communicate in the language of the project's location. If they cannot, they need the ability (and the desire) to learn rapidly.
- The project manager should draw more on team knowledge, best practices, and proven procedures rather than issuing edicts.
- Allow, but manage, the Owner's contribution of knowledge and resources.
- Eliminate remote offices. Alignment of mind-sets and behaviors is more easily accomplished when the project delivery team is in one place.
- Manage by monitoring key personnel and tackling head-on any subperformance issues.
- Offer rich employee experiences (professional development, job satisfaction).
- Install up-skilling mechanisms to rapidly bring new noncore hires up to speed.
- Adhere to rigorous, objective employee assessment criteria with regular feedback.
- Balance the focus on project delivery with creating a desirable work environment.
- Streamline meetings to a minimum; focus on executing the project.

MAKEUP OF THE PROJECT MANAGEMENT TEAM

The functional disciplines that need to be represented in the project team were noted in Chapter 17. Not all disciplines need full-time representation on the project; one person may be able to cover several functions. But the designated discipline person needs to be actively present whenever decisions are made affecting his or her area. A truly rigorous project management assessment procedure is a fundamental requirement for selecting the appropriate management personnel, both in terms of timely bringing in all the requisite job classifications that make up a competent team and with regard to the experience qualifications of the individual members.

Every major project requires two key positions in place throughout the project life:

1. A full-time, experienced project manager, and
2. A competent, pragmatic project controls manager.

At some point in the project life cycle the following roles will all also be required:

- Project sponsor
- Deputy project manager
- Project engineer
- Contracts administrator
- Risk manager
- Cost estimator(s)
- Scheduler
- Quality manager
- Financial modelers
- Project accountant
- Owner assets accounting representative
- Owner operations and maintenance liaison
- Engineering manager
- Process engineer(s)
- Functional discipline engineers (civil, structural, piping, mechanical, electrical)
- Instrumentation specialist
- Procurement manager
- Sourcing specialist(s)
- Expeditors
- Logistics advisor
- Materials management and warehousing manager
- Construction manager
- Construction area managers
- Construction trade supervisors
- Health and safety supervisor
- Site security advisor
- Labor relations specialist
- Environmental and permit compliance liaison
- Social acceptance and sustainability experts
- Government relations advisor
- Start-up organization personnel

An organization chart for a team charged with delivering a new grassroots project is given in Figure 18.1. While a project team has a definite leader and hence has a line structure as shown, it will function best as a combination matrix–line organization. Figure 18.1 attempts to capture all the positions that are likely to be needed over the project life, but for any individual stage not all the personnel shown would be required.

The organization needed to execute a major project on an existing mine site would be similar to that shown in Figure 18.1, but there will be added complexity if there is a need to interface with an authority level already in place (likely that of the Owner). A structure that was successfully used by the authors to deliver a major project expansion at a Colorado underground mine in the late 1990s is shown in Figure 18.2 as an illustration of what needs to be set up at project kickoff to keep the parties comfortable working alongside each other.

Many of the necessary project team personnel will already be in place from the project's study phases, but team numbers will need to dramatically escalate for the engineering phase

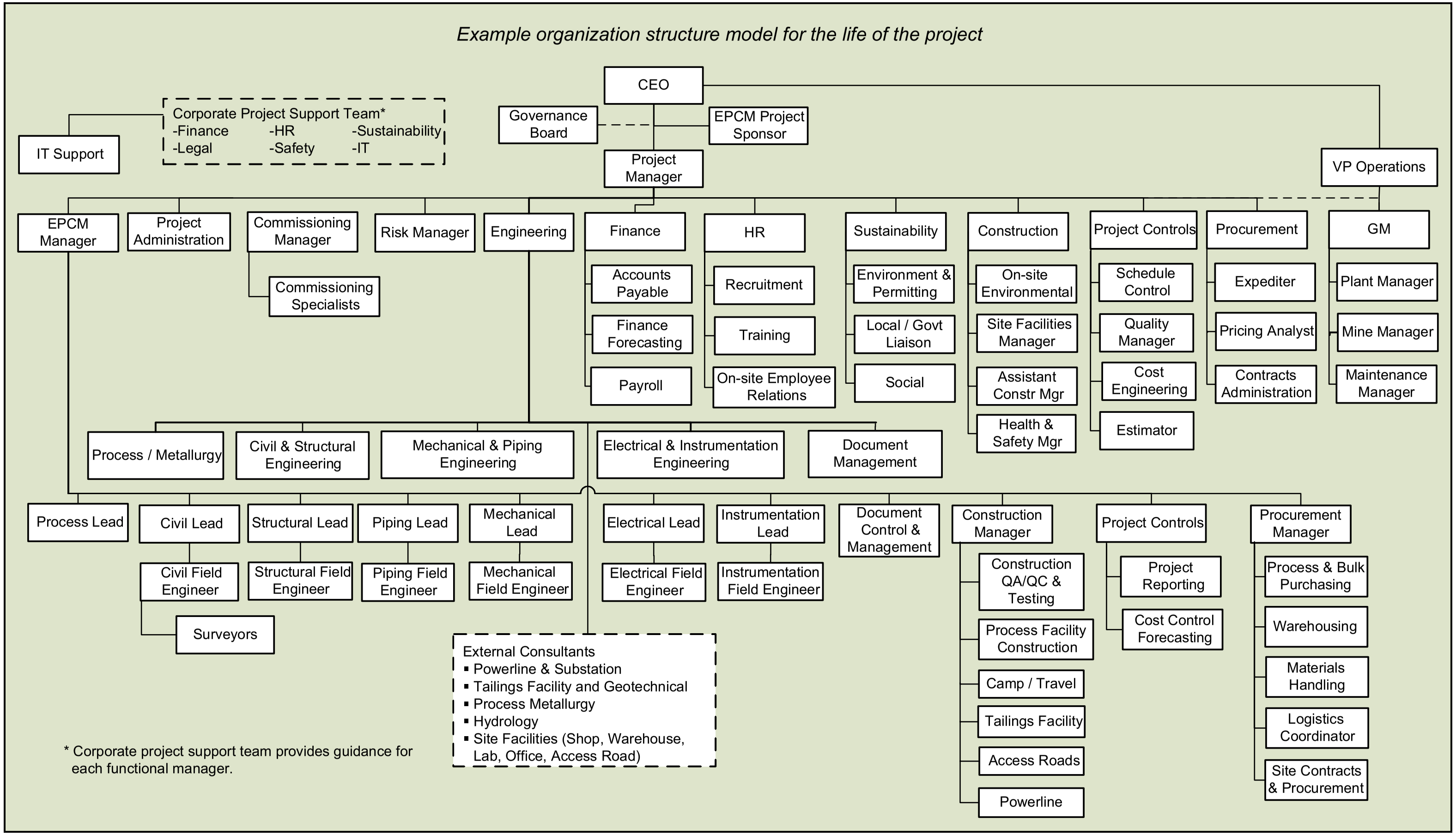


FIGURE 18.1 Project organization—greenfield project

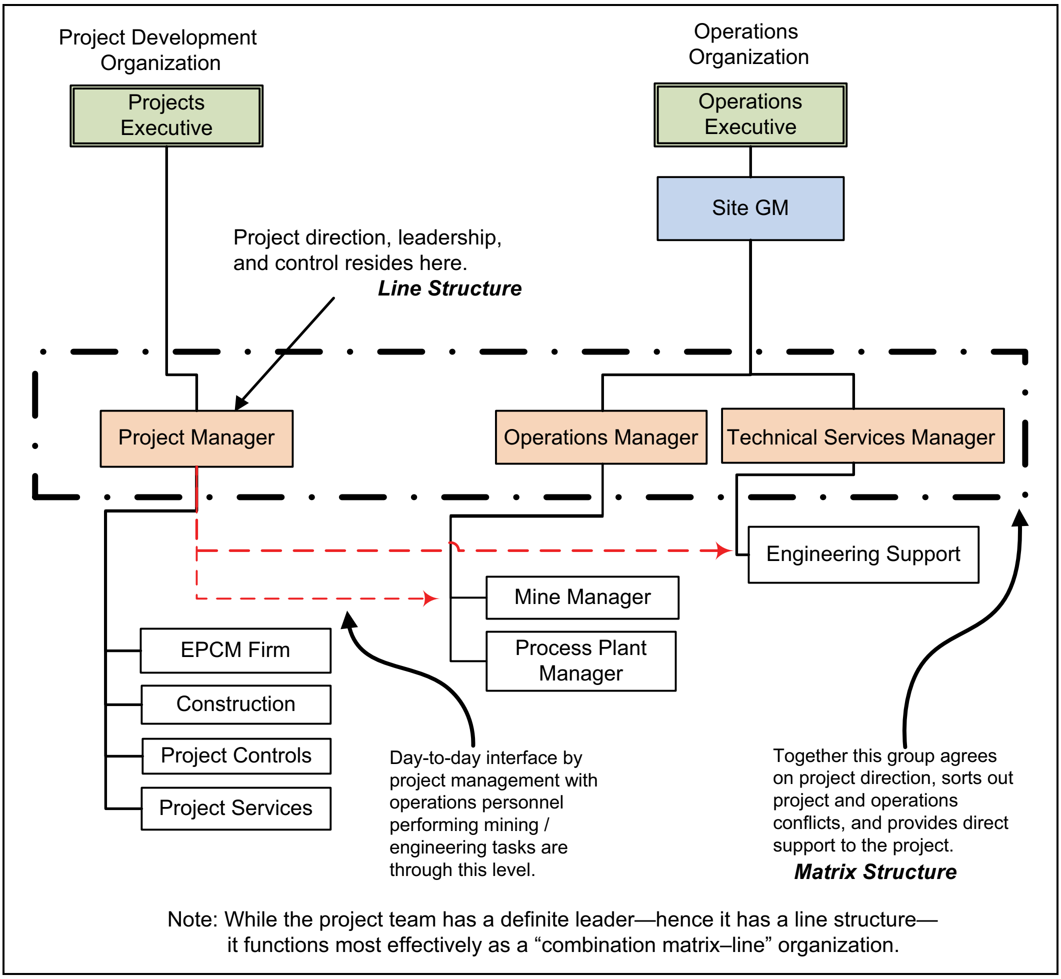


FIGURE 18.2 Project organization matrix—brownfield site

and will reach full peak strength in the overlap period of detail engineering completion and field construction initiation. Figures 18.3 and 18.4 are taken from an actual grassroots mine project in British Columbia in 2013, and they illustrate well the typical buildup and workforce peak to expect.

SPECIALIST CONSULTANTS AND CONTRACTORS

In the majority of cases, the necessary technical and management talent to efficiently manage a project is not available within the mining company organization, so it is normal for the project team to be augmented by specialist consultants and contractors. In fact, the mining company senior management will generally want external oversight, and boards, lending institutions, and stock exchange compliance may even require such.

Specialist consultants have taken on a vastly more significant role in the project execution process in the past 30 years, thanks in part to tightened regulations and legislation, and stricter reporting standards (e.g., NI 43-101 in Canada, JORC [Joint Ore Reserves Committee] Code

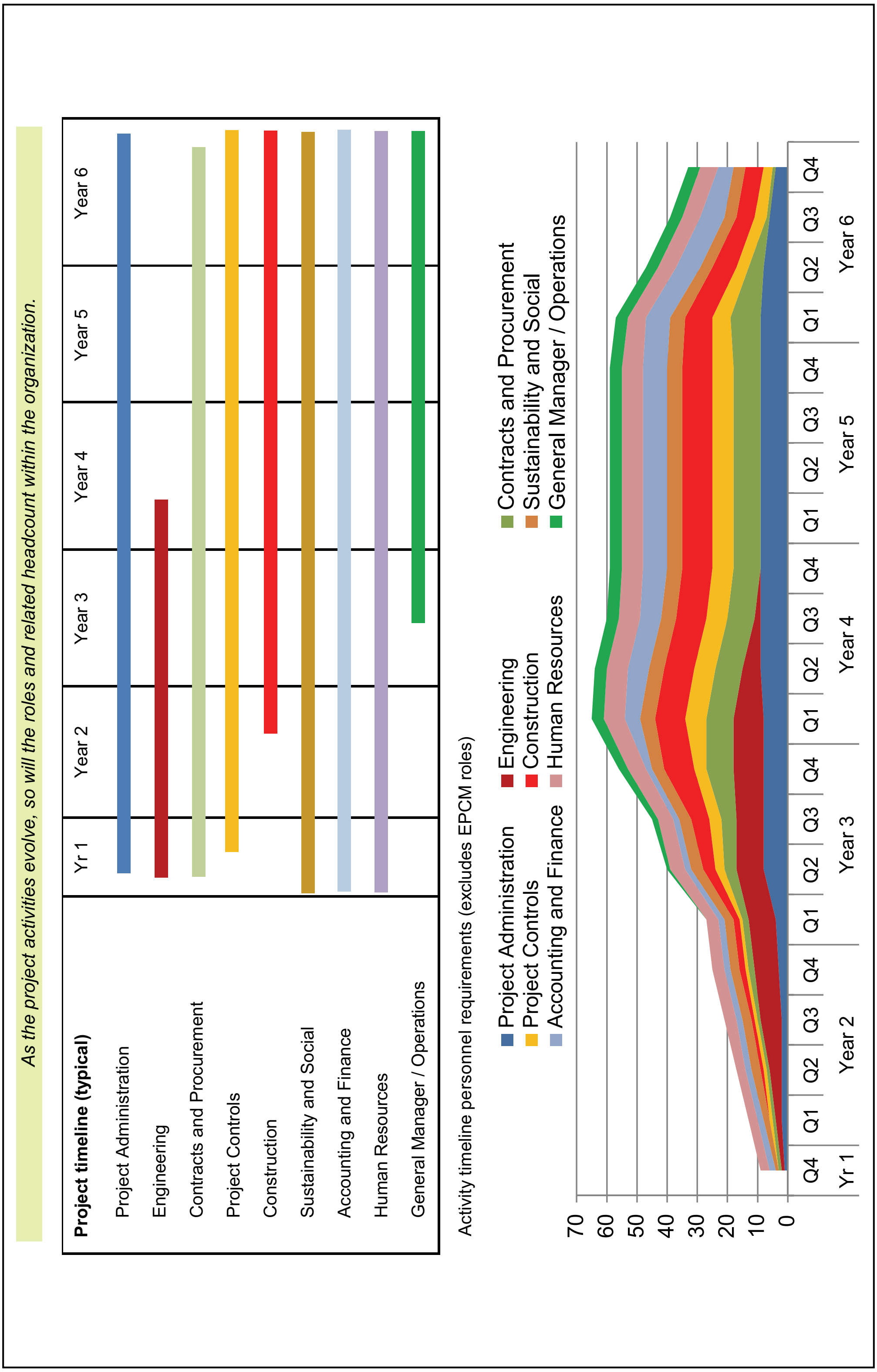
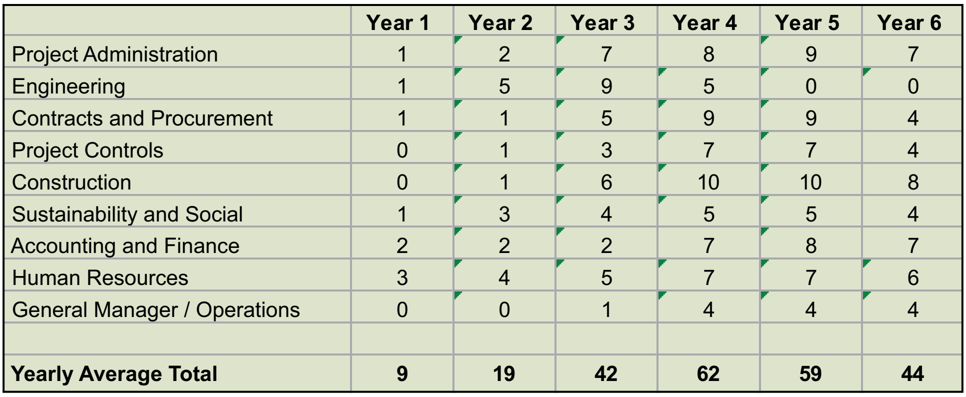


FIGURE 18.3 Project organizational headcount evolution



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Project Administration	1	2	7	8	9	7
Engineering	1	5	9	5	0	0
Contracts and Procurement	1	1	5	9	9	4
Project Controls	0	1	3	7	7	4
Construction	0	1	6	10	10	8
Sustainability and Social	1	3	4	5	5	4
Accounting and Finance	2	2	2	7	8	7
Human Resources	3	4	5	7	7	6
General Manager / Operations	0	0	1	4	4	4
Yearly Average Total	**9**	**19**	**42**	**62**	**59**	**44**

FIGURE 18.4 Project organization headcount evolution example

in Australia, and the Sarbanes–Oxley Act in the United States), but more so from the diminishing skill base within the traditional mining houses.

During the past three decades, the attitude of mining companies toward independent consultants has had to change dramatically (Lovejoy and McCarthy 2013). Thirty years ago, mining companies were the repository of technical expertise—they generally did not need outside advice. But this is no longer the case. In response to commodity down cycles, to stay competitive, mining companies removed their “nonessential,” nonproduction personnel from their ranks. To bridge this knowledge gap, the companies now have to bring these furloughed individuals, in essence their “custodians of the industry knowledge,” back into their fold on an hourly basis to satisfy the mining company’s needs (which really never went away, and certainly not where projects are concerned).

When bringing in specialist consultants to the project team, there are some tenets to follow:

1. Only bring in people that the team leaders know and trust.
2. Be prudent. Introduced experts must add value. Some organizations sell services that put layers of processes in place that only hamper project nimbleness.
3. Maintain skepticism; just because some experts were involved on an earlier large project does not mean that they contributed meaningfully to that project’s success. Check references.
4. Look out for project team members who are reluctant to embrace experts and/or are unwilling to be challenged. Expert help should be welcomed, not attacked.

When EPCM personnel, specialist consultants, and construction contractors are brought into the team, professionally facilitated alignment sessions (e.g., partnering) need to be invoked rather than confrontational approaches. Projects cannot succeed without all parties working together in an open, shared-problem atmosphere. A proactive approach is needed for issues.

SUPPORT RESOURCES FROM WITHIN THE OWNER’S ORGANIZATION

Helpful resources for project planning and execution can always be found from within the Owner mining organization:

- Operations
- Exploration

- Business development staff
- Corporate and operations support departments
  - Legal
  - Controller
  - Treasury
  - Environmental affairs
  - Information technology
  - Sourcing
- Internal project management group (if such exists)

Owner personnel possessing the requisite project skills and/or operations people wishing or needing to acquire project management skills should be given, whenever possible, full consideration in filling appropriate project positions.

Two cautions, however:

1. A mining project, particularly a grassroots, international project, is not well suited as a teaching medium for untrained personnel. There is a onetime opportunity to get a project right. Key personnel assigned to lead the project team need to have the skills to immediately function at a 100% level. On-the-job training for persons appointed to key positions can rarely be accommodated. (Question: So how does one acquire project experience? Answer: By taking on non-key-support positions in multiple project situations over a number of years.)
2. There is a fundamental mind-set difference between successful, steady-state operators and do-it-one-time constructors. Repetition optimizes an operation; but repetition (undertaking what should be a one-off task more than once) kills a project schedule.

Good project people are a rare breed that can function in both the operations world and the construction world. While these project people may not be comfortable for long in a steady-state operations world, they know enough to take a project through its various stages and then get it into a successful operations mode at the end.

It is incumbent on the Owner to recognize the difference between the major project world—with its fast pace and ever-changing work requirements—and its more familiar steady-state operations world. Owners without large project experience who force their best operators into key roles on a project think that they are doing their people and the project a favor, but more times than not, they introduce project shortfalls or worse, project failure.

OWNER'S PROJECT MANAGEMENT GROUP

The main resource for successful project delivery within most major international mining organizations is the Owner's own internal project management group. The role of a mining company's project management group has multiple facets:

- Provide corporate direction to the development and management of projects.
- Ensure that all projects are properly executed and completed.
- Install the appropriate leadership personnel into projects that require board approval.
- Make certain that effective project control systems are in place for all projects.
- Monitor projects for adherence to best practices.

- Supply PEPs and/or audits when requested by operations.
- Give constructive feedback on project performance.
- Create project management training opportunities for operations personnel.
- Nurture in-house project management skills and encourage project career aspirations.
- Maintain a reference library for the company's future projects.

RESPONSIBILITIES, AUTHORITY, AND ACCOUNTABILITY

The precise function and responsibilities of individual team members will vary from team to team, as well as between projects, depending on factors such as experience, project complexity, and Owner preference. The key responsibilities and authority are common in all projects and are as described in the following sections. Detailed responsibilities and accountabilities are best specified for each individual project by using a project management roles and responsibility RASCI chart matrix, such as illustrated in Figure 18.5. The letters in the acronym RASCI stand for the following:

- R = Responsible—person responsible for delivering the project or task successfully
- A = Accountable—person with ultimate accountability and authority (R reports to A)
- S = Supportive—person or team of individuals needed to do the "real work"
- C = Consulted—someone whose input adds value or whose buy-in is needed
- I = Informed—persons notified of results or actions taken but are not part of the decision

A RASCI chart is the cornerstone for devising clear lines of responsibility (Kosmala 2009), as shown in the following list:

- It lays out the role of each player with regard to duties required within the organization.
- It determines ownership of a particular task.
- It promotes teamwork by clarifying roles and responsibilities.
- Everyone can see what their role is in relationship to all others in the organization.
- It improves decision making by ensuring that the correct people are involved.
- It eliminates duplication of effort.
- It improves communications by getting the right people involved.
- It reduces misunderstandings among project team members and stakeholders.
- It helps mitigate project risk and models good management behavior.

Figure 18.5 is taken from an actual RASCI chart used by one of the authors in 2007 for expanding an EPCM organization; a similar chart can be created for developing a mining project.

When creating a RASCI chart, there should be no gaps (i.e., there should not be a line-item activity without an R assigned) and there should be no overlaps (i.e., there should only be one R and one A for each activity).

OWNER

The Owner's role in the team makeup obviously varies if the Owner elects to go with an Owner-directed project rather than selecting an EPCM or an engineering, procurement, and construction (EPC) contractor for project delivery. But certain responsibilities stay with the Owner regardless of delivery model.

RASCI Responsibility Chart Nomenclature

R = Responsible - owns the problem / project. Responsible for making this step in the process happen. The prime mover.

A = Accountable - person to whom “R” is accountable and who must sign off (approve) the work before it is effective.

S = Supportive - can provide resources or play a support role.

C = Consulted - must be consulted, has information and/or capability necessary to complete the work.

I = Informed - must be notified of results, but need not be consulted.

	President & CEO	Sr. VP Operations (Corporate)	Operations Manager (Office)	Technical Manager (Corporate)	Discipline Manager (Corporate)	Discipline Supervisor (Office)	Sr. VP Project Delivery	Project Manager	VP Finance & Accounting	Human Resources Manager	VP Marketing & Client Development	VP Business Development
Business Management (Operations / Administration)												
- Business / Financial Performance												
- Company-wide operations reimbursibility management	A	R	C/S						S		S	S
- Single operation reimbursibility management	C	A	R		S				S		S	S
- Backlog workload forecast	A	R	C/S				C		S		C	C
- Company-wide operations budget management	A	R	C/S	C	C		C		C/S	C	C	C
- Single operation budget management	C	A	R	C	C		C		C/S	C	C	C
- Administrative policy, procedure, and practices implementation		A	R						C/S	C/S		
- People Management												
- Assignment of personnel to projects		A	R	C	C	C	C	C				
- Recruiting and hiring	C	A	R	C	C	C	C		C/S	C/S		
- Development of personnel (employees)	C	A	R	C	C	C	C		C	C/S	S	S
Technical Management (Technical)												
- Standards and Technical Knowledge												
- Establish and maintain the engineering standards		C/S		A	R	C						
- Maintain quality process to ensure standards are met	C	C/S		A	R	C						
- Establish and maintain technical libraries (paper & electronic)	S	C/S	S	A	R	C						
- People and Related												
- Hire and develop qualified people for each engineering discipline			C/S	A	R	C			C	S		
Project Delivery Management (Projects)												
- Assign project managers to projects		A	R	C/S	C/S	C/S	C/S	C	I	S	S	S
- Establish and maintain the project management process	S	A					R	I		C/S		
- Identify project managers to hire. Install process to develop them	C/S	A	C/S	S	S	S	R	I	C/S	C/S		
- Maintain the process to ensure project quality is delivered	C	A					R	C/S				
- Deliver projects on budget & schedule performance, safely	S	C/S	S	S	S	S	A	R			S	
- Client red phone—to handle client’s project management issues	C/S	A	S				R	C/S			S	
Finance and Administration												
- Financial management / cash flow	A	C/S	I						R	I	I	I
- Establish the budget process	C	C/S							R/A			
- Maintain the office infrastructure		C/S	R						A			
Marketing & Client Development												
- Customer development (time frame of 3 months to 2 years)	A	C/S	C/S	C/S			C/S				R	C/S
- Yes / No decision on business opportunities / proposals	A	C/S	C/S	C/S	S		C/S		C/S		R	C/S
- RFQ responses and RFP preparation	A	C/S	C/S	S	S		S		S		R	
- Final proposal / budget / margin decisions	A	C/S	S	S	S		S		C/S		R	
Human Resources												
- Maintain recruitment and hiring process (incl. skills development)	A	C								R		
- Establish and maintain people development processes	A	C/S	C/S	C/S	C/S	C/S				R		
- Maintain policy, procedure, guidelines, and practices	A	C/S	C	C			C		C/S	R		
- Establish an employee performance / objectives review process	A	C/S	C	C	C		C		C/S	R		
- Take on the employee ombudsperson role												
Business Development (focus 2 years and beyond)												
- Establish new international offices	A	C/S		C/S	C/S		C/S		C/S	C/S	C/S	R
- Meld new international offices into operations	C/S	A	C/S	C/S	C/S				C/S	C/S	C/S	R
- Establish culture of innovation	A	C/S	C/S	C/S	S	S	C/S			C/S	C/S	R
- Identify new international resources (people) for project support	A	C/S	C/S	C/S	C/S		C/S			C/S	C/S	R

Courtesy of McIntosh Engineering.

FIGURE 18.5 RASCI chart—EPCM organization

Owner Responsibilities

The following responsibilities belong to the Owner:

- Provide the physical assets—the mineral deposit, surface lands, and operations expertise.
- Assemble the human assets and tools to achieve the project's goals after start-up.
- Develop the business rationale for the project.
- Select the project manager.
- Support the project manager in procuring project funding (including Authorization for Expenditure [AFE] submission).
- Facilitate the project manager's presentation to the board for project approval.
- Establish the project risk priority ranking.
- Assign project resources as determined and requested by the project manager.
- Provide the operating and process control philosophy.
- Commission the laboratory and pilot-plant testwork to confirm process design.
- Establish the data output requirements for the engineer.
- Sign off drawings, specifications, purchase orders (POs), contracts, and so forth, within the time schedule allotted.
- Approve scope changes (and funding) before the changes can be implemented.
- Demonstrate proactive support for the project and the project team at all times.
- Take responsibility for commissioning and start-up, after "practical completion" (see Chapter 29).
- Implement training programs for the future project facilities personnel.
- Ensure that personnel needs (transfers, training, etc.) are complete before start-up begins.
- Have operating and safety procedures and maintenance programs in place before start-up.
- Perform all mine development, surface prestripping, waste dump preparation, tailings dam facility construction, and so forth, as necessary for the plant facility operations to start up.
- Have purchasing and warehousing personnel and procedures in place before start-up.
- Create the set of necessary management reports for operations start-up and ramp-up.
- Participate in project audits. Assess project performance.
- Assign one or more full-time Owner employees to represent the Owner on the project. These assigned persons take on the following:
  - Represent the Owner for all aspects of design evolution and finalization.
  - Lead the operability reviews during the engineering drawing phases:
    - Ensure that a plant-savvy operator is involved throughout design phase.
    - Bring in a maintenance person from operations for maintainability.
    - Confirm basic equipment selection, size, and configuration.
    - Confirm surge capacity, installed spares, spare parts, and supplies.
  - Participate in hazard and operability (HAZOP) reviews.
  - Sign off drawings, specifications, POs, contracts, and so forth, on behalf of the Owner.
  - Help resolve conflicts between operations personnel and the project team.
  - Obtain the necessary operating or maintenance personnel for commissioning.
  - Produce and then implement the operations readiness plan.
  - Make acceptance decisions on the project manager's certification of completion.

Owner Performance Measures

The concept of success for a completed project depends very much on one's area of responsibility. The Owner will measure success on the basis of overall long-term operating performance and sustainability, that is, the business performance of the completed project:

- An operations start-up and ramp-up that delivers full facility operability
- Project achievement of the stated production and cost objectives
- Validity of the original project assumptions
- Risk management and risk mitigations performed to stakeholder satisfaction
- Strategic fit of the project into the overall corporation
- Delivery of saleable, profitable new products; emission reductions; and so forth

Several of these accomplishments can only be measured by business audit after project completion, so they fall outside the domain of the project manager, but the project manager still needs to know how the client, the Owner, defines success.

LEADERSHIP

The characteristics of a successful project manager were introduced in Chapter 1. The single most distinguishing attribute needed is leadership (Guzman 2012a). The following leadership qualities serve the project head best:

- The ability to define the project vision and to motivate people to go in that direction
- A willingness to build relationships with the stakeholders and sell the vision
- An awareness of the environment and a readiness to embrace a country's culture
- Verbal confidence coupled with a desire to be in charge
- The capability to integrate project management skills with emotional intelligence
- An aptitude to build competencies via situational experience and multiple assignments

While it is accepted in many quarters that some individuals are born with innate leadership skills, it is actually by training and practice that people can learn these skills. But it will be easier for some than for others. Scientific studies show that certain personality types with specific traits have natural preferences that can more easily lead to competency in project leadership (Gehring 2007). Attributes and characteristics that have been shown to make the most effective project leader include the following:

- Be task driven. Job One is to complete the project.
- Thrive on relationships and influence.
- Have the ability for both conceptual and analytical thinking.
- Be able to perform several diverse activities at the same time.
- Believe in yourself.
- Be comfortable in leading a team.
- Use alternative approaches for different team members: chameleon leadership.
- Have an Owner orientation and be capable of changing to meet changed Owner expectations.

It is interesting that most people become project managers by accident. Organizations draft good technical and administrative managers into project manager roles because they were competent at what they did before. But this is not necessarily a good yardstick. Studies show that those project managers who come from situations with a variety and complexity of activities tend to evolve into better project managers than those who come from functional management environments.

However, having a project manager with all the desirable competencies still does not guarantee project success. A competent manager in a dysfunctional organization can easily end up with an unsuccessful project. But it is almost guaranteed that an incompetent project leader will deliver an unsuccessful project. Moral: choose your project leader well.

One challenge that is difficult to overcome is transferring leadership skills from small firms and small projects to large organizations and large projects, and vice versa (Turner and Crowley 2007). Project managers in small organizations tend to have to cover more roles and duties, requiring more self-reliance and less willingness to delegate; thus, their leadership abilities tend to be stymied by the bureaucracy of large projects and organizations. On the other hand, project managers from large organizations tend to be more specialized and are used to having access to deeper resources; thus, they tend to run into difficulties when they have to do some of the other project duties themselves. A key determinant of success or failure in the project leadership assignment is how thoroughly the needs of the individual match the needs of the position.

PROJECT MANAGER

This book subscribes to the *strong project manager* concept, in which the responsibility for project results is vested in the project manager, from inception through completion. The project manager directs and manages the project team and is responsible for the design, quality, execution, and delivered performance of the approved project scope. The project manager has the overall responsibility for meeting the Owner's requirements and completing the project within budget and on schedule. Bottom-line accountability for the success of the project resides with the assigned project manager.

Project Manager Responsibilities

The principal functions of the project manager are as follows.

Plan the project. Planning takes the overall project requirements and divides them into manageable elements (within the work breakdown structure). Effective planning avoids unnecessary crises and anticipates problems that cannot be avoided, making them easier to control. Good planning involves the following elements:

- Develop the project AFE and funding requirements with the Owner's team.
- Prepare, control, and route the AFE documentation.
- Define, with the Owner, the project's outcome expectations.
- Establish the project plan in all aspects, for example, scope, schedule, budget, and quality.
- Ensure that the project is accurately budgeted and technically sound.
- Determine the skill sets required on the project.
- Produce the PEP.

Administer the contract(s) for engineering, procurement, and construction services. The project manager selects and communicates with the qualified candidates, sets out the project requirements and concerns along with key target dates, and develops the scope of services for the bids. Ideally, the project manager handles the contract negotiations with the selected bidder(s):

- Manage the bidder selection process and contract awards for the Owner.
- Ensure that contract terms are followed; secure supplemental agreements as required.

Prepare a control budget and develop a master schedule. These budgets are typically produced in collaboration with the selected EPCM (if such an entity is brought in). The project manager produces forecast updates as necessary.

Organize the project. The project manager develops the organizational structure of the project team and then defines and assigns project responsibilities:

- Procure the project team, external resources, and contractors.
- Prepare staffing forecast requirements for the different project phases.
- Produce an employee handbook outlining in simple language the expected employee conduct on-site and the company programs in effect.
- Determine the need for consultants and external specialists.
- Take the key role in selecting project team members.
  - Review the capabilities of the people that the EPCM proposes to assign.
  - Reach concurrence with the Owner about EPCM personnel who match the project requirements.
- Assemble the project procedures manual.
- Organize and conduct the project kickoff meeting.
- Ensure that team member activities of procurement, scheduling, cost control, capital effectiveness, risk management, and commissioning are truly coordinated with the broader disciplines of engineering and construction.
- Activate the project communications plan.
- Establish and implement proper documentation management and control.
- Ascertain that all requisite licenses and permits are in place, prior to work start.

Lead the project. Once the project is underway, the project manager directs the efforts of the project team. Strong organization, delegation, and communication skills are essential in keeping the project team, the Owner, technical staff, contractors, specialist consultants, and regulatory agencies on track and coordinated:

- Gain and maintain commitment.
- Manage Owner and stakeholder expectations.
- Maintain stakeholder relationships and commitment.
- Represent and speak for the project when dealing with the Owner, contractors, subcontractors, suppliers, manufacturers, fabricators, and/or agencies.
- Delegate. Do *not* take on the Owner's or the EPCM's responsibilities.
- Install accelerated decision-making protocols that support contractor progress.
- Frame the issue, get the proper analysis done, then supply the right expertise.
- Direct project team members in the performance of their project duties.
- Maintain a work environment that fosters innovation and productivity.
- Motivate the team, coach key team members, and bring out the best in people.
- Call and chair project meetings, but participate as a team member.
- Promote team building, and manage personnel conflicts.
- Be the facilitator who nurtures the alignment building or partnering process among the key stakeholders (Owner, EPCM, contractors, key suppliers, etc.)

- Acknowledge and celebrate successes throughout the project journey.
- Maintain a good working relationship and communication with the Owner.
- Remain responsive to the Owner's project objectives.
- At any given time, be able to explain concisely how the project is proceeding.
- Adhere to ethical principles. Absence of malice is an axiom of leadership.

Provide technical supervision. The operational success of most mining projects largely depends on the technical expertise and prowess of the engaged engineering design firms and staff. The project manager must be capable of dealing with a sufficiently advanced level of technical sophistication to gain the respect of the EPCM, specialist consultants, and regulatory agencies, as well as the project team (O'Connell 1997; Guzman 2012a). Proper supervision entails the following components:

- Ensure that project procedures and standards are established and followed.
- Coordinate all conceptual, design, and technical reviews, including HAZOPs.
- Manage the timely delivery of plans, specifications, and all other documents.
- Review project documents for quality responsiveness to Owner directives for
  - Conformance to project requirements,
  - Conformance with industry standards, and
  - Coordination of drawings and specifications within work packages.
- Provide guidance and training to technical staff team members.
- Ensure that daily reports are complete and correct, correspondence and meeting note inaccuracies are corrected, and files are properly archived.

Control the project. As the project progresses, the project manager controls the technical quality, budget, and schedule to ensure that the Owner client remains satisfied and the project objectives will all be met. Ways to control the project include design reviews, HAZOP reports, construction progress and quality analyses, audits, and both formal and informal progress updates. The delegation of tasks from the project manager to other team members demands close control to ensure proper coordination of all project elements:

- Take appropriate actions to maintain project schedule and budget.
- Establish formal dispute resolution tactics early in the project life.
- Discourage scope change.
- Set a thrifty tone early and often. Budget constraints need to be respected from Day 1. Preaching austerity when contingency is depleted is too late.
- Avoid surprises for the Owner and stakeholders.
- Ensure that all project controls are established and implemented.
- Manage project changes.
- Monitor project progress to determine actual work accomplished versus work scheduled, and actual cost versus budgeted cost.
- Communicate project status to Owner, project team, and approved stakeholders.
- Produce weekly flash reports that track and calculate % budget, % schedule, and % project complete based on earned value metrics.
- Be familiar with the insurance coverage and limitations (e.g., deductibles and caps).
- Deal with delay claims and claims for extras promptly.
- Ensure that project reviews and audits are conducted and completed as required.

- Maintain complete records of the work performed. Good records will avoid unfounded contractor claims for extra payment.

Actively manage the project risks. Active management involves these tasks:

- Resolve project challenges and conflicts fairly and expediently.
- Intervene on specific project risks before a crisis occurs.
- Ask tough questions. Assign the right amount of time and resources to mitigate issues.
- Manage the safety program on the project.
- Manage the project risk mitigation action plan.
- Deal with the conflicting necessities of materials scarcity, lack of infrastructure, incessant labor demands, and proliferating environmental stipulations.
- Manage by walking around. This is a great practice for project managers. Get out of the office every day (preferably early, before distractions appear), and walk around and listen at the work site to gain an unfiltered awareness of progress and problems.
- Adjudicate contractor claims and Owner directives, either as change orders or not.
- Be prepared to handle litigation before, during, and after the project.
- Conduct peer reviews of the project at appropriate intervals.
- Monitor the progress of other projects that could possibly impact this one.

Maintain permit compliance and social acceptance. The project manager is charged with ensuring that the concerns of external project stakeholders, local community, and regulatory agencies are satisfactorily addressed:

- Ensure that all necessary regulatory approvals are obtained in a timely way.
- Ensure that Owner policies are observed by project staff.
- Represent the Owner with actions and communications that are conducted in a professional manner at all times. Confidential items must remain confidential.
- Coordinate timely project permit delivery to the Owner, contractors, and agencies.

Manage the project finances. The project manager is the final authority for change orders and contingency drawdown, is responsible for proper accounting of project costs, negotiates all contractor claims, and approves all purchase orders and project payments. Properly managing the project finances involves the following:

- Approve project-related overtime and expenses.
- Monitor billings and collections.

Close out the project. The project manager ensures that all aspects of the project are properly and timely completed and closed out, in accord with established procedures:

- Ensure that all completion protocols and precommissioning activities are fully completed by the constructors and properly signed off before Owner acceptance.
- Support those responsible for start-up of the new operations facility.
- Ensure that the Owner has completed the necessary operating and safety procedures, maintenance programs, and training before initiating start-up.
- Conduct the final project evaluation and closeout audit. Provide a report to the Owner within 60 days of project completion.

- Capture the learning and document the lessons learned. What was done right? What should be done differently next time?

Project Manager Limitations

Decisions involving major risk to the project and/or Owner's company must be reviewed and approved by the appropriate level of Owner management higher than the project manager. The governance policy spells out the level; it will typically depend on the degree of risk. Decisions involving major scope changes to the project will similarly need review and approval from the appropriate level of Owner management above the project manager.

The Owner's public affairs personnel, rather than the project manager, usually handle releases to the news media and presentations to the community. The project manager should, however, expect to contribute to news media releases and be an active participant in most Owner presentations regarding the project.

Project Manager Performance Measures

The project manager has the authority to implement the approved project and select any external resources within the established scope, costs, and schedule restraints, using the established procedures and complying with company policies. Accordingly, the project manager is held accountable for all major project decisions and outcomes. This accountability is the basis by which the project manager's performance is measured, that is, the comparison between planned and actual results in project implementation, including the following:

- Budget variance
- Scope variance
- Schedule variance
- Technical performance
- Choice and use of external resources and/or contractors
- Project safety record

These accomplishments are measured by the project's reporting and cost-monitoring systems, the project management audit process, and the Owner's business audits.

Four Sins of the Project Manager

In reverse order of seriousness, here are the top four sins:

4. Letting the job get into trouble. Every project manager is guilty of this sooner or later. No one is perfect.
3. Not knowing the job is in trouble. More serious, but a project manager can learn from this mistake and not repeat it.
2. Knowing the job is in trouble but not asking for help. This is much more serious. Project managers need to curb their ego issues.
1. Hiding the fact that the job is in trouble. This is the most serious sin, which will eventually prove fatal to the project manager's career.

IDENTIFICATION OF THE CRITICAL ROLES WITHIN A PROJECT

Several roles beyond that of the project manager are critical for successful project execution, and these positions deserve attention when assembling the project organization. First, these critical roles have to be identified. Figure 18.6 identifies the most important roles for a typical project and the reasons for their criticality, which essentially relates to the individual's financial and nonfinancial responsibilities during actual project execution and the impacts on the project if these responsibilities are not met (economic loss, damage to company reputation, etc.).

PROJECT CONTROLS MANAGER

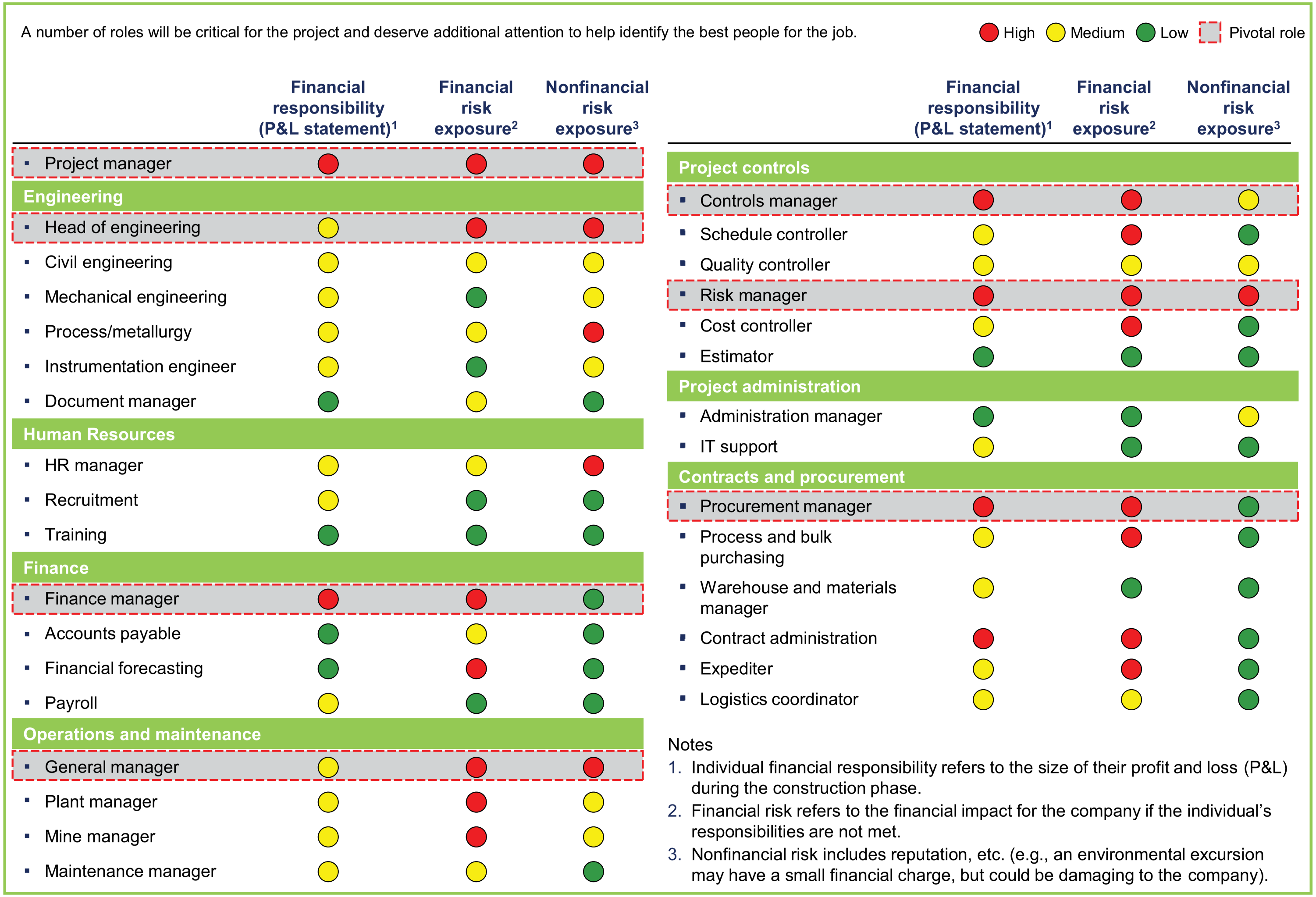
The project controls manager has the responsibility of administering the project's control mechanisms on behalf of the project manager. The principal functions of the project controls manager are described in Chapter 21, in the "Project Controls Team" section.

ENGINEERING MANAGER

The engineering manager (often a project engineer on smaller projects) plans and supervises the overall preparation of schematic, design, and construction documents for the project, in accordance with the project's design procedures and standards.

The engineering manager's functions are as follows:

1. Report directly to the project manager.
2. Act as deputy in project manager absence (when there is no assigned deputy project manager).
3. Establish the design and analysis parameters together with the project manager.
4. Obtain professional engineering license(s), where required. Usually this necessitates the hiring of a registered professional engineer in the particular jurisdiction where the project is to be built, as well as a registered professional engineer in the jurisdiction where the project is engineered.
5. Prepare and/or approve project design criteria.
6. Be responsible for the design data sheets for the project and updates as required.
7. Plan and supervise overall preparation of
    - Calculations,
    - Equipment selection and product evaluations,
    - Analysis of value engineering alternatives and design parameters,
    - Specifications,
    - Drawings (actual drawing supervision is the responsibility of the discipline leads),
    - Coordination with non-EPCM disciplines (e.g., mine pit slope designers),
    - Governmental regulations and/or building code research,
    - Site surveys, and
    - System and design concepts.
8. Stamp and seal drawings (if licensed) or provide the same through others.
9. Provide guidance to other members of the technical team.
10. Give input to construction cost estimates and schedules (but estimating itself is the responsibility of the senior project estimator in the project controls department).
11. Know the limitations of the engineering team and seek specialized help when needed.
12. Ensure that all Owner and EPCM policies, procedures, and standards are followed.



A number of roles will be critical for the project and deserve additional attention to help identify the best people for the job.

🔴 High 🟡 Medium 🟢 Low ▨ Pivotal role

	Financial responsibility (P&L statement)[1]	Financial risk exposure[2]	Nonfinancial risk exposure[3]
▨ ▪ Project manager	🔴	🔴	🔴
Engineering			
▨ ▪ Head of engineering	🟡	🔴	🔴
▪ Civil engineering	🟡	🟡	🟡
▪ Mechanical engineering	🟡	🟢	🟡
▪ Process/metallurgy	🟡	🟡	🔴
▪ Instrumentation engineer	🟡	🟢	🟡
▪ Document manager	🟢	🟡	🟢
Human Resources			
▪ HR manager	🟡	🟡	🔴
▪ Recruitment	🟡	🟢	🟢
▪ Training	🟢	🟢	🟢
Finance			
▨ ▪ Finance manager	🔴	🔴	🟢
▪ Accounts payable	🟢	🟡	🟢
▪ Financial forecasting	🟢	🔴	🟢
▪ Payroll	🟡	🟢	🟢
Operations and maintenance			
▨ ▪ General manager	🟡	🔴	🔴
▪ Plant manager	🟡	🔴	🟡
▪ Mine manager	🟡	🔴	🟡
▪ Maintenance manager	🟡	🟡	🟢

	Financial responsibility (P&L statement)[1]	Financial risk exposure[2]	Nonfinancial risk exposure[3]
Project controls			
▨ ▪ Controls manager	🔴	🔴	🟡
▪ Schedule controller	🟡	🔴	🟢
▪ Quality controller	🟡	🟡	🟡
▨ ▪ Risk manager	🔴	🔴	🔴
▪ Cost controller	🟡	🔴	🟢
▪ Estimator	🟢	🟢	🟢
Project administration			
▪ Administration manager	🟢	🟢	🟡
▪ IT support	🟡	🟢	🟢
Contracts and procurement			
▨ ▪ Procurement manager	🔴	🔴	🟢
▪ Process and bulk purchasing	🟡	🔴	🟢
▪ Warehouse and materials manager	🟡	🟢	🟢
▪ Contract administration	🔴	🔴	🟢
▪ Expediter	🟡	🔴	🟢
▪ Logistics coordinator	🟡	🟡	🟢

Notes

1. Individual financial responsibility refers to the size of their profit and loss (P&L) during the construction phase.
2. Financial risk refers to the financial impact for the company if the individual's responsibilities are not met.
3. Nonfinancial risk includes reputation, etc. (e.g., an environmental excursion may have a small financial charge, but could be damaging to the company).

FIGURE 18.6 Critical project roles

13. Be responsible for adherence to all applicable codes.
14. Be responsible for quality of design calculations, design elements, and drawings.
15. Perform quality reviews for
    - Conformance with requirements of Owner standards,
    - Responses to Owner requests,
    - Engineering calculations (obtain calculation checks from third parties), and
    - Synchronization between drawings and quantity estimates.
16. Be responsible for the accuracy of each segment of the engineering work.
17. Be responsible for the final check of the engineering deliverables.

OTHER KEY MEMBERS OF THE PROJECT TEAM

The principal functions of the other key players within the project management team are covered within the relevant chapters of this book that deal with their duties:

- Procurement, sourcing, and logistics advisors—Chapter 28
- Contracts administrator—Chapter 20
- Scheduler—Chapter 10
- Construction manager—Chapter 29
- Electrical and instrumentation specialists—Chapter 30
- Safety supervisor—Chapter 29
- Owner operations and maintenance liaisons—Chapter 33
- Environmental liaison—Chapter 8
- Project accountant—Chapter 21
- Owner assets accounting representative—Chapter 32

Early recruitment for the project team members is a key aspect of properly setting up the project. Recruitment activities need to account for the hiring lead times as well as the anticipated duration of employment for each position. Figure 18.7 illustrates the kind of effort that needs to be undertaken to get the project construction management team timely in place. Similar efforts would be needed for the engineering, procurement, and commissioning phases, as well as for the project administration (human resources, finance, information technology, etc.), project controls, and contract management functions.

PROJECT SPONSOR

When a project uses an EPCM firm, the EPCM assigns an executive of its company as project sponsor. This person has the ultimate responsibility to the Owner for successful execution of the EPCM project work scope and to the EPCM for the firm's actions.

This sponsor is the ultimate go-to person for the Owner if the EPCM project manager (and/or the project) is not performing to the Owner's satisfaction. As such, the Owner needs to take great care in agreeing to a nominated sponsor candidate. The Owner needs to ensure that the sponsor has the necessary power and position to make the appropriate changes in the event of EPCM underperformance.

The project sponsor responsibilities and duties include the following:

1. Determine whether to seek and/or accept the project work.
2. Verify initial viability of the project and the client's financial soundness.
3. Establish EPCM objectives for the project, including compensation for services.

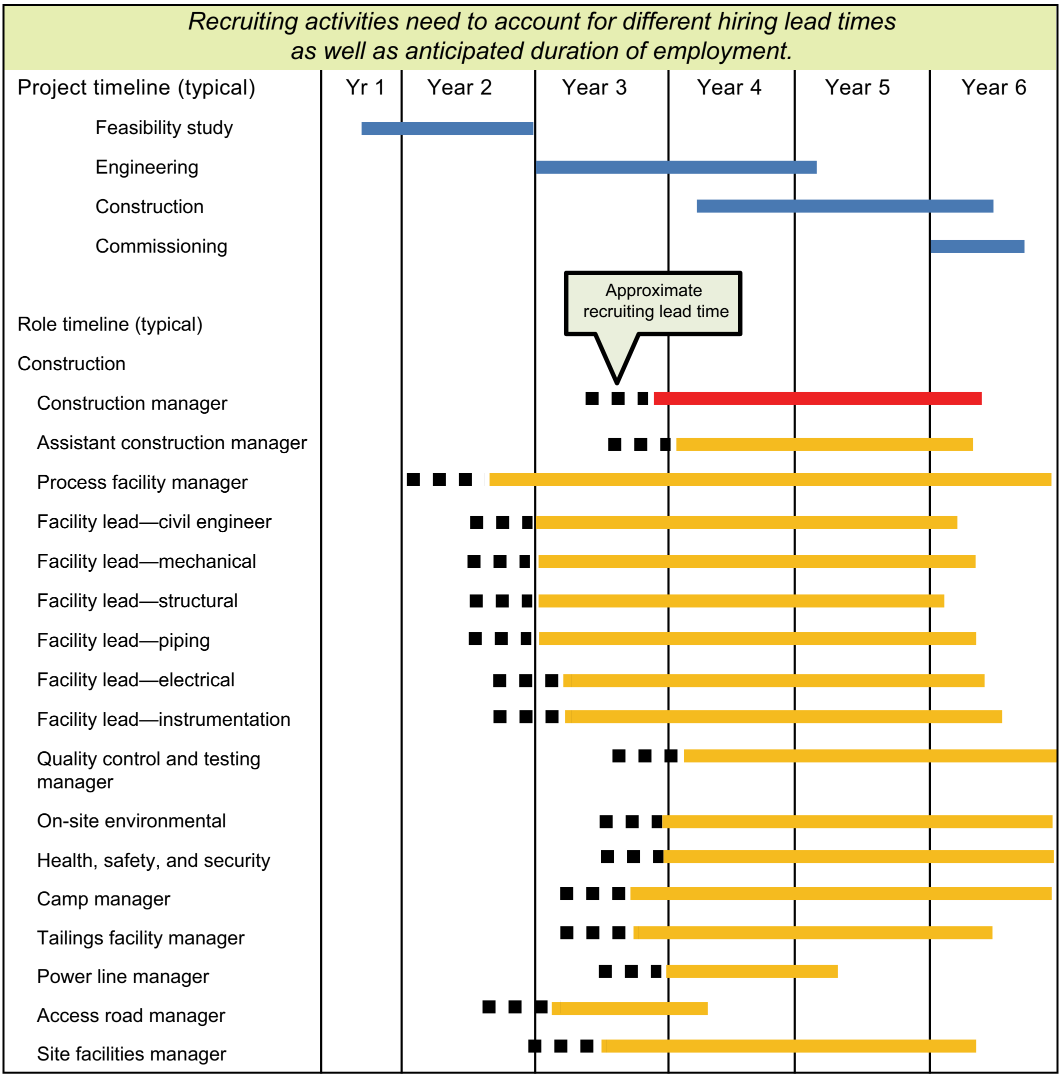


FIGURE 18.7 Recruitment chart—for construction

4. Present the EPCM proposal and the EPCM project manager candidate to the Owner.
5. Establish a mutually agreed-on project scope for the EPCM with the Owner.
6. Negotiate the contract agreement for services with the Owner.
7. Assign and supervise the EPCM project manager.
8. Provide guidance to the EPCM project manager for execution of project tasks.
9. Take necessary measures to remedy issues with EPCM project manager performance.
10. Approve or direct the activities of the EPCM project manager, including
    - Assignment of the principal team members;
    - Project work plans, including schedules and budgets;
    - Project criteria and specifications;
    - Subcontracts for EPCM services and contract adjustments;
    - Management of project consultants;

  - Invoicing and collections; and
  - Issuing change orders and bid award.
11. Keep informed of project status, including plans, accomplishment, expenditures, team management and Owner relations, to ensure satisfactory project progress.
12. Review the planned work and the results over the duration of the project.
13. Ensure that the finished deliverables meet the quality standards of the Owner and EPCM.
14. Allocate peer reviewers for project performance appraisal, as required.
15. Monitor project problems and sensitive issues until resolved.
16. Provide guidance to the EPCM project manager for correcting project problems.
17. Serve as a confidant to the EPCM project manager on potential moral or ethical issues.
18. Guide and enable the EPCM project manager's career aspirations.
19. Together with the project manager, identify EPCM personnel performance deficiencies and training needs.
20. Assign a replacement EPCM project manager, when necessary.

To enable the sponsor to properly carry out his or her duties, the sponsor is required to be involved at all key stages of the project, not just the kickoff meeting and the final review. The sponsor has to understand the project and the client (i.e., the Owner). Therefore the sponsor must participate in presenting proposals, attend the project orientation sessions between the Owner and the key project and engineering design staff at project start, and if possible, go on at least one site visit. The PEP should specify the internal checkpoints where the sponsor will review the methodology and results of each completed project phase, before the commencement of any subsequent phase. If work requires expert or peer review, it is the sponsor's task to determine if this has been properly completed.

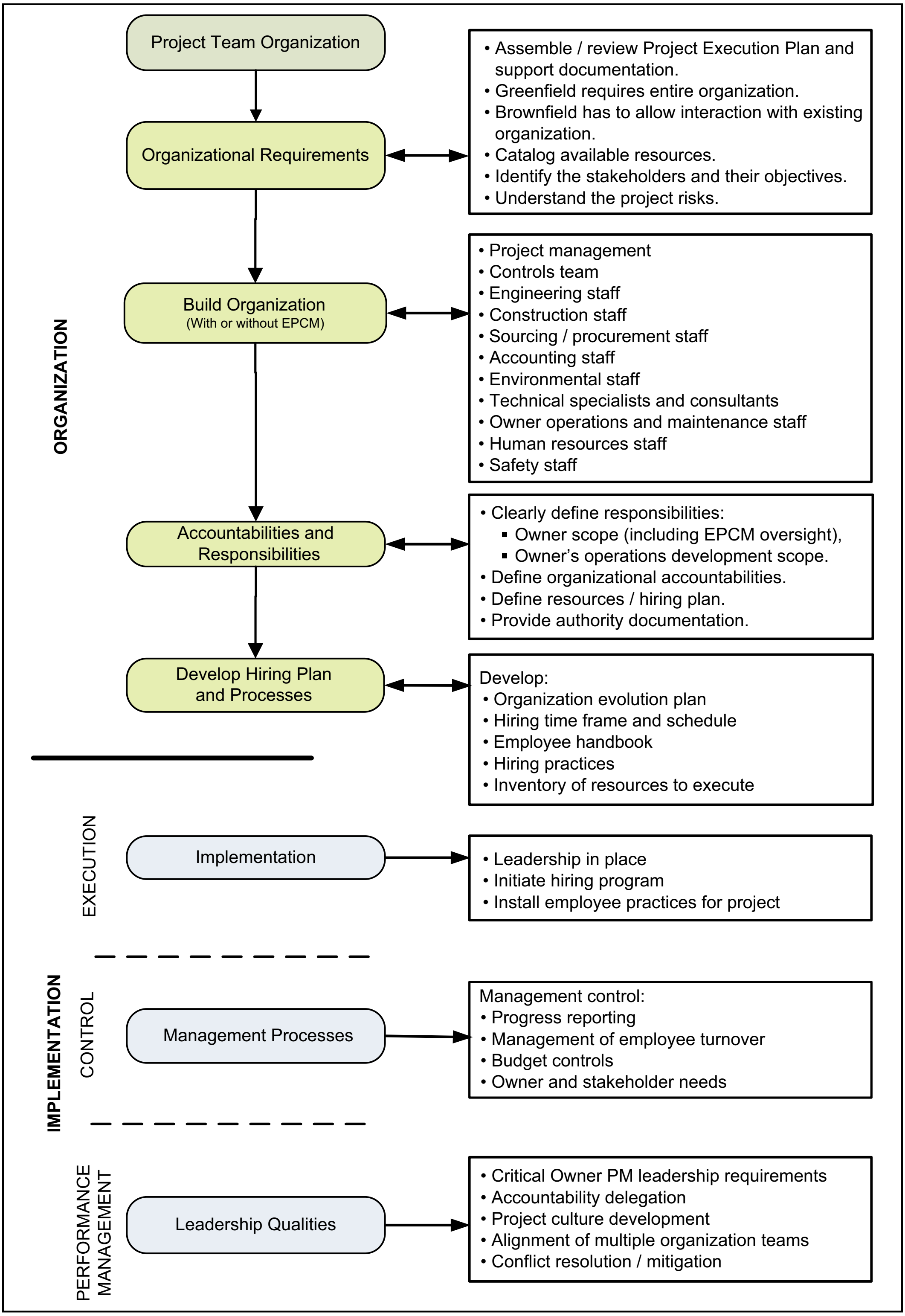
Key correspondence between the EPCM project manager and the Owner, as well as between the EPCM project manager and the construction contractor, should be copied to the project sponsor. The sponsor has to maintain contact with the progression of the work. This requires receipt of the weekly flash reports and frequent informal meetings with the EPCM project manager. If the sponsor is doing his or her job, there are no surprises. The degree of sponsor involvement is determined in part by the size and complexity of the project, and in part by the level of experience of the assigned EPCM project manager.

BONUS INCENTIVES FOR TEAM PERSONNEL

Bonus incentives for achievement of successful project completion are worthwhile. The bonus needs to be established up-front, when recipients have the maximum chance of influence over outcome. The bonus should not be set, however, until after the project scope has been set in the approved feasibility study. A bonus scheme should include key EPCM and Owner staff (though they will almost certainly be administered through separate programs).

CHECKLIST 18.1 TEAM ORGANIZATION

No.	Item	Status	Date	Initials
1	Project execution plan—reviewed and consensually accepted by all			
2	Owner's internal resources—identified			
	A. Owner resources that will be part of the project team			
	B. Owner corporate resources to support project team			
3	Stakeholder objectives and expectations—understood			
4	Organization structure (Owner—EPCM—others)—developed			
	A. Size of team appropriate for project			
	B. Organization based on greenfield or brownfield requirements			
5	Dedicated organization—assembled			
	A. Project manager			
	B. Project management core leadership (including risk management)			
	C. Schedulers and cost estimators			
	D. Project administration			
	E. Accounting (including Owner assets representative)			
	F. Project controls			
	G. Quality management			
	H. Contracts administration			
	I. Engineering (including engineering manager)			
	J. Procurement (expediting, logistics, materials management)			
	K. Construction (including construction manager)			
	L. Environmental and permitting liaison			
	M. Social and sustainability (including government relations)			
	N. Security			
	O. Technical specialists and consultants			
	P. Human resources (including labor relations)			
	Q. Health and safety			
	R. Owner operations and maintenance liaisons			
	S. Future operations (commissioning, start-up, and ramp-up)			
6	Project sponsor—appointed (an executive with authority to effect change)			
7	Individual team member accountabilities and responsibilities—defined			
	A. RASCI chart—created			
	B. Authority documentation—in place			
8	Hiring plan—in place			
	A. Hiring time frame and schedule—established			
	B. Employee handbook—published			
	C. Up-skilling mechanisms for noncore employees—in place			
9	Management controls for handling personnel issues—established			
	A. Conflict resolution process—prepared			
10	Alignment (partnering) process for kickoff—prepared			



- Assemble / review Project Execution Plan and support documentation.
- Greenfield requires entire organization.
- Brownfield has to allow interaction with existing organization.
- Catalog available resources.
- Identify the stakeholders and their objectives.
- Understand the project risks.

- Project management
- Controls team
- Engineering staff
- Construction staff
- Sourcing / procurement staff
- Accounting staff
- Environmental staff
- Technical specialists and consultants
- Owner operations and maintenance staff
- Human resources staff
- Safety staff

- Clearly define responsibilities:
  - Owner scope (including EPCM oversight),
  - Owner's operations development scope.
- Define organizational accountabilities.
- Define resources / hiring plan.
- Provide authority documentation.

Develop:
- Organization evolution plan
- Hiring time frame and schedule
- Employee handbook
- Hiring practices
- Inventory of resources to execute

- Leadership in place
- Initiate hiring program
- Install employee practices for project

Management control:
- Progress reporting
- Management of employee turnover
- Budget controls
- Owner and stakeholder needs

- Critical Owner PM leadership requirements
- Accountability delegation
- Project culture development
- Alignment of multiple organization teams
- Conflict resolution / mitigation

FLOWCHART 18.1 Team organization

CHAPTER 19

Selection of Project Delivery Provider (Owner, EPCM, or EPC)

Nothing focuses the mind better than the constant sight of a competitor who wants to wipe you off the map. — Wayne Calloway, PepsiCo CEO, 1986

OBJECTIVE

The chapter lays out the rationale behind selection of outside assistance for project delivery such as engineering, procurement, and construction management (EPCM) companies and/or specialist support contractors. It identifies the skill sets required from key external personnel and defines the responsibilities and accountabilities of the provider if selected. The different contract choices with an external provider of services are presented in Chapter 20.

PROJECT DELIVERY PROVIDER OPTIONS

Four classic provider options are used within the mining industry for project delivery, each with its own unique advantages and disadvantages and distinguishing characteristics:

1. Owner
2. EPCM
3. EPC (engineering, procurement, and construction)
4. Hybrid (combination of select parts of prior three models)

Owner

With an Owner-directed project (also known as Owner-integrated project) the Owner is fully responsible for project management and for the integration of all project activities. The Owner contracts with the entities and suppliers necessary to perform project execution through completion; that is, the Owner team owns and manages all site activities. This provider model comes with the following characteristics:

- It requires active project management by the Owner.
- Multiple contracts are held by the Owner; there are multiple contractors for the Owner to align.
- It involves a minimal level of outsourcing during the project execution phases.
- It requires constant active oversight of the contractors by the Owner's team.
- Project success depends significantly on the Owner team.

- The highest risk exposure is to the Owner. Success is very dependent on the Owner team, though risk may possibly be partly diluted in individual contract negotiations.
- It is an effective model for projects driven mostly by a lowest-cost requirement.
- It is good for simple, very well-defined projects using known technology, where the Owner and the construction contractor have a long-standing, successful relationship.
- It is the best model if the Owner wants to protect intellectual property.
- It is often used for open-pit mine development (where the Owner's knowledge is superior).
- It is capable of handling brownfield projects (if the Owner team is reasonably robust).
- It is good for Owners with mature procurement capability and strong purchasing power.
- It is generally not a good model to use on logistically complex projects.
- It is best used on projects in familiar, developed environs with well-understood regulations.
- It is good for projects with company-standard designs and few system interfaces.
- It requires a good supply of qualified contractors with local knowledge.

Owner-directed organizations have been found to be poorly suited for projects where the following conditions are present:

- The volume of work is prodigious, and the scale of project is large.
- The work scope is highly ambiguous, and project execution is complex.
- There are a high number of interfaces between project subsystems.
- Work elements are required to be executed in parallel.
- The work is diverse in terms of required expertise and training.
- Recruiting, retaining, and integrating qualified people is a painstaking process.
- The Owners consist of partners with different cultures and languages.
- The Owner has insufficient resources or experience to manage construction.

To have a chance of succeeding, an Owner-directed project needs

- An aligned organizational structure that does not hinder work flow;
- An Owner with an appetite for actively managing all aspects of the project;
- A willingness to stage the development in manageable chunks if the project is large;
- Clearly articulated roles and responsibilities within the Owner organization;
- A project team that is cross-functional and integrated;
- Effective performance management systems in-house with aligned incentives;
- Top-notch functioning project management systems that sustain effective interaction;
- Highly competitive markets with multiple engineering and construction contractors available both locally and globally, all with strong project management capabilities; and
- A strong relationship between Owner and key suppliers.

EPCM

With the EPCM project delivery model, the Owner contracts with an EPCM provider firm as well as with the project suppliers. The EPCM firm is responsible for providing all aspects of engineering, procurement, and construction management. Even if the contracts are predominantly written between the Owner and the contractors, the contractors and the subcontractors are still normally managed by the EPCM.

The EPCM acts as the Owner's agent and creates the direct contractual relationships between the Owner and the project suppliers and construction contractors. The role of the EPCM is to manage overall project execution to achieve the Owner's objectives (Goodbody 2011).

The EPCM project delivery model has the following characteristics:

- Multiple contracts are held by the Owner, but most are aligned by the EPCM contractor.
- Management of the site construction contractors is outsourced to the EPCM firm.
- There is a medium (or balanced) amount of outsourcing for project execution.
- It requires some level of project participation by the Owner's team.
- Project success is minimally dependent on the Owner's capacity.
- Execution risk is spread and diluted among EPCM and contractors, though exposure to full project risk mostly remains with the Owner.
- It is well suited for projects driven equally by the drivers of quality, cost, and schedule.
- It is best suited for complex projects requiring high degrees of interface and integration.
- It is well suited for large-scale projects and for projects involving technical innovation.
- It provides minimal protection for Owner's intellectual property.
- It is a good fit for process plants with many interdependencies and projects that need exacting control during construction.
- It is capable of handling brownfield or greenfield projects.
- It is generally best for controlling projects where external forces advocate scope changes.
- It needs an EPCM firm with broad procurement capability and strong purchasing power.
- It is an applicable model for a project with logistics complexity.
- It is a good model for projects with geographic uncertainty (geology, climate, cultural, etc.).
- It is the best model for remote projects in undeveloped environments with ill-defined regulations.
- It works best with a good supply pool of qualified contractors with local knowledge.
- It is an adequate model even when contractor availability, capacity, and capability are limited.

EPC

With an EPC-managed project, the Owner contracts with a single contractor to handle all the engineering, procurement, and construction for the defined project scope. The contractor is responsible for all aspects of project delivery including planning, equipment and materials supply, construction execution, subcontractor performance, and commissioning. In other words, the EPC contractor owns and manages all the contracts and site activity.

This model comes with the following characteristics:

- A single contract is held by the Owner; there is only one contractor for the Owner to manage.
- Limited oversight is required by the Owner.
- There is maximum use of outsourcing for project execution.
- It entails minimal project participation by the Owner.
- The Owner's team size will be smallest with this model.
- Project success is not dependent on the Owner team capacity.

- *If* the contractor is qualified, this model represents the least risk exposure for the Owner, but the Owner must verify that the contractor's economic viability and the contract wording truly off-load the risk.
- Contractor execution and contractor risk ownership will result in a contract premium charged to the Owner.
- It is generally a good model for projects with a schedule-driven focus.
- It is usually inappropriate for complex projects with multiple interfaces and integrations.
- It is not appropriate if the Owner wants to protect significant intellectual property.
- It is often used with a lump-sum contract for well-defined, stand-alone project work packages such as access road, power line, truck shop, warehouse, and camp.
- It is generally not suited to brownfield projects, but it is adequate for greenfield projects.
- It is applicable for projects with a very clear scope and no possibility of scope change.
- It is good for projects with industry-standard designs and very few system interfaces.
- It needs a contractor with broad procurement capability and strong purchasing power.
- It is generally not a good model to use on projects with logistical complexity.
- It needs a contractor who is familiar with the geographic locale.
- It is best used on projects in well-developed environments with well-defined regulations.
- It requires one well-qualified contractor with strong local community knowledge.
- It requires a contractor with the ability and willingness to deploy a full contingent of EPC personnel on the ground.

The Owner should select a contractor with a long history of successful large project execution.

Hybrid

The hybrid project delivery model is a catchall term for a project delivery model that combines different aspects of the three prior models. Typically, the Owner assumes a lead role on certain project elements (e.g., design and procurement) and contracts out the remaining elements (e.g., engineering and construction) to various parties. The hybrid model will not be discussed any further within this book, because its actual manifestations are infinite, depending on an Owner's individual preferences.

Figure 19.1 compares two of the key differing characteristics between the Owner-integrated, EPCM, and EPC delivery models, that is, Owner team size and Owner risk.

STRATEGY FOR SELECTION OF PROJECT DELIVERY PROVIDER

The strategy for selecting the entity to deliver the project entails establishing three key linked project elements:

1. **Determine the delivery model that best matches Owner capability**.
   - What gaps exist within the Owner's project skill sets?
   - Which, if any, project value chain steps can or should be done internally?
   - What is the optimal scope split between Owner and contractor?
   - Into how many components should the project scope be split?
2. **Organize the award process.**
   - What elements will make the award process most effective?
   - How many and which contractors and suppliers should be invited?
   - What are the evaluation criteria for selecting the winning contractor(s)?

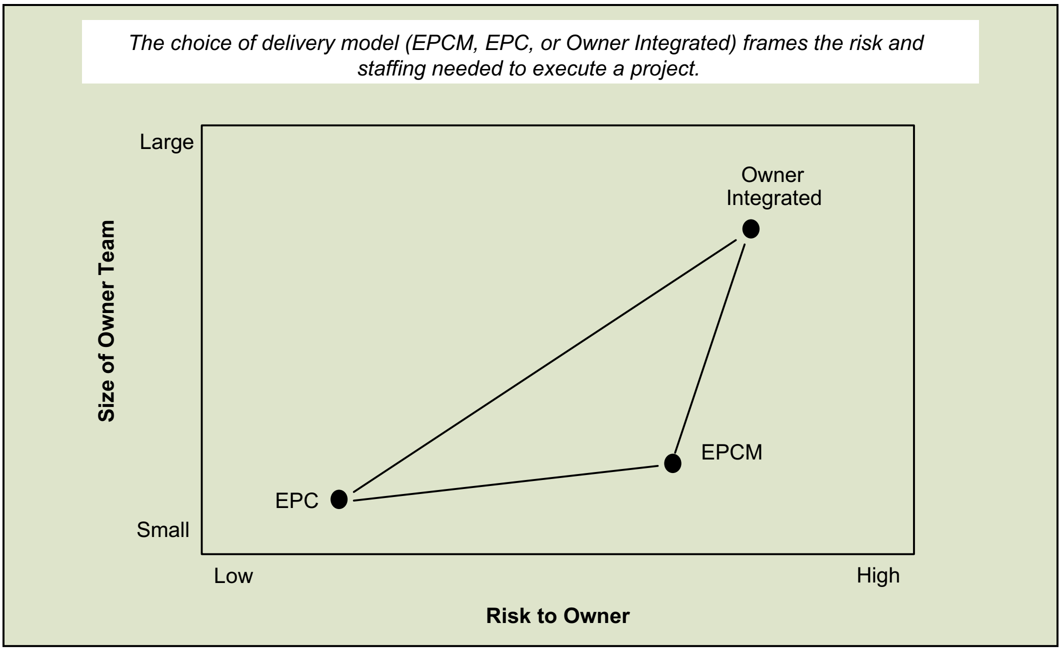

The choice of delivery model (EPCM, EPC, or Owner Integrated) frames the risk and staffing needed to execute a project.

FIGURE 19.1 Project delivery model comparisons

3. **Set the most beneficial contract terms.**
    - Who is the natural owner of the risks?
    - What is the most beneficial contractor–Owner relationship to manage risk?
    - What mechanisms exist to transfer or share risk?
    - Does the Owner prefer to actively manage or off-load risk?
    - How best can Owner and contractor objectives be aligned for efficient project execution (e.g., through compensation, incentives, penalties, and/or warranties)?

SELECTION OF PROJECT DELIVERY PROVIDER

Going through the mechanics of selecting an optimal delivery model is a good practice, even if the Owner ends up with the same provider used during the feasibility study. If nothing else, this process ascertains whether the selection is still valid. The delivery provider decision should be based on four key criteria:

1. **Project characteristics**
    - Project complexity
        - Project uniqueness (level of design repetition or standardization)
        - Technical requirements
        - Number of interfaces between project subsystems
        - Degree of innovation required
    - Clarity of scope definition at project kickoff
    - Project size and value
    - Project geography: familiar or unfamiliar, remote or developed locale?
    - Site conditions: greenfield or brownfield?
    - Social, political, environmental, and human rights issues

2. **Owner capability, capacity, and preferences**
    - Owner's philosophy as to the appropriate level of involvement
    - Owner's aspirations to develop project delivery skills as a core competency
    - Prior experience of the Owner in executing such projects
    - Project management skills of the Owner
    - Project management tools and processes existing within the Owner's organization
    - Functional competency strengths of the Owner
    - Owner technical knowledge to resolve technical issues
    - Owner purchasing power and procurement readiness to handle the project
    - Ramp-up timing preferences of the Owner
3. **Construction and contract environment**
    - Market supply and demand for required services, strength of local supplier and workforce base
    - Lead times for required project components
    - Stability in prices of project components
4. **Project value drivers**
    - Project cost, schedule adherence, and quality requirements are the three main drivers. Is the project driven by just one, a combination of two, or all three?

The project manager leads the process of selecting a suitable delivery model on behalf of the Owner. This is often an appropriate time to bring in an external management consultant such as Ernst & Young or the Boston Group to facilitate the selection process. This can bring comfort to the Owner's management, by showing that a correct path has been chosen.

The characteristics (advantages and disadvantages) of the different project delivery options (Owner, EPCM, EPC, or hybrid) drive the ultimate provider selection. Figure 19.2 illustrates the issues typically considered in the selection of a project delivery provider. (In this example, an EPCM provider is chosen.)

When selecting the project delivery model, there will rarely be a perfect answer. The selection team has to maintain a holistic view of *all* the project characteristics. The delivery model with the best match to the overall details of the project and the makeup of the Owner company determine the right answer. Do not fall into the trap of defaulting the selection on the basis of a single motivating factor without understanding the ramifications of ignoring the other selection criteria. To ensure successful project delivery, it is critical to assess and align the delivery model against the full suite of project characteristics, Owner preferences, and contracting realities.

If the Owner has significant knowledge of the local community, then the model used should leverage that advantage. A project is always best served when an Owner with internal skills and experience retains a voice in the project execution process. Never assume that an EPCM or an EPC firm can bring all the needed expertise to the project location. There will be gaps. Chose a model that can cover the shortfalls. The best approach to take in selecting the delivery model is to

- Use a formal assessment grid to evaluate the project across the relevant set of factors;
- Summarize the findings in a simple display to identify trends and draw conclusions;
- Prioritize the most critical decision factors;
- If necessary, perform a trade-off analysis, then analyze the results for a best fit;

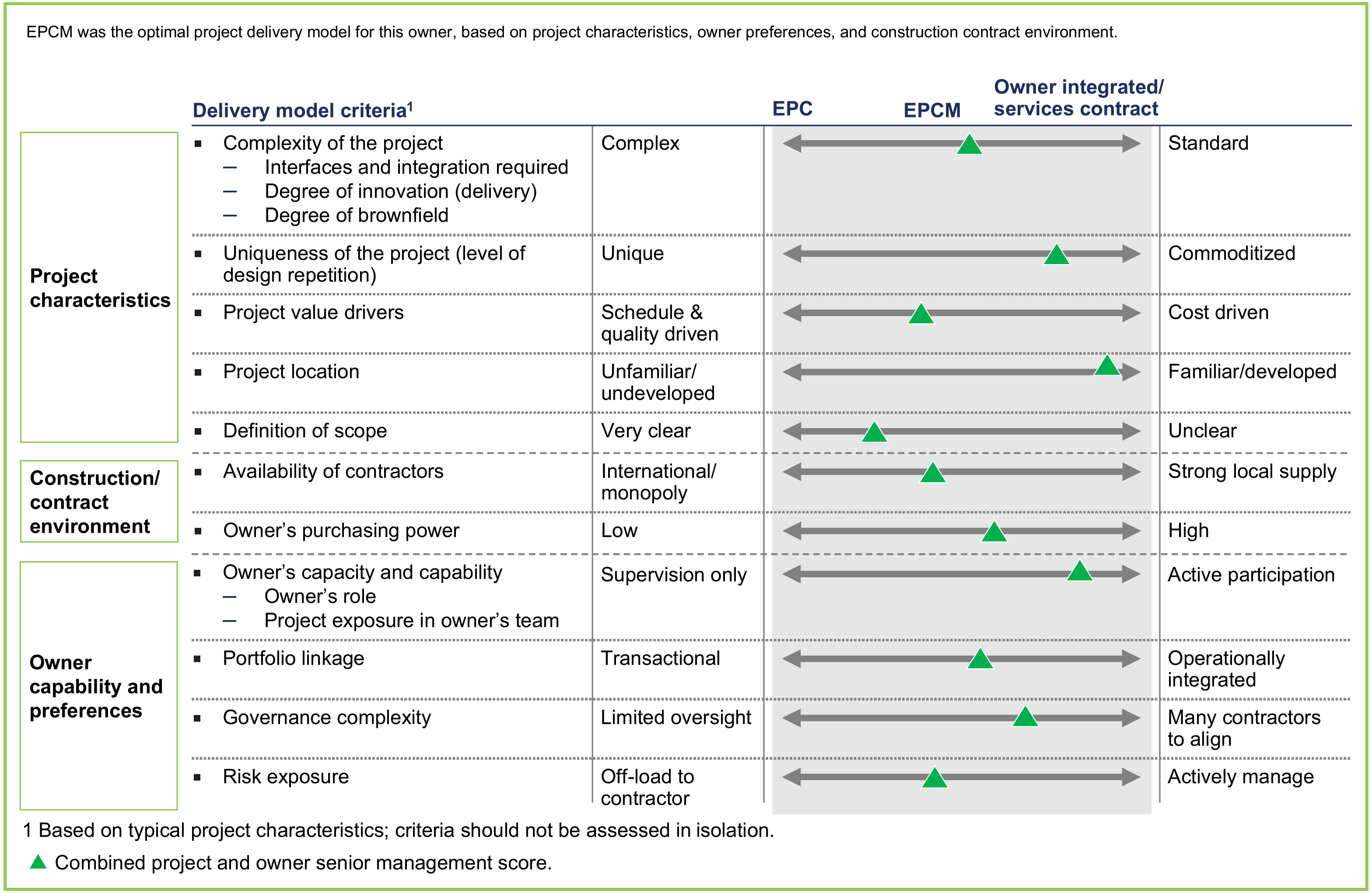


FIGURE 19.2 Project delivery provider assessment

- Select the appropriate delivery model; and
- Review the implications of the selected option.

If the contractor that delivered the feasibility study has the additional skills to provide the engineering effort, then the Owner is often best served by selecting this same contractor to manage all the project delivery efforts going forward.

ADVANTAGES AND DISADVANTAGES OF STAYING WITH THE SAME CONTRACTOR PROVIDER

There are benefits to using a single, qualified entity to deliver all the tasks required for project viability determination *and* for project execution. The advantages include the following:

- Where an alignment between contractor and Owner already exists, an enhancement to the working relationship will always be conducive to successful project execution.
- It provides project continuity.
- There are fewer contracting interfaces.
- The schedule is potentially shorter. The time to bring a new contractor up to speed is eliminated.
- The team that is managing subsequent project phases is less likely to want to change strategy and/or technology.
- Partnering opportunities are enhanced.
- Warranties can be more comprehensive with only one contractor involved.
- A single, continuing contractor arrangement tends to accommodate an Owner with a mind-set of retaining significant influence over project decisions.
- The in-place contractor's desire for more work facilitates negotiations that can yield meaningful price reductions.

The following are some of the disadvantages of staying with a sole provider of contractor services:

- Competitive market forces are not used (the best way to achieve price reasonableness).
- The best skilled contractors are not necessarily chosen for the project execution phases.

Notwithstanding that an EPCM contractor may have already satisfactorily delivered the feasibility study, any proposed continuation of service from the EPCM should always be reviewed by the Owner, to verify that the relationship is still viewed as beneficial. Whether or not the Owner decides to stay with the study provider for the project execution phases, the Owner needs to recognize and take advantage of its negotiating power before any awards are made. Securing the next phase of work with a current client is probably the number-one goal of any contractor. Thus the Owner should use the transition from one project phase to the next to remove existing contractor weaknesses in personnel and/or processes, to garner concessions, and to strengthen contractual relationships.

USE OF AN EPCM CONTRACTOR FOR PROJECT DELIVERY

After going through the discipline of delivery model comparisons for the project, the project manager and the Owner will find that, in the vast majority of cases, the EPCM delivery model will come out the winner. Such is today's reality. The use of an EPC model or an Owner-integrated team is becoming a rarity for project delivery. This does not mean that the exercise of delivery model selection should not be undertaken; it just means the reader should be aware of the likely outcome.

Implications of an EPCM Contractor Selection

Whenever a mining company employs an EPCM firm for project delivery, there are implications for the Owner, for organization design, and for project management strategy.

Governance. The Owner must establish a governance policy, outlining the degree of EPCM autonomy and set in place an audit function to review EPCM performance.

Owner team. The Owner has to establish an appropriately sized, full-time project team for EPCM oversight, without duplication of roles (duplication negates the outsource advantages). The Owner's team has to manage its own activities on the project and approve the contracts, packages, and major purchase orders that the EPCM assembles. The Owner should use the internal strengths and wisdoms of its team, not just for oversight but also in active advisory, vetting, and quality assurance roles to meaningfully support the EPCM. This is particularly useful in the engineering and commissioning phases and will likely be helpful in the procurement and construction phases. In addition, the Owner has to provide and/or make available certain support functions (e.g., treasury, accounting, human resources) to enable the project's roles and responsibilities.

Contracting strategy. The Owner has to develop a contracting strategy that aligns the interests of the EPCM and Owner. The Owner has to set the desired level of Owner involvement in the management of project contracts beyond the EPCM contract. Typically, the EPCM is responsible for writing and tendering all remaining contracts, with the Owner and EPCM negotiating together, and the Owner approving and making the award.

Procurement strategy. The Owner has to set the desired level of Owner involvement in the award of project packages, equipment, and materials. Typically, the EPCM is responsible for tendering all packages and writing all purchase orders (generally on the Owner's paper), with the Owner making each award following the EPCM recommendation. The smaller purchase orders and expense items are typically managed solely by the EPCM.

Risk. The Owner needs to recognize that project performance risk is still in its hands. The EPCM only takes on project execution risk. The Owner should retain management of the high-risk, sensitive elements that affect reputation (environmental permit compliance, community relations, and sustainability), but the Owner can include the EPCM in the actual execution of these initiatives.

Project controls. To be effective, the active management of project controls is best placed with the EPCM. It is generally dysfunctional for efficient project execution for the Owner to retain this responsibility. Certainly, there is disagreement on this issue; often, Owners elect to retain this function even after appointing an EPCM firm. This is not necessarily wrong, but it is not a best practice. Project control can only be fully used as a beneficial tool for successful project delivery when it is managed by the party holding the responsibility to execute the project.

The Owner still has to develop its own cost controls for managing Owner scope (i.e., control processes and personnel). The Owner needs to define its accuracy requirements for the cost estimate and for the schedule in each project phase. This dictates the level of detail required from the EPCM.

Project metrics. The EPCM and Owner have to develop a common, interfaced reporting methodology that supports consistency and allows timely information flow. The interfaces (communications, approval mechanisms, reports, dashboards, etc.) between the EPCM and the Owner have to function effectively from Day 1, and the project metrics must serve the interests of both parties.

EPCM self-perform. The Owner has to make an up-front project governance decision on whether or not it will allow the EPCM to bid on contract packages. Because of potential conflicts of interest and the ethics optics, many Owners forbid self-perform bids from their EPCMs. The authors concur with disallowing EPCM self-perform. If self-perform is allowed, then a checks-and-balance policy with transparent monitoring is needed.

Advantages of an EPCM Contractor Selection

There are several advantages for a mining company that is employing a competent EPCM contractor for project delivery (Goodbody 2013a; Hickson 2000a):

- It prevents the project from being a distraction to the mining company's core business.
- The mining company can expand without hiring additional permanent staff or increasing overhead.
- The Owner team gains immediate access to broad technical and project management expertise.
- Bringing in an EPCM firm offers multidisciplinary engineering design and engineering field support.
- It provides specialist know-how that spans many sectors, far beyond just mining and process; for example, project control, cost and scheduling, contracts management, logistics, purchasing and receiving, construction management, commissioning, quality assurance, security, health and safety, environmental compliance, and project accounting.
- The EPCM is skilled in identifying hazards within new facilities and in running hazard and operability (HAZOP) reviews.
- It increases project predictability, if the EPCM brings in proven execution teams from like projects.
- EPCMs generally have a better capability for hiring the thousands of personnel needed to build a major mine in a timely way.
- EPCMs understand the level of interface management needed between site contractors.
- Some EPCMs can provide the operational and maintenance personnel training needed for start-up.
- EPCMs are familiar with strategic thinking about ways to improve project design and delivery.
- The EPCM understands very well the importance of up-front planning in the project's early stages.
- The EPCM is proficient in establishing and maintaining Web-based project management systems.
- EPCMs are knowledgeable in earned value methodology for reporting accurate project progress.
- EPCMs already possess systems for monitoring and reporting against budget and schedule.
- EPCMs maintain trained staff to expedite and audit the procurement and supply processes.

- The EPCM has honed skills in the management and control of the project change process.
- The EPCM is proficient in handling contractor progress claims.
- EPCMs already have in-house document management and control systems that can handle a project.
- The EPCM can provide the cash flow and financial management systems to satisfy the Owner's financial loan reporting requirements.

From this point on, it will generally be assumed that the contractor chosen to provide the core project services is a single external EPCM company.

The use of a single EPCM company for both engineering and construction, while generally beneficial for successful project outcome, is certainly *not* mandatory. Today's reality, however, is that for most mining projects of any size, after the prefeasibility study, an outside EPCM firm is likely the best resource to successfully deliver all the project tasks through to project completion.

The reason is that today few mining companies and no site operations have personnel who have the time to take on the additional duties of a project or, more importantly, the necessary skills to effectively control a major project. The huge post–World War II mining organizations, such as Kennecott or Consolidated Gold Fields, that had the several hundred trained staff who could comfortably handle such tasks have either disappeared or been downsized to just a few individuals. Within today's mining companies, the muscle to perform well in the project delivery area is simply not developed. Placer Dome in the 1980s, with its project staff of over 100, was probably the last organization that could manage a large Owner-directed project.

This reality makes sense given that most mining companies do not annually grow that much via external additions, so there is little need for them to be accomplished in the full suite of project skills. Consequently, in only a few limited circumstances (mainly small, noncomplex projects) should an Owner's site operating unit consider taking on the project delivery role. Some Owner operations staff may disagree, citing an insider knowledge advantage. But insider operations knowledge, while a key ingredient to a project's success and traditionally residing more within operations personnel than in any outside EPCM entity, cannot be the prime criterion for selection of project management. Saying that "outsiders do not know the facility needs as well as we do" is not an acceptable reason for staffing or trying to control a project with inappropriately qualified personnel from the Owner's ranks. Rather, insider operations knowledge is best inserted into a project by placing key operations personnel into the EPCM engineering office at the earliest of stages as part of the project team. Ideally these "Owner's people" will become the operators of the facility after the project is complete.

Guiding Principles After Selection of an EPCM Firm for Project Delivery

Once the EPCM has been chosen, there are basic tenets to observe:

- Clearly define the interfaces within the Owner organization and outward to the EPCM to minimize opportunities for conflict and miscommunication.
- Keep the layers of reporting to a minimum (ideally less than four).
- Minimize bureaucracy. Enable nimble, responsive on-the-go decision making.
- Avoid duplication of roles. Prevent ambiguity in decision-making authority.
- Match skills and experience to responsibility level. Put the right people in the right roles.

- Avoid building project structure around individuals—a liability if turnover occurs.
- Remember, true collaboration is not created, or limited, by reporting lines.

OWNER AND EPCM PERSPECTIVES ON EACH OTHER

Successful building of a new mine project requires not only a clear understanding of the goal by the participants, but also an awareness of what the two major players, the Owner and the EPCM, are seeking from each other (Hickson 2001a).

Owner Perspective on EPCM Companies

What is it that mining company leaders expect when they select an EPCM company? The answer is simple: competence to successfully execute the project while, at the same time, providing the Owner with real project risk reduction. Generally, the bigger the mining company, the more risk averse it will be. The following are some of the components an Owner looks for within the EPCM organization:

1. **Successful track record**—of completing similar projects on time and within budget
2. **Engineering competence**—instantly available, specific, above-average specialized process and technical skills, that is, those skills that the Owner does not keep in-house
3. **Project management capability**
    - Familiarity with the particular geographic location
    - Experience in building projects of comparable size
    - Knowledge of the selected technical process type
4. **Best team**—a core of key players who have successfully worked together before
5. **Global interacting offices** with genuine willingness to provide skills from all offices, not just the signature office. Owners seek an EPCM organization with offices that can work together worldwide and complement each other to provide a best global solution that maximizes local in-country experience and knowledge.
6. **Real understanding of the request for proposal (RFP) requirements**, not a mere reworded RFP response.
7. **Sourcing prowess**—that is, volume pricing, inspection capability, expediting competence, and logistics skills. The EPCM contractor should have appropriate technical and global understanding of the scope of supply and a sufficient network relationship with vendor firms to provide procurement opportunities as well as to facilitate resolution of potential problems before they become major project issues.
8. **Contracts management proficiency**—acumen to protect the Owner
9. **Qualifications**—the full suite of necessary qualifications (and experience) in-house
10. **Exceptional safety performance track record**
11. **Cost estimation capability**—Getting the budget right, up-front, is key.
12. **Up-to-date in-house cost estimation database**—comprehensive and reliable
13. **Realistic forecasts** of cost, schedule, and process technical performance
14. **Honest cost accuracy**—The figure claimed should reflect work done, not be a wild guess. Any accuracy better than requested will reduce Owner's finance costs.
15. **Project controls**—in-house proven ability to control time and cost
16. **Reliable reporting**—to punctually and accurately report project progress

17. **Quality**—in-house processes and personnel that can reliably deliver a project that meets Owner's requirements
18. **Competitive rates**—EPCM cost is important, but is rarely the final decider.
19. **Value**—provision of services and final product at reasonable cost
20. **Proven advanced technology designs**—the ability to deliver internal know-how
21. **Nonalignment** with a particular technology or subcontractor. Owners mistrust an EPCM's own patent recommendation, even when it is truly the best.
22. **Bottom-line focus**—an EPCM that can think in terms of total project, not as separate phases for engineering, procurement, construction, and start-up. Segmentation of project elements can create gaps. It takes successful execution and meshing of all project phases to achieve a successful project outcome.
23. **Professionalism**—consistent professional behavior and manners
24. **Empathy attitude**—genuine interest to understand and support the Owner's needs
25. **Owner embracement**—willingness to involve the Owner in all project aspects
26. **Partner** that truly desires to align with Owner and all other key project players
27. **Availability**—project manager always easily available for Owner contact
28. **Responsiveness**—prompt reaction to Owner issues
29. **Problem resolution**—anticipates and resolves problems to Owner satisfaction
30. **Sponsor with authority**—who can fix project management issues for the Owner
31. **Longevity**—an unswerving commitment to finish the total project and to stay in the minerals industry—to be there for the Owner tomorrow

EPCM Contractor Perspective on Owners

What does an EPCM contractor hope for when it vies for an Owner's business? The answer is more than just being chosen for the job. Winning the work but then being treated unfairly can be worse than losing. What the EPCM contractor really wants is a better-than-average chance to succeed so that it creates Owner loyalty and will be awarded the Owner's next project (Garrison 2006). So, along with winning the bid, an EPCM seeks the following from the Owner:

1. **Owner that is willing to do things right**—no forcing of the EPCM to cut critical corners
2. **Open and frank communication**—When an EPCM can discern the Owner's latent needs, an opportunity arises to exceed expectations and earn repeat work.
3. **No hidden agendas**—all parties working to the same key schedule dates and budget
4. **Total cost focus, not transaction price**—Quality goes down when the lowest price is most important.
5. **Allowed usage of EPCM's own in-house systems**—that is, their 3D computer-aided design (CAD), document management, materials sourcing, project controls, scheduling systems, and so forth. Forcing an EPCM firm to use another party's system is a major detriment to a successful outcome.
6. **Timely freezing of scope and design**—and then sticking to the freeze
7. **Owner involvement**—an Owner willing to invest substantial time in the project
8. **Owner staff (with design and engineering sign-off roles) sited in EPCM office**—Even in today's cyber world, human interface remains critical.

9. **Partner—**The Owner must view the EPCM as a partner for success, not the enemy.
10. **Open-minded willingness to benchmark and incorporate lessons learned**
11. **Belief in the merit of project controls**—willingness to adequately fund and staff
12. **Willingness to act upon (and issue) negative trend notices**—Owner's project leadership that insists on burying negative trends (to avoid bad news getting to their head office) eliminates the best chance of reducing undesirable consequences.
13. **Realism in setting Owner review times** for design criteria, drawings, studies, bid lists, contracts, purchase orders, change orders, and so forth. Owners who extend their own review times, but still expect the overall schedule to stay on track, are being unfair.
14. **Project completion criteria clearly defined at kickoff**—with concurrence by all
15. **Ability for the EPCM to earn a reasonable profit margin**
16. **Gainshare reward opportunity**—with delivering the Owner's objectives
17. **An honest and realistic Owner**—Too many facts are being spun today. Owners should not demand that the EPCM buy into dubious data as the price of project work.
18. **Owner understanding of the downside risks incurred in fast tracking**
19. **RFP should be a bid document, not a guise for free value engineering**—A billion-dollar RFP costs thousands of dollars to prepare. Asking for multiple rebids is unethical.
20. **Payment of invoices**—A few mining companies do not pay their entire bill. There is a disquieting trend to not pay the final invoice or retention. With retention often greater than the EPCM profit margin, such nonpayment practice can destroy an EPCM.
21. **Litigation or arbitration as the final resolution of differences, not a first step**—Disagreements between Owner and contractor too quickly go to legal resolution rather than to face-to-face settlement by the parties. It seems that any issue is fair game today, whether or not it was in the original work scope. Lawsuits are being filed against EPCM contractors today for project overproduction, for underproduction, for the EPCM not accepting the Owner's data, as well as for the EPCM accepting rather than challenging the Owner's data when they were provided up-front.

DETERMINATION OF CONTRACT TYPE

Part of the development strategy in EPCM (or any contractor) selection is determination of the type of contract to be entered into with the contractor. The advantages and disadvantages of the differing contract types can be found in Chapter 20.

Just remember, however, that risk cannot be fully mitigated by contract or by delivery model selection. For example, in the 1990s a mining company with just two small operating mines began a grassroots effort in South America to construct its most expensive project to date. To hedge their corporate risk (or so they thought), they persuaded an EPC firm that was eager for work to build the facility as a turnkey lump sum. When a third-party consultant identified numerous likely problems with the quality and operability of the facility being constructed, the Owner responded, "No problem. We have been watching them screw up, but the EPC is contractually bound to meet certain operating thresholds, and if they are not met, it is the EPC's nickel to fix." One year after initial construction completion, the EPC had spent an additional 25% over the original budget, but the facility was still only operating at 60% of design and was losing money for the Owner. At this point the EPC balked at assuming any more financial liability, so the matter was eventually settled out of court with the Owner then having to insert millions of its own retrofit dollars into the project, but it still had an underperforming plant to deal with.

Moral of the story: select the right project delivery model and provider at project front end; do not rely on the contract to make it come out right.

STEPS IN HIRING THE PROJECT DELIVERY CONTRACTOR

To engage an EPCM contractor, the following steps should be initiated:

1. Seek requests for qualifications (RFQs) or requests for expressions of interest from potential contractor candidates.
2. Prequalify the bidders.
3. Send RFPs.
4. Interview the bidders and hold a bid-clarification meeting:
    - Structured 1-day site visit with all bidders together at the Owner's location.
    - Informal clarification meeting with each bidder (in bidder's office).
5. Submit and/or present the bids.
6. Evaluate the proposals.
7. Select the winning firm.
8. Finalize the contract.

An activity process flow diagram depicting these contractor selection steps is shown in Flowchart 19.1 at the end of this chapter.

While the focus of this chapter is selection of contracted services for the first stage of project execution (i.e., engineering), the steps discussed in the sections that follow are just as applicable for selecting deliverers of other project activities, for example, scoping evaluations, prefeasibility and feasibility studies, procurement, logistics, construction, and commissioning.

The processes to procure a contractor for any of the above services are essentially similar, but a more explicit bidding process for the critical construction contractor selection step can be found in Chapter 29. The focus herein is the selection of the contractor for the engineering phase. This takes place after the project control documents (Project Execution Plan [PEP] and feasibility study) and project team selection are complete, and the project philosophy has been established.

REQUESTS FOR QUALIFICATIONS

To gauge market interest and to help keep the number of prequalification packages that have to be reviewed down to a manageable level, it is useful to send out an RFQ or to solicit an expression of interest response from perceived qualified bidders. This is an optional step in the contractor-hiring process, and it can be formal or informal; but either way, these solicitations help to cull the disinterested and the obviously unqualified.

An RFQ is also a mechanism for allowing persistent but probably unqualified suitors to be treated diplomatically. It is easier to justify not putting a firm on the bid list when the firm is aware that the project has at least reviewed its qualifications.

An RFQ solicitation should include the following:

1. Owner's statement that a short list of bidders will be selected from the prequalification responses received (commonly termed the *prequals*)
2. Project location
3. Summary scope of work (SOW), including any underlying Owner project objectives
4. List of deliverables required from the bidder during project execution

5. Minimum response requirements expected from each bidder in the RFP, that is,
   - Corporate commitment to meet the project objectives;
   - Company capability statement, listing experience and pertinent references;
   - Bidder's safety record;
   - Organizational chart with the names, roles, and résumés of the probable key personnel;
   - Plan of execution outline (how the project will be executed to meet the SOW); and
   - Identification of the locale(s) where bidder's work will be performed.
6. Expected basis of compensation
7. Contractor licensing requirements
8. Bonding requirements
9. Insurance limits
10. List of documents to be provided with the RFP to the selected bidders, for example,
    - Latest version of the project feasibility study;
    - Technical specifications (including engineering standards and criteria);
    - Safety, environmental, and health requirements;
    - Typical contract terms and conditions required; and
    - Any special instructions or specific criteria uniquely relevant to the project.
11. Desired project schedule, including a listing of the key RFQ deadlines, for example, the date for prequals to be received (needs to be a hard, fixed date) and the date the Owner will notify the EPCM that it is on the short list of qualified bidders
12. Outline of EPCM contractor selection steps once qualified candidates are determined:
    - Date RFP to be sent to the qualified EPCM candidates on the short list
    - Structured 1-day simultaneous site visit by all bidders (with date, if known)
    - (Optional) clarification meeting with each bidder (in bidder's office)
    - Date of submission of proposal (generally by courier at a specified time)
    - Formal proposal evaluation by Owner
    - Date of selection of EPCM firm
    - Contract finalization
    - Project kickoff date
13. Key attributes the Owner seeks from the successful bidder (The path to a successful project does not keep bidders in the dark; the best Owners tell bidders what they seek.)
14. Person and address to receive the RFQ response

If alternate solutions are to be solicited in the RFP, then the bidder needs to be informed of this in the RFQ.

PREQUALIFICATION OF BIDDERS

The selection and appointment of the EPCM contractor has a significant impact on the success of the project. Thus *only those companies with likely appropriate resources, knowledge, and experience should be allowed to submit a proposal.* This is the sole purpose of the prequalification process.

To generate the list of potential suitors that will receive the RFP, the following factors have to be considered:

- Technical competence and size to handle the project
- Familiarity with similar environments

- Track record on similar size and type of projects
- Familiarity with the geographic location of the project
- Availability of key personnel
- Compatibility with the project team and the project-specific requirements
- Financial stability
- Serious interest by the EPCM contractor in the project
- Trust and support of the contractor by Owner's senior management
- Relevant construction and management capabilities and experience
- Location and office availability
- Flexibility with respect to contractual and commercial terms

The prequalification process should attempt to reduce the number of potential bidders that will receive the RFP to no more than six, no less than two (four is ideal).

Allow 8 weeks (±2 weeks) between the RFQs and the RFPs being distributed:

- Allow a minimum of 3 weeks for bidders to respond; 1 month is recommended.
- Allow 2 to 3 weeks for the project team to review the responses.
- Allow at least 1 week for Owner review and input.

REQUESTS FOR PROPOSALS

The development of the RFP begins with the control documents (mostly the PEP). The portion of the project that will be performed by the EPCM firm is extracted and expanded, and this forms the basis of the SOW to be performed. The RFP needs to be as specific as possible. Contents need to minimally include the following:

1. **Bidding instructions**
   - Form of tender (bid format)
   - Contractor's bid bond (if required)
   - Items to be submitted by bidder (see the "RFP Response—What the Owner Would Really Like to See" section for suggestions)
   - Bid submission
     - Date and hour for bids to be received (must be a hard specific time)
     - Person and address to receive the bids
     - Statement of number of copies required (electronic and/or hard copy)
   - Instruction for requests for clarifications and alternatives to bid request
   - Date of any site visit for the bidders (state whether visit is required or optional.)
   - Instructions for submission of requests for additional information
   - Statement that exceptions, if any, must be clearly stated
   - Expected date of bidder selection notification and/or bid award
   - Payment and performance bond requirements; payment retention impositions
   - Permit requirements
   - Contractor licensing requirements (domestic and foreign)
   - Insurance limits
   - Conditions affecting the work
   - Confidentiality requirements

2. **Scope of work**
   - An unambiguous, complete, and comprehensive SOW is mandatory within the RFP. The SOW is the basic control document to which the project is directed from and referenced against. While each project's work scope is unique, most require similar component information. Scripting the scope in the RFP forces a descriptive discipline on project status, constructability, and end use, all in one document. Requisite items include project objectives (tons per day, dollars per ton, percent recovery, etc.) and performance test requirements (to demonstrate plant can perform on a continuous basis at full design capacity).
   - List of Owner-supplied items
     - Feasibility study executive summary (if available and not confidential)
     - Site utility services (those applicable)
   - List of expected Contractor-supplied items
     - Site utility services (those applicable)
     - Equipment to be supplied by contractor
   - Project controls reporting requirements and methodology
   - Audit requirements
3. **Owner's project schedule**
   - Date of desired project kickoff
   - List of all key deadlines
   - Any schedule constraints
4. **Mandatory items to be submitted by bidder**
   - Contractor's setup plan and work methodology
   - Project work location(s)
   - Pricing basis
     - Payment terms, including any progress payment requirements
     - Handling of overhead costs
     - Handling of changes to the work
     - Incentive or penalty (if appropriate)
   - Any specialist subcontractor needs
   - Contractor schedule, if different than Owner's (highlighting all differences)
   - Exceptions (if any)
   - Bid deposit
   - See the section on "RFP Response—What the Owner Would Really Like to See" for suggestions on additional items to be submitted by bidder.
5. **Project specifications**
   - Definitions
   - Technical specifications
     - Design criteria
     - Engineering standards (welding, electrical, pipe, etc.)
     - Process control philosophy
     - Any unique Owner standards or requirements
   - Quality assurance requirements
   - Safety, environmental, and health requirements (regulatory and Owner)
   - Pertinent social acceptance requirements and sustainability constraints

  - Owner obligations to stakeholders, native peoples, etc.
  - Owner EEOC (Equal Employment Opportunity Commission) policy statement
  - Project and/or Owner standards for reporting, etc.
  - Records retention mandates
6. **Form of agreement**
  - Type of contract envisaged (when such guidance is deemed beneficial)
  - Typical contract terms and conditions
  - Warranties (standards of performance)
  - Conflict resolution procedures (arbitration, etc.)

In addition to this list, any special instructions and/or specific criteria unique to the project have to be included such that a complete bid may be prepared by the contractor.

Whenever appropriate, alternate solutions should be solicited to take advantage of the experience and knowledge base of the bidders. Requests for alternative bids can sometimes open up previously unconsidered, easier paths to successful project completion. However, any alternate solution received must be submitted as a second, additional bid response to the RFP, not an instead-of response. Otherwise, there is no basis to compare bids.

Bidders must be treated equally in all respects throughout the bidding period. Inquiry responses have to be sent to *all* bidders, not just the inquirer. Verbal inquiries should not be accepted. It is the project manager's job to issue addenda clarifications and revisions. The bidders need to know that the bidding is competitive. Informing the bidders how many competitors there are (and even the names of the competitors) is acceptable.

It can be beneficial to specify the type of contract being sought, but often it is better to leave this area open until after the bidder is chosen. However, whenever a contract type *is* specified in the RFP, then the contract award process will be simpler and will proceed faster, particularly if the RFP defines the key payment issues. The less precisely defined the contract type and payment terms within the RFP, then the more time and cost that should be allowed to wrap up the negotiation process after bidder selection.

The type of contract being sought and the general terms and conditions to which the bidders will be held are important aspects of the RFP. Input should be sought from the mining company's legal department in the preparation of these conditions to ensure that company standards are adhered to. After all, the final contract will generally be prepared and executed by the company's legal department (or legal personnel within the sourcing or contracts department), not the project team.

At least 6 weeks should be allowed for the bidders to respond. Anything less than a month is insufficient, and beyond 2 months serves no useful purpose. A period of 6 to 8 weeks allows time for clarifications to go out (which usually happens; interested bidders ask questions).

RFP Response—What the Owner Would Really Like to See

A minimum content for the bidder response to the RFP has to be laid out for the bidder by the project manager within the RFP package. But the more detail that can be made available to the contractor in the RFP package, the more complete the bid will be, and this in turn will facilitate the RFP evaluation and, ultimately, the award. The bid package format, the bid assessment procedure, and the procurement requirements all affect the project timing and the cost submittal of the contractor.

Thus the bidder's response to the RFP can be as brief as the minimum list shown in the preceding section or as extensive as the following list:

1. **Corporate commitment**—to meet the project objectives
   - Name of project sponsor
   - Name of project manager
   - Names of key individuals
   - Commitment letter to retain all key individuals for the duration of the project.
2. **Company capability statement**—listing experience and pertinent references
   - Evidence of personnel expertise availability to execute all facets of the project
   - List of similar size and complexity projects engineered and built in last 5 years, with year completed, scope, project cost, key personnel, and contacts
   - Table of mining companies worked for in past 5 years, with reference contacts
   - Substantiation of project area knowledge
   - Bidder's experience in the project locale
3. **Bidder's safety record**
4. **Individuals' experiences**
   - Organizational chart of project team, with names, roles, and resumes of key individuals
   - Clear identification of all contracted and subcontracted individuals
5. **Plan of execution**
   - Description of how the project will be executed to meet the SOW
     - Management approach and organizational structure
     - Identification of all subcontractors and consultants and their roles
     - Statement of how Owner standards and criteria are to be incorporated
     - List of the anticipated project activities and their sequence
     - Any deviations to the desired schedule provided in the RFP
     - List of the key project milestones and their critical path
     - Expected trade-off studies (value engineering), if any
     - How CAPEX (capital expenditure) and OPEX (operations expenditure) costs will be derived.
     - Statement of the accuracy level of the cost estimates (CAPEX and OPEX)
     - Risk management approach (risk identification and mitigation strategy)
     - Clear depiction of all exceptions to the RFP SOW
   - Identification of the locations where the EPCM work will be conducted
   - Description of the project control system to be employed
   - The progress-reporting methodology and communications strategy
   - The document management and document control systems to be used
   - The expected degree of Owner involvement, approvals, etc.
   - Any project team alignment or partnering programs, if applicable
6. **How the bidder expects to successfully deal with external stakeholders**—for example, federal, regional, and local government agencies, and indigenous peoples
7. **List of bidder deliverables** to be provided during project execution. This should likely include, but not be limited to, the following:
   - Project procedures manual
   - PEP

- Master project schedule (with critical path)
- Capital budget and operating cost estimates for the project
- Financial analysis (if applicable)
- Work breakdown structure
- Engineering deliverables
  - Design criteria, drawings, plans, process flow diagrams, mass balance, piping and instrumentation diagrams, calculations, and equipment specifications
  - HAZOP review(s)
  - A plant design that is easily maintained and efficiently operated
- Consultant and subcontractor reports
- Procurement plan
  - Equipment and material package breakdown
  - Bidder lists
  - Identification of long lead-time items
  - Expediting strategy
  - Logistics and transport plan
- Construction plan; contracts administration methodology
- Commissioning plan
- Audit reviews (including lessons learned at project completion)
- Safety plan
- Environmental protection and sustainability support plan
- Training programs and local recruitment plans
- Operations and maintenance manuals
- Weekly, monthly, periodic, and final reports

8. **Expected basis of compensation**
   - Description of any progress payment expectations
   - If cost reimbursable, list of the actual base labor-hour rate by employee category
     - If multipliers are proposed, list of what is included and excluded
     - The multiplier for covering wage-related and administrative overheads
   - If schedule of rates, list of the standard rate for each job classification
   - Delineation of EPCM overhead (Owners prefer that home office support personnel be in overhead, *not* individually reimbursable)
   - How EPCM personnel overtime will be handled (should be actual cost)
   - Any fee for profit
   - List of the reimbursable costs that will be passed though at cost (Note: Expenses not listed in the proposal will end up not being reimbursed.)
9. **Incentive or penalty proposal** (e.g., gainshare or painshare; final configuration can be negotiated post-award)
10. **Total estimated EPCM cost**

It will generally serve the EPCM to provide more than the minimum; the more the bid response approaches the preceding list, the better the EPCM response will be viewed.

INTERVIEWS WITH BIDDERS

After the bidders have been selected and the RFP issued, a prebid clarification interview with each of the bidders is useful. It helps to ensure a full understanding by the bidder of the project requirements, and these interviews give the project manager an opportunity for an early due diligence evaluation of the team being proposed by the bidders. Preferably, these meetings should take place in the bidder's office. This gives the project team an opportunity to better understand the bidder's real work delivery capability.

On large, complex projects each bidder must be required to make a formal presentation of its proposal. This presentation allows the bidders to articulate how they will execute the SOW. It also allows the Owner's project management team to meet, hear, and assess the various members of the contractor team. On smaller projects these interview meetings can be informal clarification meetings. Either way, care should be taken to ensure that each bidder is afforded the same opportunity. No bidder should end up with an unfair advantage.

The focus in these clarification meetings needs to be on qualifications and availability of the team rather than on cost. The project team has to gain the confidence that the contractor‘s team can develop and execute a plan to meet the overall project goals. Whether or not the prebid one-on-one clarification interviews take place, a structured 1-day site visit by all the bidders together at the Owner's location (preferably the project site) should *always* be conducted.

SUBMISSION OF BIDS

Enough time needs to be allowed for the bidders to research and prepare high-quality bids, but a cutoff time for written questions and substitution requests needs to be set, along with a deadline for the bid submissions. Bids should not be accepted after the stated deadline. Bids should be tendered to one office only. Proposals are generally received by courier at a specified time. An exact hour and minute on a specific date needs to be stated. The Owner is technically in charge of bid opening, but the opening event is typically managed by the project manager. The bid opening is normally a closed private event with no bidders present.

EVALUATION OF PROPOSALS

After all the bids have been received and formal presentations made, the official assessment by the project team will take place. A period of 6 to 8 weeks should be allowed to properly review the bids and adjust them on an equal basis. This includes 1 week for Owner review. Due diligence is conducted internally and externally. Anything less than a month is not enough; beyond 10 weeks is too long.

The internal due diligence comprises the review of each proposal, the site and office visits, bidder presentations, and any meetings to evaluate the bidder's understanding of the project—all to better assess capabilities, systems, processes, and depth of competency.

The external due diligence involves leveraging external analysts, industry sources, and the objective observations of bidder interactions—all to formulate an opinion on past performance, a confidence (or lack thereof) in the contractor's future financial strength, and the nature of bidder relationships and/or exposure to nongovernmental organizations (NGOs), labor, and government.

The project manager then prepares a formal bid tabulation sheet on all bidders to determine if the contractor is fully prepared to take on the project. Bid evaluations are broken down into the following aspects.

Execution (Typical Weighting 40% ± 4%)

- **Proposed plan of execution.** Is the proposal responsive to the original request? Are remedial actions necessary to upgrade the quality of the plan to acceptability?
- **Leadership competency and project management competency**
- **Ability to perform.** Are the contractor's systems and processes likely to be effective for project execution? Are the mobilization and logistics plans, and the proposed equipment adequate for successful project delivery?
- **Schedule.** Assessment of the proposed rate of work output in relation to the personnel assigned, and the ability of Owner's team to accommodate the required approvals.
- **Safety record**
- **Environmental impact, social acceptance, and sustainability approach**
- **Code of conduct and ethics management**
- **Contractor corporate commitment.** A measure of the support from senior management.
- **Legal and contractual.** Review terms and conditions for where the bidder's proposal varies from the standards set out in the RFP. (Sign-off from the Owner's legal department will be needed for any changes or exceptions.)

Technical Competency (Typical Weighting 32% ± 3%)

- **Technical expertise.** The availability and experience of the team proposed.
- **Past project performance.** The recent track record of the contractor in delivering similar plants and in similar environs. Any cost, schedule, or operability issues? What were the frequency and/or impact of NGO, labor, or government interventions?
- **Contractor's past history.** Owner's previous experiences with the bidder.
- **Quality.** The contractor's workmanship quality record and attitude toward quality.
- **Market share.** Contractor's market share of similar projects and any contractor ownership of likely project success factors.
- **Contractor's capability.** An assessment of whether the presented historical data truly represents bidder's current capability. Examine the proposed team size, experience, and the contractor's personnel attrition rate.

Contractor Performance Assessment (Typical Weighting 20% ± 2%)

- **Personnel capacity.** Determine if the contractor has the depth of people resources necessary to complete the project requirements or whether additional staff hiring will be needed to staff the peaks. What is the ratio of full-time personnel to temporary?
- **Proposed work locale.** Inspect the physical location, condition, and percentage allocation of the contractor's facilities and equipment. Are they suitable for the project?
- **Project governance and performance metrics.** Check the contractor's in-house systems to establish if they can accurately monitor and report progress in a timely way.
- **Financial health.** Examine the contractor's credit strength and enterprise scale (revenues, net cash, and backlog) along with its exposure to claims and litigation.
- **Risk management.** Appraise the contractor's ability to manage the risk it is being asked to handle.
- **Compliance assessment.** Conduct a value analysis of negotiable terms, the likelihood of the contractor negotiating on deal breakers, and the probability of creating an acceptable risk relationship.

Value (Typical Weighting 8% ± 4%)

Cost competitiveness. Review of the contractor's hourly rates, work-hour estimate, and work schedule. Care should be taken to evaluate total cost and the relationship to the total proposed labor hours, as a low labor-hour rate may not yield the lowest total cost.

- Unit rates need to be compared to industry norms. Are they reasonable?
- Arithmetic within the proposal estimate needs to be checked for errors.

Interestingly, between competent contractors, cost is rarely the determining factor. Personnel, experience, proposed plan of action, and corporate commitment will almost always weigh heavier in the assessment than cost. In fact, when the SOW in the RFP is well defined and when only competent contractors are allowed to bid, then the costs from the bidders will all be fairly equal. If they are not, this is a red flag as to either a poorly laid out SOW or an incompetent (or disinterested) bidder.

The evaluation must ensure that bids are compared on an even basis. This may require normalization of a bidder's submittal. Normalization is necessitated whenever the bidder has proposed an inappropriate number of labor hours or an unrealistic productivity.

Contractor selection has to be based on a total value or total cost basis to the Owner, never on the contractor's initial transaction price estimate. Frequently the project team will need to obtain clarifications or modifications to the bid. Requests and bidder responses must be in writing. Clarifications sent to a bidder must go to all bidders simultaneously to ensure that no bidder has an insider advantage.

Many times additional background information or subcontractor proposals are requested to ensure that the SOW is adequately covered. The project team is tasked with helping the bidder ensure that no mistakes or oversights have occurred. Bid solicitation is not a game of "who gets it right"; the goal is to obtain good, complete bids from everyone.

The Owner's selection of the EPCM contractor should be objective. Usage of a grid form such as shown in Figure 19.3 is a proven methodology to accomplish this task. The evaluation grid builds a detailed assessment scorecard weighting the key criteria of RFP document compliance and bidder capability.

The criteria and the criteria weights used on the evaluation grid need to be consensually set by the project team *prior* to receipt of bidder packages, reflecting the project's specific goals and strategies as well as the Owner capabilities. (Note: The weights in Figure 19.3 are from one specific project in the authors' past; they are not a recommendation for any other project.)

Use of a project bidder selection evaluation and ranking forms provides an objective methodology for contractor selection, but these forms are not a panacea; judgment of intangibles still comes into play. A helpful technique is to write down which firm one thinks is best *before* filling out the evaluation ranking sheets (but after the interview and receipt of proposals). If the same firm comes out on top in both exercises, then the decision is probably okay. If there is a difference, then a discussion between the evaluators needs to take place. Are the weights wrong? Are important criteria missing?

As a conclusion to the assessment, the team will produce a report and recommendation to the Owner giving reasons for bidder selection and then setting out the preferred conditions for award of contract to the chosen bidder. This report will form part of the control documents for the project and the basis for a later revisit with the selected (lead) bidder for removing weak elements from its bid proposal.

No.	Item	Weight Factor	ABC Company		CBA Company		BAC Company	
			%	wt	%	wt	%	wt
1	Project Team Strength & Qualifications	(37)						
	A. Executive Management / Sponsor Support	2						
	B. Project Manager	9						
	C. Total Engineering Capability – Civil, Structural, Material Handling, Mechanical, Piping, Electrical, Instrumentation	6						
	D. Project Controls Competence:	5						
	1. Controls Manager							
	2. Estimator / Scheduler							
	E. Procurement / Expediting / Logistics Knowledge	3						
	F. Construction Management Experience and Site Capabilities:							
	1. Construction Manager	5						
	2. Field Engineering – QA/QC, Contracts Administration, Safety	4						
	G. Feasibility Study – Financial Analyst	1						
	H. Organization Chart – Completeness and Responsiveness	1						
	I. Key People – Commitment to Keep on Job	1						
2	Technical Expertise	(14)						
	A. Process Technology Familiarity	3						
	B. Process Controls Design Capability	1						
	C. Product Expertise, e.g., Cu, Au, Ni, Coal	3						
	D. Familiarity in Building a Similar Facility	5						
	E. Infrastructure Design and Tie-in Capability	2						
3	Responsiveness to Project RFP	(15)						
	A. Technical Understanding of Project	4						
	B. Design Innovation and Alternatives	3						
	C. Mine Plan Integration Capability	1						
	D. Constructability	2						
	E. Operations Simplicity	1						
	F. Maintenance Minimization	1						
	G. Performance Warranty	2						
	H. Operating and Maintenance Manuals	1						
4	Location Knowledge	(9)						
	A. Familiarity with Client	1						
	B. Construction Experience at Project Site	2						
	C. Construction Experience in an Ongoing Operation	3						
	D. Special Concerns: e.g., Host Country / Bonds	3						
5	Project Implementation	(7)						
	A. Work Plan Approach	2						
	B. Ability to Align with Owner – Partnering	2						
	C. Environmental / Permitting Know-how	2						
	D. Safety Commitment	1						
6	Project Control System	3						
7	Schedule Reasonableness	6						
	A. Ability to Complete by Target Date							
	B. Establishment of Key Milestone Dates							
8	Operating Cost Estimation Expertise	2						
9	Capital Cost Estimate Reasonableness	2						
	A. Is It Lowballed? Is Cash Flow Optimized? Batter Limits?							
10	Commercial Terms	3						
	A. Responsiveness and Alignment with Owner Requirements							
	B. Is an Incentive or Penalty Fee Option Proposed?							
	C. Clarity and Simplicity							
11	Office Location	1						
12	Presentation and Communications Effectiveness	1						
13	Total Score	100						

FIGURE 19.3 Project bidder selection, evaluation, and ranking form

SELECTION OF THE WINNING FIRM

The project team either recommends award to one bidder or rejects all bids. If all bids are rejected, the project manager has to develop a detailed rationale for the action. Once the project team selects a bidder, then Owner approval of the project team's recommendation has to be obtained. Depending on the size and complexity of the project, this could be a simple verbal authorization or it may involve a presentation by either the project team or both the project team and the recommended contractor.

Following Owner concurrence of the project team's selection of a winning bid, the successful bidder is notified that it is the lead contender, and the contract negotiations are started. If the weak elements of the selected contractor's bid have not already been removed, then this is the first item addressed. Areas of concern within the winning bid (for both sides) are addressed in these bid refinement negotiations. Throughout this bid refinement process, the Owner needs to maintain a competitive threat as part of the negotiations.

If the chosen bid is over budget, a review of the original estimate needs to be made to determine if the estimate was appropriate. If changes to the bid are feasible, these need to be negotiated with the successful bidder to bring the amount within budget. Quality should never be lowered to bring a bid into line. Scope reductions may be in order. If no changes can be made, the budget will need to be revised. If the lead bidder's proposal cannot reach an acceptable final offering for the Owner within a reasonable period, then the Owner will cease negotiation with that bidder and attempt to obtain an acceptable offering from the second-ranked bidder.

It typically takes about 2 months to reach final agreement with the best bidder. With lawyers involved, the project manager will find that he (or she) will need all of this time. Once these weak elements are removed and/or made acceptable, then the contractor can be notified that it has been selected, and the contract finalization negotiation can be initiated. With an acceptable bid in hand, the project manager can notify the other bidders, in writing, that they were unsuccessful. The project manager then completes the bid award paperwork for the Owner and prepares the contract documents for execution by the contractor and the Owner.

CONTRACT FINALIZATION

The exact terms of the final contract are not normally secured until after selection of the bidder. Contract finalization is conducted with guidance from the company legal department. The project manager is responsible for obtaining all required documents from the successful bidder such as bonds, insurance certificates, subconsultant lists, and so forth.

For tax efficiency reasons, most large, international projects require the contract scope be split into two: onshore and offshore. Contract terms within offshore and onshore contracts will not be identical. Thus, legal counsel should be sought.

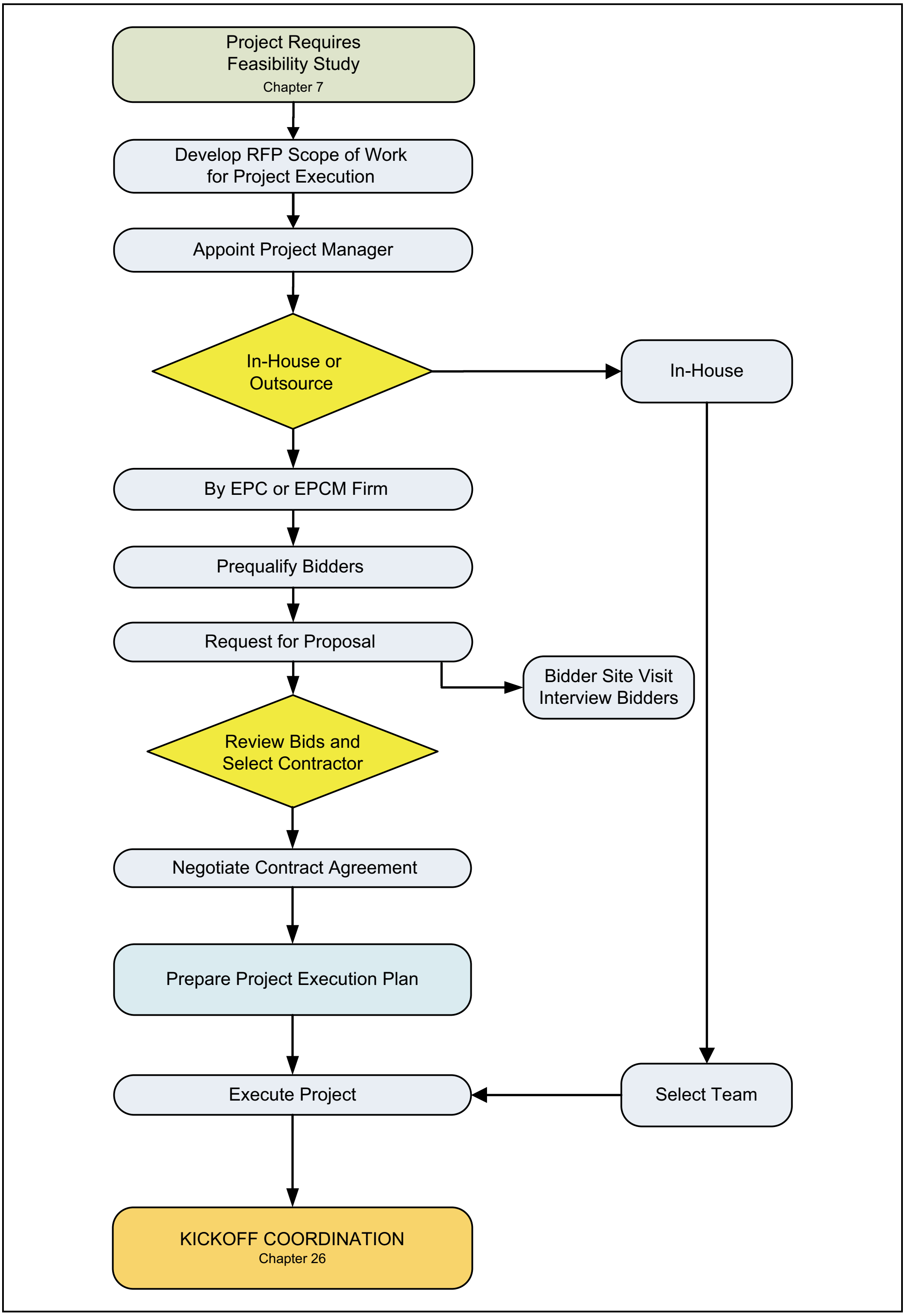
CHECKLIST 19.1 SELECTION OF PROJECT DELIVERY PROVIDER (OWNER, EPCM OR EPC)

No.	Item	Status	Date	Initials
1	Project delivery provider selection issues—defined			
	A. Project complexity—determined			
	B. Owner capability, capacity, and preferences—identified			
	C. Construction contractor market environment—researched			
	D. Project value drivers—derived			
2	Project delivery provider selection philosophy and strategy—set			
	A. Determination of model that best matches Owner capability			
	B. Identification of natural owners of the project risks			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
	C. Organization of the contractor award process			
	D. Setting of evaluation criteria for contractor selection			
	E. Establishment of the most beneficial contract terms			
	F. Determination of how best to align Owner and contractor			
3	Project delivery model—selection from one of following options:			
	A. Owner directed			
	B. EPCM			
	C. EPC			
	D. Hybrid			
4	Contract for EPC(M) firm—selection of one of the following types:			
	A. Lump sum			
	B. Time and materials (cost plus)			
	C. Fee plus (cost plus fixed fee)			
	D. Guaranteed maximum price			
	E. Design build			
5	Selection process for EPC(M) contractor—undertaken			
	A. Request for qualifications (RFQ) or expressions of interest—done			
	B. Prequalification of bidders—conducted			
	1. Compatibility, financial stability, commitment—OK			
	2. Experience, capability, availability, location—OK			
	3. Flexibility with respect to contractual issues—OK			
	C. Request for proposal (RFP)—sent to 4 ± 2 firms			
	1. Bidding Instructions (including bidder deliverables)			
	2. Scope of work (including project schedule)			
	3. Project specifications			
	4. Form of agreement			
	5. Basis of compensation (optional)			
	6. Bonding and insurance requirements			
	D. Interview of bidders—undertaken			
	1. On project site with all bid competitors			
	2. One-on-one meeting in bidder's proposed work base			
	E. Bid assessment: evaluation ranking form—completed			
	1. Plan of execution			
	2. Technical competency			
	3. Likely contractor performance assessment			
	4. Value			
	F. Selection of winning firm—recommendation to Owner			
6	EPC(M) contractor—selected by Owner			
	A. Contract agreement—negotiated			
	B. Appropriateness of contract language and type—reviewed			
	C. Contract incentive or penalties—considered			
7	Appointment of EPC(M)—award, if negotiations are successful			
8	Possible modification of PEP—determined			
	A. Modify PEP and refine SOW—as necessary			
	B. Follow-up on permitting and environmental issues—as necessary			



FLOWCHART 19.1 Selection of project delivery provider (Owner, EPCM, or EPC)

CHAPTER 20

Contract Agreement

Never contract friendship with a man that is not better than thyself.
— Confucius, 551–479 BC

OBJECTIVE

The underlying objective of this chapter is to guide readers in the selection of the appropriate contract type for their projects. Additionally, basic information about avoiding contractual disputes is provided. The attributes of the different types of contact available for use when hiring project service providers such as engineering, procurement, and construction management (EPCM) companies, construction contractors, and/or technical specialists are covered within the chapter. Reasons for selecting a particular contract type are laid out. The main components that need to be included in any project service provider's contract are presented, including the best way to structure an advantageous incentive or penalty clause.

WHY HAVE A CONTRACT AGREEMENT?

Contracts lay out the rights and responsibilities of the contractor and the project Owner. A clearly written understanding between the Owner and contractor describing relationships, expectations, and obligations of the two parties forestalls misunderstandings and dissatisfaction that can lead to litigation.

The emphasis with contracts should always be on preventing problems; then if problems do arise, the emphasis shifts to providing a clear path to solve those problems. There are three general rules for the project manager regarding contracts:

1. Create a contract that accurately reflects the scope of work (SOW) and the business terms (warranties, payment terms, etc.) agreed on between the Owner and the contractor.
2. Modify the contract by written amendment as soon as the SOW changes.
3. Quickly move to understand and deal with any dissatisfaction that either party (the Owner or the contractor) expresses.

For the project manager, a signed agreement is an important tool for keeping the project on budget, by being clear about the scope of services. It is also the prime instrument for avoiding lawsuits, limiting liability within lawsuits, and enabling the proper documentation if lawsuits do occur. Always remember that the primary reason for a written project agreement is not for the purpose of having a contract that is enforceable in a court of law; the primary intention is to keep disputes from arising between parties in the first place. After all, these parties have a mutual interest in cooperating. The agreement helps to keep the parties from committing to arrangements that are not in the project's best interest.

An agreement should be completed and signed as soon as the scope, services, and compensation are established. No work, other than marketing and project management, should be performed on the project before the agreement is completed. If work starts without an agreement, which unfortunately is all too often the case in mining, the agreement document must be completed as soon as practical thereafter.

A well-written project agreement should express the contractor services to be performed, Owner obligations, responsibilities of the parties, and compensation to be paid. From the contractor's point of view, a signed agreement facilitates billing for additional services and provides an unambiguous mechanism for being able to collect on accounts receivable. For the EPCM (and sometimes the construction contractor), it is the first and often the best defense against a professional liability claim. The vast majority of claims brought against design professionals are generally based on an allegation that the professional breached a duty owed to the client. If it can be shown by the contract that there was no duty owed, then no duty was breached and the claim can be dismissed.

A project agreement is a living document. The project manager should draw from the agreement to govern project management actions and to formulate checklists of dates, services, and methodologies to guide the project work.

CONTRACT PREPARATION

Both the Owner and the project manager normally participate in contract negotiations, with the project manager taking the lead. The agreements are signed by the Owner. When the contracts are in place, they are typically administered for compliance by a contracts administrator who reports directly to the project manager.

Most EPCMs and Owners have their own standard forms for these project agreements. In most instances, the Owner's standard contract forms will be the starting point, though some smaller, junior mining companies that do not have such forms on file may choose to use the EPCM's standard forms. Whichever forms are used, draft agreements that contain nonstandard contractual terms or variations from the standard agreement forms of the reviewing party should always be passed through to legal counsel and/or professional liability insurance counsel for review before being executed. Red flags to pay particular attention to are language strike-outs in the standard contract forms and/or additional language, documents, or letters that purport to explain or expand upon a standard contract.

WHAT SHOULD BE IN A CONTRACT AGREEMENT?

First and foremost, no matter how knowledgeable the project manager, the Owner should always obtain counsel from a specialist construction contract attorney before agreeing to any specific contract language.

Contract agreement documents should not be created from scratch. They should always start with a model document in which the general wording (boilerplate) has stood the test of time. Most boilerplate will need only minor modification. Only the special considerations and technical specifications will need any significant drafting effort.

Technical Specifications—Unique Provisions Relevant to the Project

The following items, unique for each project, are needed in any mining project contract:

- Owner's legal name and the name of the Owner's representative authorized to direct the work. Note: The legal name of a private client should always be verified by the EPCM or contractor to ensure that the client is truly a legal entity.
- Contractor's legal name and the contractor's representative authorized to manage the conduct of the work.
- Owner's ownership interest in the property. This may be critical if the contractor becomes compelled to place a construction lien on the property.
- Services to be provided, that is, a clear SOW.
    - Identify work products and methodologies as much as possible.
    - Set the performance requirements.
    - State the level of effort required. The EPCM should state that if the level of effort is significantly different, there will be a charge for the additional services.
    - Establish the communication management requirements (progress reports, dashboards, meetings, etc.).
    - Set the number of meetings. The EPCM needs to clarify that if the number of meetings is significantly different, there will be a charge for additional services.
    - Clearly differentiate between basic and additional services.
- Key performance criteria for the end product(s)
- Term of the agreement
- Time limits for performance
- Responsibilities of the Owner
- Responsibilities of the contractor
- Documents ownership
    - Ownership of documents normally belongs with the Owner, even though these documents are predominately created by the EPCM.
    - However, to protect the EPCM firm from use of its work products by others, it is reasonable for the EPCM to require the Owner to indemnify the EPCM against any use or reuse of the documents not authorized in writing.
- Invoicing and payment procedures
- Remuneration
    - Total compensation amount
    - Fees
    - Expenses: identification of reimbursable expenses, over and above the fees, for example, subconsultant plans, charges for documents sent to bidders
    - Interest on unpaid bills (Most contracts state that interest can be charged on late payments, but the reality is that few contractors invoke this clause.)
    - Compensation for extra work, and the right of Owner to request such work
    - Retainers, when appropriate
- Notice requirements: notice methodology, along with the addresses of authorized representatives
- Any penalties and/or work makeup requirements for nonperformance
- Reasonable limitation of liabilities for both parties. The limitation of liability clause in the agreement limits to a specific dollar amount the liability of the contractor for

damages suffered by the Owner arising out of nonperformance and/or negligence in the services provided by the contractor. Typically, the contractor will want the limit to be the lesser of a portion of either the fees paid to the contractor (the contractor will want less than 50%, the Owner will want at least 100%) or the insurance proceeds actually payable by the contractor's insurers. The contractor will expect the Owner to indemnify the contractor against claims for greater amounts as well as against consequential or punitive damages. The time period for the Owner to claim damages after performance of the work has be spelled out (the contractor will want no more than 12 months; the Owner will want at least 36 months).

Boilerplate Terms and Conditions

The following generic terms and conditions (T&Cs) universally appear in all project agreements, though the language will vary somewhat, depending on the parties.

- Definitions
- Relationship of parties—states that the engineer and/or the construction contractor will act as an independent contractor, not an employee or agent of the Owner
- Taxes—asserts which taxes (e.g., state, federal, sales, value-added tax [VAT]) are whose responsibility
- Liens—language will typically point out that liens can be avoided by the contractor paying subcontractors and vendors in a timely way
- Assumption of risk—contractor acknowledgment that it has had an opportunity to visit the job site and understands the risks associated with performing the work
- Suspension—spells out the Owner's right to suspend work, and on what basis
- Default—defines what constitutes a material breach or default of the agreement
- Force majeure or delays—identifies the occurrences not considered a default
- Termination—provides the right of either party to terminate; specifies whether with or without causation; clarifies payments due (Such termination provisions need to be fair to both parties.)
- Compliance with law—obligation of all parties to comply with all governing laws
- Compliance with standards and policies—obligation of the contractor to comply with the Owners' rules and procedures
- Confidentiality—obligation of confidentiality on both parties; term of obligations
- Books and records—requirement for contractor to keep correct, complete records
- Audit—Owner's right to audit; notification and payment requirements for audits
- Cooperation between parties—requires the Owner to make timely decisions and to not delay the work of the contractor
- Information and documents furnished by the Owner—obligation of the Owner to provide a complete set of all pertinent information timely to the contractor and to immediately notify the contractor of any discrepancies as they become apparent; contractor is obligated to provide confirmation that the supplied material will remain the Owners' property
- Performance warranty—warrants that the contractor's services will be performed in accordance with the standard of care, skill, and diligence customarily provided by a professional firm in the execution of comparable services in a similar location

- Materials warranty—warrants that the contractor-supplied materials or equipment shall be of a grade and quality that meet all agreement specifications
- Indemnification—reciprocal indemnification of each party against
  - Breach of the agreement by the other party,
  - Property damage caused by the other party,
  - Personnel injuries caused by the other party,
  - Environmental damages caused by the other party, and
  - Third-party claims brought against the other party.
- Withholding of remuneration—grants the Owner the right to withhold a portion of the invoice payment if contractor performance is deemed inadequate
- Dispute resolution—agreement by the parties on the methodology to settle disputes; typically first by negotiation (within a set number of days, usually less than 15 days), followed by structured professional mediation (within a set number of days, e.g., 30 days to settle), then finally by binding arbitration. (It is rarely in either party's best interest to seek settlement in court.)
- Insurance—sets out the contractor insurance obligations (see the "Insurance Requirements" section in this chapter)
- Assignment—reciprocal requirement that neither party can assign the agreement without consent of the other, but that such consent cannot be unreasonably withheld
- Binding effect—states that the agreement is binding upon successors and assigns
- Subcontracts—provides the contractor the right to enter into subcontracts with others to perform the work as long as the contractor maintains full responsibility for the work and the Owner gives consent; such Owner consent cannot be unreasonably withheld.
- Equal employment—certification that contractor is an equal opportunity employer
- Antibribery compliance—commitment by both parties to not make improper payments to government officials; contractor confirmation that no government official is on the payroll
- Publicity—no release of project information by the contractor to the public without the Owner's prior written approval
- Waiver—no waiver of any part of the agreement without each party's consent
- Severability—mandates that if certain provisions within the agreement are held invalid by a court, the validity of all remaining provisions shall not be affected
- Entire agreement—states that the document constitutes the entire agreement between the parties and nullifies all prior communications (written or verbal)

Insurance Requirements

The following lists the types of insurance that the contractor should be asked to carry.

- Workers' compensation and employer's liability—Insurance needs to comply with the laws of the jurisdictional entity (state, province, etc.) and assert a minimum limit for each accident and each disease. Typically, this is at least $1 million for each employee, with $2 million limits now becoming common. Some Owners are even starting to require as much as $3 million.
- Automobile liability—Typically, the limit is set the same as workers' compensation, that is, a minimum of a $1 million.

- General liability (comprehensive personal injury and property damage liability)—This is always set to at least the minimums of automobile and workers' compensation, but more frequently three to five times the automobile liability minimum. For specialty subconsultant firms the limit would be much less, often as little as $500,000.
- Builders risk (all risk), also known as "course of construction" insurance—It is generally maintained with a minimum limit of "the value of the work at risk."
- Transit or ocean marine cargo—The insurance limit is generally maintained at "the value of the cargo (materials, equipment, etc.) at risk."
- Excess (umbrella) liability for bodily injury and property damage in excess of the other prescribed insurances—This is typically set with a combined minimum single limit of $10 million for each occurrence and the same $10 million figure for an annual aggregate. However, some recent projects have carried as little as $5 million and some megaprojects have gone over $20 million. Obviously these limits are very case specific.

Insurance companies used by the contractor should require approval of the Owner. All policies need to name the Owner as an additional insured. The Owner should require at least 30 days' notice on any insurance policy renewal, change, or cancellation.

Keep in mind that EPCMs and construction contractors will have limits on what insurance they can offer (set by their brokers), so at some point, if the Owner asks for too much, the contractor may not be able to respond to the bid request. Nevertheless, most EPCMs of any stature have no problem providing the insurance that the Owner seeks. The EPCM usually charges the client for the insurance as a pass-through cost, though not always; it depends somewhat on how good a negotiator the Owner is.

Special Considerations

Other issues that need to be addressed between the Owner and contractor prior to project execution are ones that may not be part of the contractual arrangement, but need to be, and include the following:

- Permits
- Licenses
- Environmental considerations
- Import–export issues
- Technology licenses
- Partner or joint venture involvement
- Financing interface requirements (including currency risk management)

Bonding requirements must also be included in the contractual arrangement. Bond costs are generally charged out as a pass-through to the Owner. The following list describes the bonds that the contractor should carry:

- The payment bond is for the payment of all claims on the payments of labor and material costs incurred in the performance of the work.
- The performance bond is for the performance of all the terms, covenants, and conditions of the contract, including listed performance guarantees and all the undertakings, obligations, and liabilities of the contractor's agents, subcontractors, and suppliers. This bond is to protect the Owner against loss by reason of breach or default in the

performance of any obligation by the contractor and/or its agents, subcontractors, and suppliers.

- The completion bond is for the completion of the project in strict accordance with all the T&Cs within the contract. (Note: An alternative to a completion bond could be a bank letter of credit.)

NEGOTIATING THE CONTRACT

The objective of all good negotiations is to produce an outcome where both parties feel that a fair agreement has been reached. If one party feels disadvantaged, it becomes difficult to maintain a successful relationship. The project manager should enter negotiations prepared with an understanding of every project detail and the interrelation of the scope of services, schedule, and fee.

Before entering negotiations, the project manager should draw up a list of issues. The project manager should further establish an aspiration level, a minimum acceptable level, the initial asking price, and a walk-away point. Contractor negotiators should not let anxiety over winning or losing the job allow underestimates of budget, personnel, or time requirements to perform the work creep into the agreement language. Such understatements only create obstacles down the road to successful completion of the work.

Both parties should know before beginning the negotiations what can and cannot be given up. They should strive for a win-win outcome, but not overlook a win-tie. The latter is when one asks for something not presently in hand and subsequently not attained. That is not a loss but a tie, since what one never had cannot be lost.

The contractor must realize that negotiating is *not* marketing or selling. At the negotiation stage, the Owner is already committed to the contractor's selection, as long as appropriate conditions and terms can be worked out. And finally, the project manager must never sacrifice the overall quality of the project during negotiations, as that could expose the Owner to an unacceptable risk.

MANAGING RISK IN A CONTRACT

Owners, EPCMs, and construction contractors have contracts and insurance primarily to protect against risk. However, every time a commitment is made by an EPCM or construction contractor to an Owner, some degree of risk is being assumed by these parties. EPCM and contractor management thus need to use their judgment in making conscious decisions to determine whether the rewards of a potential project are worth the risks to their organizations. The party taking on performance risk will be the contractor in most cases. The savvy contractor will lower its return (profit) if its risk can be lowered. Return is always directly related to risk. Three factors are examined when a contractor looks at project risk:

1. The dollar value of the risk in a worst-case scenario
2. The likelihood of occurrence of those risks
3. The contractor's ability to control or prevent the risks

The allocation of risk among the parties will affect the bid amount, as will the bonding and insurance requirements. The goal in any project should always be an equitable allocation of risks between the parties, with the various risks each being borne by the party best equipped to handle it. Ultimately, the risk taken on by any party to the agreement has to be worth the potential reward.

Financial and Insurance Concerns

Financial issues can sometimes be a risk concern, particularly with hitherto unknown local contractors and/or junior mining companies. Questions arise such as the following:

- Is the Owner's project financing source and status viable?
- Does the contractor have sufficient financial strength to take on the work?
- Is credit information or a credit report available?

One way of obtaining credit information on businesses and individuals is through a commercial credit service, such as Dun & Bradstreet, to which most Owners and EPCMs subscribe. Credit information can generally be obtained the same day. When an Owner's financial status is unknown or in doubt, it is reasonable for the contractor to ask the Owner to complete a client information form that provides details on Owner financial status prior to executing the agreement.

One issue that frequently arises for constructors and EPCM firms is an Owner requiring insurance coverages in excess of the firm's normal limits. Resolution will require

- Determination by the contractor as to whether the insurance can be obtained,
- Factoring the extra insurance cost into the contract as a reimbursable expense,
- Possible purchase of the additional insurance by the Owner, and
- Possible waiving of the insurance requirements by the Owner.

The point is that when such concerns are present, they need resolution prior to signing the agreement.

TYPES OF CONTRACT

There are a variety of project contracts, and depending on the type, one party may benefit from a specific type of contract more than the other party. Each contract carries with it advantages and disadvantages that will affect the contractor and the Owner in different ways. Contracts can be based on various costing arrangements. The party responsible for cost overruns will differ, based on the type of contract. Contracts can also be classified by the activities to be performed by the contractor, as well as by reference to the method of payment. By combining these two classifications, a wide variety of contract types become available:

1. Turnkey (also known as turnkey lump sum)
2. Lump sum
3. Time and materials (T&M, also known as cost plus)
4. Fee plus (also known as cost plus fixed fee)
5. Schedule of rates
6. Guaranteed maximum price (GMP)
7. Unit rates
8. Design-build

Contract designs vary with the chosen performance mechanisms (warranties, incentives). The choice of contract can significantly impact the success of the project. Because the interests

COST ELEMENT	1	2	3	4	5	6	7	8	9	10
Design Services	L	L	L	R	R	R	R	R	R	R
Engineering Services	L	L	R	L	R	R	R	R	R	R
Management Services*	L	L	L	L	L	L	L	R	R	R
Equipment Supply	L	R	R	R	L	R	R	R	R	R
Material Supply	L	R	R	R	L	R	R	R	R	R
Construction Mgmt	L	L	L	L	L	L	L	L	R	R
Construction	L	L	L	L	L	L	R	R	R	R
Indirect Costs	L	L	L	L	L	L	R	R	R	R
Profits and Overheads	L	L	L	L	L	L	L	L	L	R

*Management Services includes project management, scheduling, procurement, expediting, logistics, cost control, and financial administration.

L = lump sum; **R** = reimbursable

Type 1: Represents the turnkey contract

Type 2 through 6: Represent lump-sum contracts, Type 5 is the most common lump-sum contract within the minerals industry.

Type 8: Represents the fee-plus contract.

Type 10: Represents the cost-plus contract where all elements are fully reimbursable. Profit and overheads would be expressed as a percentage.

FIGURE 20.1 Types of contract

of the Owner and the contractor tend to be in conflict in any particular situation, no contract can be considered ideal (Batchelor 1997). Various combinations of lump sum and reimbursable elements are possible, as shown in Figure 20.1.

The allocation of roles and responsibilities among Owner, EPCM, and construction contractor influence the decision as to which contract type to use. The use of partnering concepts will help minimize potential conflict by aligning the interests of the parties, but partnering does not eliminate the need for a clearly defined scope.

Incentives or penalties could be applied to any of the contract types, though in the past they have been more generally reserved for lump-sum contracts (turnkey or otherwise) and fee-plus contracts than for T&M or rates contracts. This predisposition is changing, and correctly so in the authors' opinion.

The form of contract chosen should give the best chance of satisfactory performance given the objective of the project. It should not force either party to assume obligations or liabilities where insufficient information is available or inadequate control can be exercised. The mining company's legal and procurement departments are the two internal resources that can help select the proper contract type.

Banks and junior mining companies prefer a lump sum contract, in the mistaken belief that their financial exposure is capped and their risk is transferred to the contractor. Major mining companies are more pragmatic about the evolving nature of pertinent data within a grassroots project; thus they tend to prefer some form of cost reimbursable contract, at least through detail engineering.

Turnkey

A turnkey contract is a business arrangement in which a project is delivered in a completed state, ready to operate. This type of arrangement is commonly used for single-building construction projects, but rarely for the complex, intertwined multiple facilities that compose a mining project. Rather than contracting with the Owner to develop the project in stages, the contractor is hired to finish the entire project without Owner input. In other words, the contractor provides the appropriate design and engineering services, supplies all equipment and materials, and undertakes all construction and commissioning. The contractor maintains a separate identity from the final Owner-operator, and the project is turned over to the Owner only once it is fully operational. In effect, the contractor finishes the project, including start-up, and "turns the key" over to the new Owner.

In a turnkey contract, the Owner is essentially left out of the project execution process entirely. Within the contractual project battery limits, the hired contractor handles all decisions and problems relating to engineering, procurement, and construction to deliver the specified outcome. The Owner simply pays the turnkey contractor to complete a project built to Owner specifications.

Unlike a traditional lump-sum contract in which the Owner is given opportunities to make decisions and changes (though such changes invariably come with additional cost and schedule delay), a turnkey contract does not provide for such Owner input. A turnkey contract creates an inflexible environment; there is a huge disincentive for making changes (on either the Owner's or the contractor's part). Any change is generally extremely expensive.

Only if the Owner has a simple project with a clear and detailed SOW in hand, and has done the extensive up-front definition work required for a turnkey, can a turnkey contract make sense.

Owner Advantages

1. If the up-front work is properly undertaken, then good, competitive bids are likely and the bids are easy to evaluate.
2. There is a single source of liability.
3. Owner involvement is relatively low.
4. The Owner should receive a facility with a guaranteed performance for an up-front price that has a reasonable degree of certainty.

Owner Disadvantages

1. Contractor bidding costs will be higher because more bid preparation work is involved.
2. The contractor will inflate the bid to cover contingencies (and will keep the unused portion).
3. An Owner insistence on a low bid price will result in a poor-quality facility.
4. The project start date will be later because of the additional up-front work.

Given the complexity of today's mining projects and the extreme difficulty of getting the required up-front scope detail in hand, the bottom line is that turnkey contracts have no meaningful place in the mining world.

Lump Sum

A lump-sum contract is an agreement for a fixed sum. The contractor agrees to provide all the services necessary to complete the SOW within the contract's battery limits as described in the Owner's supplied specifications for a fixed price, and the Owner agrees to pay the contractor the lump-sum price. The price reflects the cost of performing the work, the purchase of material, and the markup for overhead and profit.

The limits of a lump sum contract are narrower than for a turnkey in that the handover to the Owner is a plant facility that is merely practically or mechanically complete rather than a plant operating at a specified output. When lump-sum contracts are used within the mining industry, they generally cover only the supply of equipment, materials, and construction services. The provision of front-end project services (i.e., design and engineering) and back-end services (i.e., commissioning and start-up) are generally excluded from the lump sum and instead obtained from others.

The advantages and disadvantages for the Owner are similar to that of the turnkey contract, just not as extreme. The straight lump sum does provide a modicum of flexibility for change (albeit at a price). The advantages of this type of contract are that the Owner now theoretically carries minimal risk in the provision of the high-dollar components of project scope, and the Owner cost has better certainty. On the contractor side, the contractor may make more profit if it takes fewer personnel and materials to complete the project than anticipated (McElrath 2012). The disadvantage to the contractor is that the contractor carries the risk if it underestimated the cost of the project. The disadvantages to the Owner are more subtle, but of significant consequence. They are the main reasons that lump sums are generally poorly suited to mining projects: changes to project scope, while allowed, can be very expensive for the Owner, and the contractor may use low-quality materials to save costs and increase profit.

Lump sums are not appropriate until after the feasibility study is complete and the vast majority of design engineering as well as significant detail engineering are in hand. If value engineering is contemplated, the Owner should require this be undertaken prior to fixing the lump-sum amount. The contract for lump-sum work has to include sufficient detail such that it reads, to all parties, as an absolute fixed SOW. Thus any allowances included within a lump-sum submittal by a contractor must be fully explained, defined, and agreed to by the Owner prior to project kickoff.

Scope Changes

Mining projects are not “cookie-cutter” projects—each one is unique. Thus, it is difficult for the Owner to come up with a truly encompassing SOW and equally difficult for the contractor to use any previous experience to accurately cost a lump sum.

Lump-sum bids should only be used when the project scope is well defined. It is a misconception that a hard-money lump-sum contract will shift the cost overrun risk from the Owner to the contractor. Lump sum is merely an agreement for the contractor to provide, for the lump-sum price, all the services necessary to satisfy the contract limits. If the limits are not precisely defined, all one gets from a lump sum are change orders to the contractor’s benefit.

But probably the biggest drawback to the lump sum for any mine project is the Owner itself. Owners are a lump sum’s worst enemy; Owners constantly want to alter specifications and change the scope to reflect new ideas and new data, even if the battery limits are well defined up-front. The problem for the mining project Owner is that exploration and metallurgical testing generally continue throughout the time period from board approval to operations start-up, as the Owner strives to improve its resource knowledge. Ore body shape changes and metallurgical response improvements invariably require facility relocations and process flow diagram modifications, which translate into change orders, which in turn destroy the lump-sum advantage of the Owner and put unbudgeted dollars into the contractor's pocket.

Most contractors know when bidding that the Owner does not have a tight work scope. So unscrupulous contractors will deliberately bid low on their lump-sum cost to win the project (even though this is a violation of the implied covenant, in contract law, of good faith and fair dealing), and then manipulatively use the change order process to gouge the Owner for all the inevitable scope changes. This is known in the industry as "the change order game."

Further, constructors who are experienced at building multiple mining facilities are much more likely to know that an SOW within a bid package is incomplete than the Owner, who perhaps builds one new facility every 10 years or so. Thus the odds of winning and coming out ahead with a lump sum are much more favorable for the constructor. Certainly, the Owner can help its cause by using an experienced EPCM to negotiate, but even then the odds still favor the contractor.

Low-Quality Materials

Lump-sum agreements essentially give contractors the right to select materials, as long as the materials meet specifications. Most mining operators are unable to accept this; operators favor certain brands, want to install specific models, and have a desire to standardize—all for a bevy of legitimate reasons. But these operator desires wreak havoc with contractors' installation time schedules and their ability to secure the materials that they included in the bid. If the mining operator's materials preferences are accommodated after contract award, then more change orders must be made, which in turn will inevitably break the project budget and schedule.

Schedule of Values

One of the more difficult tasks for a project manager is to determine the actual status and values of the completed and remaining work within a lump-sum contract job. When a lump-sum project begins, the contractor submits a schedule of values (SOV) to the Owner for the review based on the original contract amount. The SOV is a detailed statement furnished by the construction contractor listing the activities that make up the contract lump sum. It allocates values for each of the work activities, and in turn, it is used as the basis for submitting and reviewing progress payments. The SOV is reviewed by all parties prior to construction initiation and, if deemed acceptable, approved. After approval, the SOV can only be amended by change order.

For monthly progress payment, the contractor bills on a percentage basis of each line item in the SOV. The project manager has the responsibility to review and approve the amount due to the contractor for each pay period. The fallacy of this entire process, however, is that by default on a lump-sum project, the monthly payment schedule becomes the reported monthly progress. The contractor's monthly SOV submittal is rarely objective, reliable, or easy to verify. Generally, the contractor's billing merely contains a description of the work completed during the month, a value (percentage) of the completed work, a value of materials stored, and the value (percentage) of the balance to finish the work (Short 2006). Thus there is rarely sufficient supporting documentation from the contractor such that the project manager can make a realistic assessment of whether the work is truly complete to the extent claimed. Determination of the actual and remaining values is thus a highly subjective process.

The use of such subjective methodology leads to disputes over job progress and the amount due for the current period. The project manager is always at a disadvantage. The contractor has the advantage of being the one who prepared the original in-depth cost estimate, the details within the project schedule, and the accompanying SOV. The contractor knows the project details far better than the project manager.

A better way to manage the overall project status and to provide for a less contentious method of determining progress status would be for all parties (contractor, Owner, and project manager) to be able to measure contractor progress on an earned value (EV) basis. With EV, progress is based on installed quantities, thus changing the verification of contractor information from a subjective process to a quantitative process. The problem, though, is that EV project controls require the contractor to provide much more internal data to the Owner than a contractor is typically willing to create (or share) for a lump-sum contract. Thus EV payment methodology is generally found more with the greater openness and data availability of cost-plus types of contract than with lump sum.

Time and Materials (Cost Plus)

A time and materials (T&M) contract (or cost plus, as it is often known) is an agreement in which the Owner agrees to wholly reimburse the contractor for its actual salary costs on an hourly basis, plus all other costs and materials. Contractor overhead, administrative expenses, and fees are then covered by additional payments, which are typically negotiated up-front as a percentage of the total project contract.

Contractor fee percentages range from 0% to 10%, but in normal times most T&M contracts end up in the 5% to 8% range. (In abnormal times, when contractors have no work, fees can drop to the 0% to 2% range.)

Overhead and administrative costs theoretically could simply be a pass-through of actual cost, but as actual costs, they are impossible to derive from most contractors, thus a percentage is negotiated up-front between the parties, typically being set around 10%.

While all costs are supposed to be actual, it is fairly common for contractors to add a handling fee on the materials they provide. Handling fees can be up to 10% but generally are in the 2% to 5% range.

The advantage of a T&M contract for the contractor is that it does not have the risk and the up-front work effort of anticipating the cost of completing the work that a lump-sum contract entails (McElrath 2012).

Owner Advantages

- The project requires less definition and can commence quickly after minimal preparatory work.
- T&M contracts typically attract more competition in the bidding process than do lump sums.
- Owner only pays for the actual time worked by the contractor.
- T&M contracts have greater flexibility and allow more post-award Owner participation.
- T&M contracts have lower contractor contingency, reflecting lower contractor risk.
- The Owner essentially controls the work; the Owner now has the option of selecting materials.

- Contract termination incurs lower cancellation costs.
- There is less conflict than with lump-sum arrangements.

This contract type is thus appropriate for projects that otherwise present too great a risk to contractors, but the drawback of a T&M contract is that it provides the contractor with little incentive to control costs or schedule. This is the main disadvantage from the Owner's perspective.

Owner Disadvantages

- A T&M contract does not necessarily provide the contractor with sufficient incentive to get the job done. Owners tend to believe that the contractor's incentive is to keep the clock running, especially if the contractor does not have the next job lined up. The contractor may work slowly or pad its hours, and there is no real penalty for contractor inefficiency or poor-quality resources because the contractor is paid regardless.
- Owner costs are higher, because T&M contracts require a large input of resources and time from the Owner.
- Evaluation of bids requires more work and is more difficult than for a lump sum contract.
- Forecast of total project cost has uncertainty before completion of detail engineering.
- It is easier for the Owner to make changes, which can delay completion and increase cost.
- It is relatively easy for the project and Owner staff to overlook the real cost of their actions.

Dispute Issues

The prime reason that Owners gravitate to T&M contracts is because of the Owner's difficulty with the up-front estimation of project costs. Most Owners do not have a system in place that will allow them to accurately estimate construction projects. Thus Owners default to cost plus. But T&M contracts are not a panacea; they come with their own issues (Stone 1999).

Project Cost Overrun Disputes

T&M contracts sometimes facilitate lackadaisical project estimating, which amplifies the chance of the original project cost estimate being too low. A low estimate will lead to dispute over money when real costs come in, and the Owner has to pay more for the job than was allowed. Therefore, it is important to take the same time to prepare an accurate estimate on a T&M job as for any other type of contract.

Owners often go into a T&M contract thinking that they have ample money to cover the job *and* the right to make whatever changes they want. But when the Owner makes changes to job scope, the cost invariably increases, and thus long before the job reaches the completion point, the project runs out of approved money. This often leads the Owner to claim that the contractor must have overspent and the contractor should now finish the job for the money that has already been paid. In other words, the Owner belatedly and unfairly tries to treat a T&M contract as a lump sum. If the Owner wants to hold the contractor to a fixed lump-sum price, then this should be stated as such up-front, so the contractor can price the job and the risk accordingly.

Project Mistakes Disputes

If a mistake is made on the engineer's plans, the engineering entity pays for the time it takes to redraw the plans, but who pays to tear out the mistake and rebuild it, and who pays for the contractor crew's downtime while waiting for the revisions and field remobilization? Logically, on a T&M contract it should be the Owner, but few Owners see it this way; they try to put these unbudgeted costs onto the construction contractor if the engineer's contract language prohibits consequential damages (and most engineering contracts do).

If the construction contractor makes a mistake on a T&M job, the contractor should pay for the fix, but invariably the contractor will try to get the Owner to pay for it. And even if the contractor agrees to cover the labor and time of rectifying the mistake, who pays for the ruined removed materials? Who pays the cost of shipping the new materials? These issues need to be spelled out in the contractor agreement.

Equipment and Materials Disputes

Owners are far more prone to want to furnish equipment and materials for their jobs when using a T&M contract. (Indeed, this is one of the main advantages of a T&M contract for the Owner). But it is unreasonable for the Owner to expect the contractor to guarantee the performance of those materials when installed (except for workmanship of the installation). The time and cost to replace defective materials supplied by the Owner should be borne by the Owner, not the construction contractor.

When the Owner elects to supply the materials but then neglects to buy a certain item, it is the Owner who should pay to bring in the missing items, including travel time, if the contractor has to supply the material the Owner forgot. And if it takes a few days to get the needed materials to the job site, the contractor will expect the Owner to pay for downtime that its work crews have to endure.

A T&M contract allows the Owner to see how much the contractor pays for materials. While Owners can sometimes see that they could have bought the same item elsewhere for less money, this contract unfortunately does not give Owners the right to pay only the amount that they could have bought the materials for themselves. The Owner still has to reimburse the contractor for the full cost of all contractor-supplied equipment and materials.

If, before the job starts, the Owner asks the construction contractor to prepare a list of materials needed for a T&M job, then the Owner should expect to pay for the contractor's time to prepare such list.

Contractors need to accept that in T&M contracts, they lose the markup that they would normally make on lump-sum contract materials and should not try to recoup it elsewhere.

Subcontractor Disputes

Some T&M contracts give the Owner the right to select the subcontractors ("subs") for the job from a list supplied by the general contractor. On other T&M contracts, the Owner can hire its own subs for either the Owner or the general contractor to supervise on the job. Problems arise, however, when subs hired by the Owner do not adhere to the general contractor's work schedule. In these instances the general contractor will expect the Owner to be responsible for delays and downtime caused by the subs' lack of cooperation. This, in turn, can lead to the Owner suing the contractor for lack of supervision and damages caused because the job did not get done on time. To avoid such issues, Owners should refrain from micromanaging and selecting subs for their selected general contractor.

Unproductive Labor Disputes

Some Owners seem to believe that their contractors' employees should be fully productive all hours of the day. This is not realistic; legitimate work interruptions happen. The Owner should expect to pay for mandated employee breaks. The Owner should expect to pay for the time of a contractor employee escorting an inspector through the job and to pay for the labor and materials to install changes required by that inspector.

Contract Billing Protocol Disputes

Because there is no universal definition of T&M for contract billing, misunderstandings can arise. There is an erroneous contractor perception that with T&M contracts the Owner is required to pay for absolutely everything. Consequently, many contractors do not always present change work orders for their out-of-scope work, falsely believing that they will automatically be paid for all the work they perform. To ensure proper payment with a T&M contract, contractors must keep a more accurate day-to-day log of labor, materials, subcontractor, and other job costs than with a lump-sum contract so they can justify their actual expenses. If they do not, they may not be able to collect, regardless of work validity.

The Owner should not expect to pay for contractor travel time to and from the Owner's office for meetings on problems that arise on a T&M job, but the contractor invariably expects to be paid for this time. Therefore, it is important to clearly spell out the payment procedure for dispute meetings up-front in the contract document.

Overhead Disputes

While it is true that a contractor will generally cost an Owner less money than if the Owner had built the project, the Owner extrapolates this thought process into an unreasonable expectation that the contractor should always charge less money than the Owner would internally incur for the same item. For instance, many Owners try to mandate that a contractor should charge no more than 6% to 8% for overhead. This makes it extremely difficult for the contractor to attain its true out-of-pocket overhead for the job. Consequently, some contractors on T&M contracts move overhead item costs into the job cost section. Owners need to be realistic in their negotiations about contractor overhead allowance. Such overhead is likely to be at least 10%.

Not-to-Exceed Features

Owners can add a modicum of additional control on a T&M contract by inserting a not-to-exceed clause. With such a contract, when the job is about to go beyond the not-to-exceed amount, the contractor must have written authorization to do that work (a signed, dated, and completely priced-out change order) or the Owner is not obligated to pay. (Note: Lenders often will not provide funds to a T&M job unless there is such a clause.)

An interesting twist introduced in recent years is the conversion of a T&M contract to a lump sum at a certain point in the project life, typically when more than 80% of the drawings are issued for construction (IFC) and the contractor is fully mobilized. In one author's career on the contractor side of the industry, such a conversion was embraced by both parties. The contractor gets to add a lump-sum margin markup to its prior T&M contract, when most of the risk has essentially dissipated or at least is pretty well known. So this generally becomes just a giveaway on the Owner's part, but interestingly, the Owner is generally happy with the deal, because the Owner believes that its capital cost is now locked. Unfortunately, this is rarely true in the change-order world of the savvy constructor.

EPCM Cost Reimbursables

A T&M contract will likely be the most suitable format for the EPCM contractor, particularly for the study phases and the engineering and procurement stages (where definitive scopes are almost impossible to nail down). When the large EPCMs that serve the mining industry take a T&M contract, they predominately apply a cost-reimbursable model with a single multiplier on their bare (actual) labor rates as a surrogate for their actual costs. The multiplier will include

- Payroll additive burdens and benefits, typically about 40% to 45%; and
- Overhead expenses (direct and indirect), typically about 55% to 65%.

The resultant multiplier on the bare paid wages thus generally comes out at around 2.3 (1.0 × 1.425 × 1.6), which is logical, as most large EPCMs have a cash break-even point with wage multipliers of between 2.1 and 2.5. Items *not* covered by the EPCM wage multiplier and thus needing to be billed as separate additional cost add-ons include intellectual property and technology usage fees (software, etc.), taxes, insurance, bonds, profit, contingency, escalation, and any external subconsultants. Together these could run the equivalent of 40% to 50% more on the wage multiplier.

In addition, the infamous home-office-expense adder that aggravates most Owners typically runs from $6 to $10 per hour, depending on the firm. It is unclear as to why EPCMs do not include this in their multiplier. It is a perennial irritation for Owners.

Thus, when the preceding information is taken into account, an Owner should typically expect to pay at least three times the worker's bare rate for each large global EPCM employee. This is an average; it could easily be higher or lower, depending on market, locale, magnitude of the project, and size of the EPCM.

Fee Plus (Cost Plus Fixed Fee)

A fee-plus (also called a cost-plus-fixed-fee) contract is a T&M cost-reimbursable type of contract, but one that provides for payment to the contractor of a single negotiated fee that is monetarily fixed at contract inception. Unlike a T&M contract, the fixed fee does not vary with the actual project cost. Thus a fee-plus contract is a hybrid between T&M and lump sum contracts.

The *fee* refers to the lump-sum element and normally covers contractor profit and overhead. The *plus* refers to the reimbursable aspect and comprises whatever else the contract terms call for the contractor to provide, charged to the Owner at contractor cost. However, to be fair to the contractor, the fee amount is adjusted for any Owner-approved changes in work scope performed under the contract.

As with a T&M contract, the advantage for the contractor is not having the risk and the up-front work effort of anticipating the cost of completing the work. The advantages for the Owner are that only the actual time worked has to be paid for, and the Owner still retains the option of selecting the materials. The real advantage of fee plus from the Owner's standpoint, compared to that of a T&M contract, is that the contractor now has a real monetary incentive to get the job done quickly and efficiently. The contractor no longer has an incentive to keep the clock running because work extensions reduce the effective fee percentage. Finishing early increases the fee percentage. The contractor may still work slowly or pad hours, but there is now a negative consequence for such contractor inaction; the contractor's fee no longer increases for the inefficiency.

In the project bid package for a fee-plus job, Owners sometimes specify that the fee sum must fit in a suggested range of total bid price, typically below a 5% to 8% maximum. This essentially tells the contractor: do not enter a bid if you want to make a higher markup—almost a take-it-or-leave-it scenario. While this theoretically makes it difficult for contractors to attain their usual target markup for a job (15% to 25%), the Owner's call for a fee limitation has not, in the authors' experiences, dissuaded contractors from entering bids. Indeed, the authors have received bids on fee-plus jobs from major EPCMs with fees as little as 0% or an effective 2% of total job cost.

With the general inappropriateness of lump-sum bids for grassroots projects and the open-ended drawback of T&M contracts, the fee-plus contract has become the most common form of contract used today on mining projects. The authors have found that a fee-plus contract generally serves a mining project best (along with possibly that of a GMP contract when the parties have the sophisticated resources available; see the section on GMP later in this chapter). Nevertheless, the decision of which contract type to select for any particular project must still be made on a case-by-case basis.

Schedule of Rates

A schedule of rates is a contractual payment methodology that most small, specialty engineering firms use wherein most of their cost items (including profit) are included in a single rate for each employee. This is simpler for the accountants within the engineering firm to handle; invoices are easier to prepare. Cost items within a scheduled rate include wages, payroll burdens, benefits, overhead expenses (direct and indirect), insurance, home-office expense, contingency and escalation, and profit.

Unlike the large EPCMs, these small, specialty engineering firms generally vary the multipliers for each employee, and so some staff members will be charged out at a rate of 5.0 times their bare wage rate, while some may be charged out at as little as 1.5 times their bare rate. These internal multipliers are highly confidential and never shared with clients; clients only see the charge-out rates. Overall, the collective multiplier for a specialty engineering firm generally comes out at around 3.0 to 3.5. Really small firms (e.g., just a few employees) will need higher average multipliers (probably 3.5 to 4.0) to cover their costs and overheads.

However, even with a schedule-of-rates contract, not every expense is covered; there will be some separately billed add-ons, such as intellectual property or technology usage fees (mostly for software), taxes, bonds, and external subconsultants. These items are typically charged to the Owner at cost or include a small handling fee (2% to 5%).

As a comparison for the reader, large EPCM firms can generally break even with a wage multiplier of between 2.1 and 2.7, and in times of desperation, large firms may go below 2.0 into the 1.8 to 1.9 wage multiplier range just to keep their staff employed and stay in business. But most EPCMs lose money with such low multipliers, covering just wages and burdens, but not benefits or overheads.

Guaranteed Maximum Price

A GMP (or not-to-exceed [NTX] price) contract is an open-book contract in which the contractor is compensated for actual costs incurred plus a fixed fee subject to a ceiling price. In effect, the contractor commits to complete the work without additional payment if the fixed-price ceiling is reached.

The contractor is responsible for cost overruns, unless the GMP has been increased via formal change order (but only as a result of additional scope from the client, not for price overruns, errors, or omissions). Savings resulting from cost underruns are returned to the Owner. This is different from a lump-sum contract where cost savings are typically retained by the contractor and essentially become additional profits.

The work within a GMP contract is reimbursed on a T&M basis. But the contractor agrees up-front to accept the lesser of the actual cost of the work plus the fixed-fee ceiling amount or the GMP. This model is thus a hybrid of lump sum and T&M. It theoretically allows the Owner to enjoy both budgetary certainty and the benefit of any project cost savings (assuming the contractor does not play the change-order game with the Owner).

When properly administered, a GMP contract, like T&M and fee-plus contracts, provides flexibility for work that cannot be fully specified at the start of construction. However, because of the open-book requirement, a GMP contract requires significantly more sophistication and additional resources from the contractor and the project manager to set up and administer in a disciplined fashion. The contractor has to do just as much up-front estimating work to arrive at its ceiling price as with a lump sum, or probably even more work (as the risk to the contractor is greater). Not all contractors are capable of, or desirous of, providing open-book construction information. And not all Owners are willing to put the necessary extra project management staff resources into a project to effectively control an open-book contract.

A GMP contract tends to resemble a lump-sum contract more than a T&M because of the amount of additional work required up-front (which results in a later start) and the inflexible environment that it creates for the parties involved. Unfortunately, this form of contract has become the most adversarial; it has a history of generating the highest degree of conflict between the parties.

Unit Rates

A unit-rate contract (or a unit-price contract, as it is often called) requires the contractor to fix a set price on each unit of work. The work, therefore, has to be broken down into parts within the bid package. The advantages of this type of contract include the flexibility in easily adjusting the scope and the fact that it is not necessary to know the complete design up-front (McElrath 2012). The disadvantage of this type of contract is the unknown up-front cost for the Owner to complete the entire project due to potentially inaccurate determinations of the quantities needed.

Unit-rate contracts work well for civil earth-moving-work packages. Thus with the civil work generally being the first work conducted on a project site, frequently well ahead of the other project site work, it can make good sense to parcel out the earth-moving work into a separate unit-price contract, separate from the main project work scope.

Caution: Unit prices suffer from the same issues as unit costs (see Chapter 11). In setting unit prices, contractors often assume that the project they are bidding on is just like the previous ones from which their pricing was drawn, when, in fact, all projects are unique. Also, the time factor is an issue. Things change—inflation increases labor and material components; technology improvements should decrease pricing. Unit prices are simple to adjudicate, but they may not be fair pricing for one of the parties to the agreement.

Design-Build

In a design-build contract, one contractor is in charge of both designing and building the facilities. Engineering, procurement, and construction (EPC) contracts are classic design-build in that the selected engineer uses its own labor to construct the project, rather than managing separate construction contractors as is the case in EPCM contract relationships. Design-build contracts can be either lump sum or T&M (with or without a fixed fee).

The advantages are that the Owner may save money by having one party implement the two phases of the project, and the builder will better understand the project since the builder designed what is to be built (McElrath 2012). The big disadvantage is that the Owner must provide substantial details about the project at the engineering bidding stage (which are generally not available). And the wisdom of the contractor being asked to determine the cost of completing the project for the Owner prior to the design or the drawings being available belies sensibility. This option has no attraction for the authors.

While design-build is still used on a few projects (more often with smelters than with mines), it has declined to a very limited use over the past half century, partly because fewer and fewer firms can effectively provide this service today.

SUBCONSULTANT AND SUBCONTRACTOR AGREEMENTS

If the EPCM's work scope requires bringing in a subconsultant or if the prime construction contractor (the general contractor) needs to bring in a subcontractor, then a completed agreement with the sub is required before the sub begins work on the project. The subconsultant or subcontractor agreement should be put in place as soon as the EPCM–Owner or construction contractor–Owner agreement, as the case may be, is executed and the project work plan agreed to.

While the EPCM and the general contractor take the lead roles in their respective negotiations with their subs, the project manager should be present, whenever possible. Owner presence is not mandatory, given that agreements with subs are typically signed by the EPCM or the general contractor, not the Owner. The EPCMs and the general contractors prefer to use their own standard forms for these sub agreements.

In general, subconsultants and subcontractors should abide by the same rules that the EPCM or the general contractor, respectively, live by with the Owner. Agreements made should pass through all risks and requirements outlined in the Owner agreement. These include indemnification, insurance, affirmative action, standards of care, billing substantiation, and any special Owner rights and privileges.

An unacceptable scenario for an EPCM or a general contractor is to have an agreement with an Owner that contains the usual provisions regarding risk, indemnification, and payment but then enter into a contract with a sub that substantially limits the sub's liability to the EPCM or to the general contractor. The problem here is that when the EPCM or the general contractor promises more to the Owner than the sub promises to the EPCM or the general contractor, the difference will come from the EPCM or the general contractor's coffers, not the sub's.

Subs are normally paid only after the EPCM or the general contractor has been paid for the work involving the particular sub's service. The date of payment to the sub relates to the payment by the Owner, not to the invoicing date of the sub. To clarify, the terms of such payments need to be included in all subconsultant or subcontractor agreements.

A copy of each sub's contract and any subsequent amendments are maintained in the project file by the project manager. Original copies are provided to the Owner. Certificates of insurance for workers' compensation, general liability, and professional liability insurance (when appropriate) should be obtained from all subconsultants and subcontractors, and care taken to ensure that all certificates are current.

INCENTIVES AND PENALTIES

There are widely differing opinions on the merits of incentive or penalty schemes. Some Owners believe them to be dysfunctional because they can encourage poor on-site practices. However, the evidence mostly favors incentive schemes. A wide-ranging survey of U.S. construction productivity by James D. Whiteside II found incentive-driven sites to be 21% more productive (based on U.S. Gulf Coast labor indices) than nonincentive sites (Whiteside 2006). Thus, whenever possible, the mining company should establish an incentive (and penalty) scheme for the prime construction contractor, as well as for the EPCM firm.

Typically, an incentive or penalty scheme for a contractor would be a gainshare-painshare arrangement within the contract tied to or triggered by deviations in

- Schedule, that is, the key milestone dates, including project completion;
- Capital cost; and
- Performance, particularly safety performance.

The purpose of incentive or penalty arrangements is to discourage falling short of project goals and to encourage exceeding those goals. Best practice is to stagger the incentive award payments with the successful attainment of discrete milestones throughout the project execution life, so as to maintain contractor commitment to the project objectives. The gain-pain approach of using cost, schedule, and performance criteria is an effective means of aligning contractor and Owner. Incentives and penalties within a contract must be clearly stated in the language of the contract. Attorneys will prefer to assess penalties as liquidated damages.

If the project incentive (bonus) is to act as a real incentive for performance improvement, the program has to be fully understood by all parties at project start, and the bonus monies must be paid to the participating parties immediately upon goal attainment. Similarly, strict penalty enforcement should immediately fall on the party responsible for nonattainment of any listed project parameter.

Incentives and penalties should only be applied to the contractor when the contractor is the cause of the project deviation, for example, for design or construction faults. Deviations caused by environmental or social issues are generally Owner controlled and thus would not typically trigger a contractor incentive or penalty.

To truly be a project incentive, a contract with an incentive or penalty clause requires accurate monitoring, measuring, and reporting of project key performance indicators (KPIs) (via dashboards, meetings, periodic updates, etc.) providing clear, frequent, and timely communication of progress status to all affected parties.

Schedule

The contract should be designed with significant monetary penalty for schedule deviations, given that schedule delays are generally the prime cause of cost overruns. Penalties must then be strictly enforced. It works best to break the contract schedule into discrete milestones (each milestone acting as a separate checkpoint of project progress against schedule), along with one major milestone for the final project completion date target.

Key milestone incentives or penalties are triggered by meeting or not meeting a major, easily visible project milestone date (e.g., shaft bottomed out, first gold pour). Project completion incentives or penalties are generally triggered by meeting the project master schedule completion date, but are sometimes generated by meeting an aggressive early completion schedule established by the project participants. A monetary value is assigned to each day of delay or day of improvement to the schedule.

Ownership of schedule overrun risk varies between Owner and contractor. Thus incentive or penalty schemes are not a total panacea to prevent project delays. For instance, delays caused by Owner decisions will not trigger a contractor penalty.

Cost

The contract should provide significant monetary incentive (or penalty) for any deviation to budget because project capital cost is the criterion most focused on by the board. Capital cost incentives or penalties are triggered by project completion above or below the approved control budget.

Performance

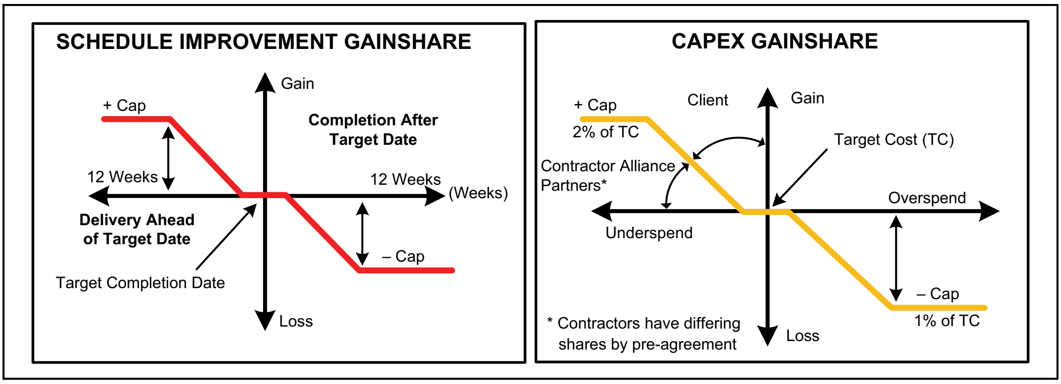
While it is desirable to design a contract with incentives or penalties that use measurable performance parameters to encourage goal achievement, creating such is not simple. Safety is the one easy performance parameter to measure and set targets for. Periodic safety incentives or penalties are triggered by deviations from a zero lost time accident (LTA) safety record in the target period. Generally, these are reset and paid every calendar quarter during the project life. Often this is an incentive only, with no penalty for any quarterly nonachievement (though the authors do not agree with this practice).

Project completion safety incentives are triggered by achievement of a zero LTA safety record target over the project life. These are paid at project completion. Some Owners pay these completion incentives out of a percentage holdback (e.g., a one-third holdback) from each quarterly safety payment. If penalties are assessed quarterly, there would be no penalty applied at the completion milestone.

Other parameters are more subjective. The more difficult parameters of "productivity" and "quality" do not lend themselves to precise definition or measurement. A lack of other performance incentive or penalties is not a flaw. Most contracts contain performance-achieving mechanisms outside of any incentive or penalty clause, that is, the warranty and liability clauses. Thus, if specified performance is not met in the incentive or penalty arena, the contractor probably already has an obligation to make good on it, otherwise legal penalties will apply.

Gainshare-Painshare

Gainshare-painshare is a widely understood, formal contractual performance mechanism that uses money to attain performance standards. Additional compensation is awarded to the



Source: Hickson 2002.

FIGURE 20.2 Gainshare-painshare incentive or penalty example

contractor depending on the level of performance actually achieved. If performance fails to meet standards, then monetary penalties apply.

Gainshare-painshare incentives and penalties are usually linked to the contractor fee and are mostly (but not always) symmetrical, that is, equal amounts around a set target point. They should have a "dead spot" of no payment for a modest change to target (e.g., no payment or penalty for up to 7 days ahead or behind schedule in a 36-month project) but should escalate as the deviations are better or worse than target; for example, zero dollars per day for the first week's gain or loss of time on schedule, $10,000 per day for the next month's gain or loss, $20,000 per day for the third month, $40,000 per day for the fourth month, and so forth.

A cost gainshare-painshare would similarly escalate as the deviations are better or worse than target. A dead spot for cost deviations is typically 0.5%, or less; for example, zero dollars for the first $5 million gain or loss to budget on a $1 billion project, $1 million for the second $10 million gain or loss, $2.5 million for the third $10 million gain or loss, $5 million for the fourth $10 million gain or loss, and so forth.

There is a school of thought that gainshare-painshare should *not* be symmetrical but rather should skew more to reward than to pain, as Figure 20.2 shows. The benefit of the system is that it can be set up either way.

A single gainshare-painshare scheme of risk and reward encompassing Owner, EPCM, prime construction contractor, and key suppliers has a lot of merit. It is one in which all the participants have the potential to share the commercial benefit of a successful outcome and the pain of failure—that is, everyone wins or everyone loses. This, however, is close to impossible to put in place, so the scheme generally manifests itself as separate gainshare-painshare clauses within each key contractor's contract.

With most gainshare-painshare schemes, each individual incentive or penalty is usually capped (generally no more than 0.5%–1.5% of total project cost), and the sum total of the incentive or penalties is also capped (typically at around 2% of total project cost), given that most Owners need to know their maximum monetary exposure from such schemes before they agree to them.

Warranty and Liability

With warranty and liability performance mechanisms, performance is either met or not met. If not, then the contractor has the obligation to make good. If the contractor fails to fulfill the contract, then legal penalties apply.

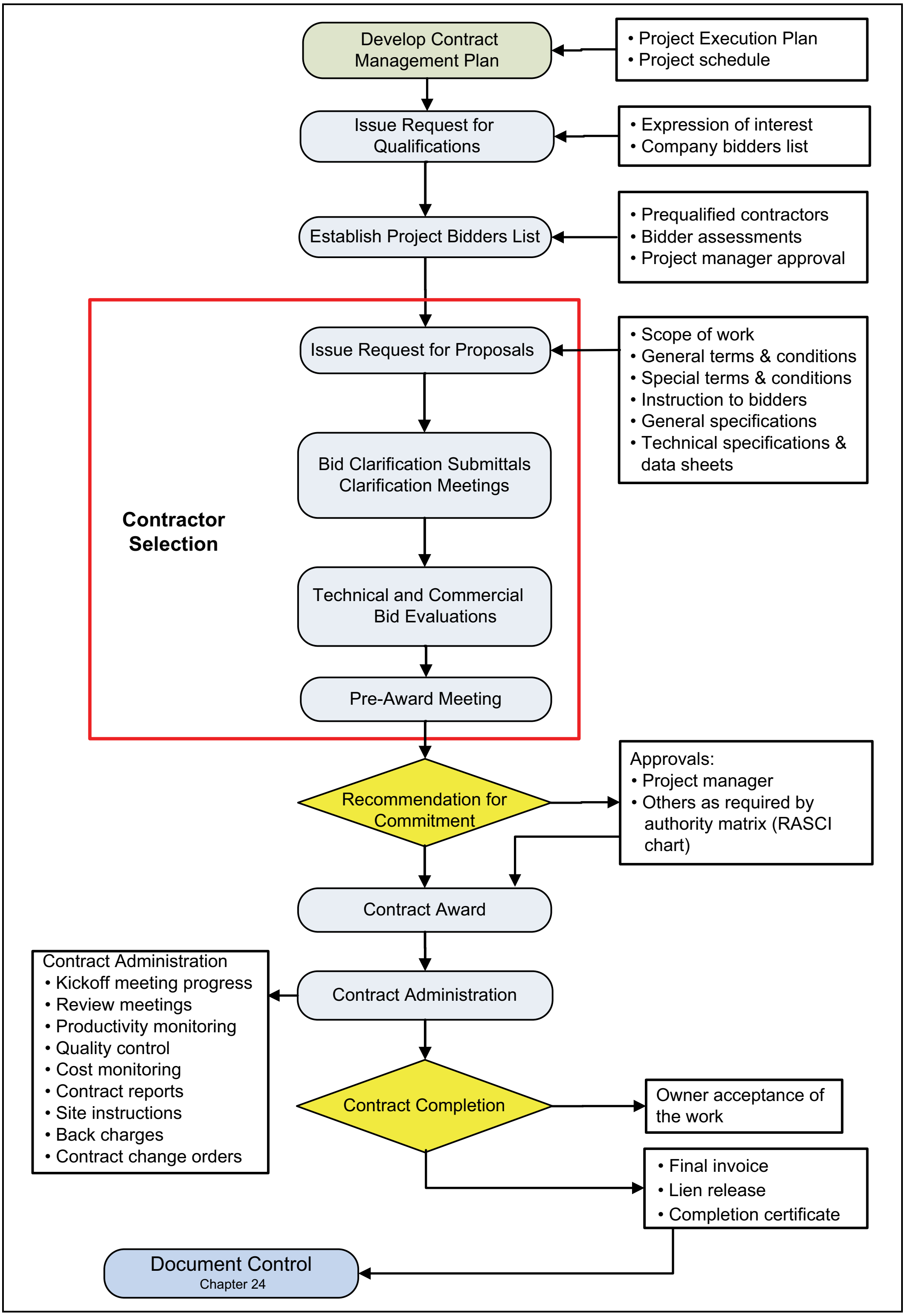
CHECKLIST 20.1 CONTRACT AGREEMENT

No.	Item	Status	Date	Initials
1	Project philosophy and strategy—understood			
2	Project Execution Plan (PEP)—in place			
3	Project delivery model—selected (Owner, EPC(M), or hybrid)			
4	Contract award process—organized			
	A. Scope of work (SOW) accurately reflected in contract documents—OK			
	B. Most beneficial contract terms for Owner—established			
	C. How best to align Owner and contractor—determined			
5	Contract management plan—developed			
6	Contract type—selection of one of the following:			
	A. Lump sum (excluding turnkey)			
	B. T&M (cost plus)			
	C. Fee plus (cost plus fixed fee)			
	D. Schedule of rates			
	E. GMP			
	F. Unit rates			
	G. Design-build			
7	Selection process for contractor—undertaken			
	A. Owner in agreement with process—OK			
8	Bidders list—developed			
9	Request for qualifications (RFQ) or expressions of interest documents—sent			
10	Prequalification of bidders—accomplished			
11	Draft contract documents—developed			
	A. All technical specifications and data sheets—complete			
	B. General terms and conditions (boilerplate)—complete			
	C. Bonding and insurance requirements—determined			
	D. Special considerations—addressed			
12	Request for proposal (RFP)—issued to 4 (± 2 firms)			
	A. Complete bidding instructions			
	B. SOW (including project schedule)			
	C. Project specifications			
	D. Required bidder deliverables			
	E. Form of agreement			
	F. Basis of compensation (optional)			
	G. Bonding and insurance requirements			
13	Interview of bidders—undertaken			
	A. On project site with all bidders			
	B. One-on-one meeting in bidder's proposed work base			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
14	Bid clarification process—provided			
15	Bid evaluation ranking form—completed and agreed to by Owner			
	A. Plan of execution—evaluated and scored			
	B. Technical competency—evaluated and scored			
	C. Likely contractor performance—evaluated and scored			
	D. Value—evaluated and scored			
16	Selected bid recommendation—provided to Owner			
17	Pre-award meeting with selected winning bidder—held			
18	Contract agreement negotiations with winning bidder—undertaken			
	A. Appropriateness of contract language and type—reviewed			
	B. Owner's financing capability—satisfactorily addressed			
	C. Contractor's financial stability—satisfactorily addressed			
	D. Business terms (warranties, payment terms)—agreed to			
	E. Project risks—assigned to natural owner of each risk			
	F. Contract incentive and penalties—considered			
	G. Completion requirements—clearly defined up-front			
19	Contract—awarded, if negotiations successful			
20	Contract administration protocols—implemented			
	A. Contracts administrator—appointed			
	B. Contract document—filed			
	C. Kickoff meeting—held			
	D. Modify PEP and refine SOW—as necessary			
	E. Site instructions process—developed			
	F. Contract change order process—implemented			



FLOWCHART 20.1 Contract agreement

CHAPTER 21

Project Controls

If project content is allowed to change freely, the rate of change will exceed the rate of progress (Immutable Law of Project Management).
— Paul Mahoney, Vice President, Sales, Aker Kvaerner Metals, July 2001

OBJECTIVE

The objective of this chapter is to ensure that adequate scope control, accounting, and project controls are established for the entire project at the outset. Achievement of this objective requires an understanding of the overall project control process.

The principal tools and procedures are identified to control the scope of work (SOW) and thus best ensure that the project stays in budget and on schedule. Project controls are a set of proactive monitoring and implementation tools that use current and historical data to provide a basis for forecasting and trending the critical elements of the project in order to take corrective action, wherever required. The details of project controls are explained.

The need for adequate project controls is frequently finessed at the beginning of the project. There is often a feeling that controls can be added later. This is a false premise; the implementation of adequate controls before the project gets underway generally means the difference between project success and project failure.

WHAT IS CONTROLLABLE WITHIN A PROJECT?

Effective project control requires an understanding of what is controllable within a project and then paying close attention to the details of the following four crucial components:

1. SOW (and its related task list)
2. Engineering design
3. Procurement implementation
4. Field construction

Changes within any of these elements will directly affect the cost, timing, and outcome of the project.

Scope of Work

A clearly defined SOW is required for *all* project cost areas, including engineering, procurement, and construction management (EPCM) costs, Owner costs, and all related financing costs. As Terry Owen observed, "You can't control a project that doesn't have a defined scope" (Hickson and Owen 1997).

After full scope definition, the general philosophy and intent of the SOW must be frozen, and then *no* changes made without approval and strict adherence to the change control procedures set up for the project.

Task List

Project tasks are the activities required to complete the project work scope. The task list, which quickly morphs into the work breakdown structure (WBS), has long been the foundation of project control because it is the basis that underpins project schedule and project budget. Each task must have

- A definable work scope;
- A duration, with at least one start and one finish date; and
- A level-of-effort requirement to complete the task.

All items specified in the project contract agreement have to be on the task list. However, while a task list defines what activities have to be done, it is acceptable to leave latitude as to how they will be done.

Engineering Design

The quality level sought from engineering and the design approaches used have significant impacts on project cost.

Procurement Implementation

The components of procurement, including the format of contract packages, bid assessment procedures, the terms and conditions of purchase, and any special requirements all have an effect on project cost and timing.

Field Construction

The careful scheduling of people, materials, and resources—not too early, not too late—is paramount for delivering a successful field construction effort. Strict adherence to scope, having final drawings on hand in a timely way, staffing the job with adequate personnel and field inspectors, doing it right the first time, working the crews sensibly within the good weather opportunities and the available daylight hours, maximizing off-site equipment assembly, and modularizing installations as much as possible are all techniques that will aid in the construction control effort. Value is added (money is saved) in a project by allocating sufficient field review and inspection resources.

RESOURCE REQUIREMENTS FOR PROJECT CONTROL

The necessary elements for effective project control are

- A competent project management team (See Chapter 18),
- An adequately sized project controls team,
- A project control system,
- Project control documents,

- An objective measurement of project performance and progress (i.e., earned value management [EVM]),
- Project control tools, and
- Regular project audits.

Figure 21.1 ties together these resource requirements into an integrated project development and control process.

PROJECT CONTROLS TEAM

At the outset, it is vital to assign a project controls team that has full responsibility for controlling the entire project. The project controls team leader is charged with providing regular feedback to senior company management in the Owner organization on all major issues. This upward information flow further strengthens the control and governance functions.

Funds committed to any component of the project must go through a single entity, preferably one person, that is, the project manager (generally via a designee, typically the project controls manager), and then on to the project accountant, who is charged with approving all payments. One cannot have effective project control and at the same time have external persons in, say, the Owner's team or the Owner's treasury group approving payments or charging costs to the project.

Responsibilities

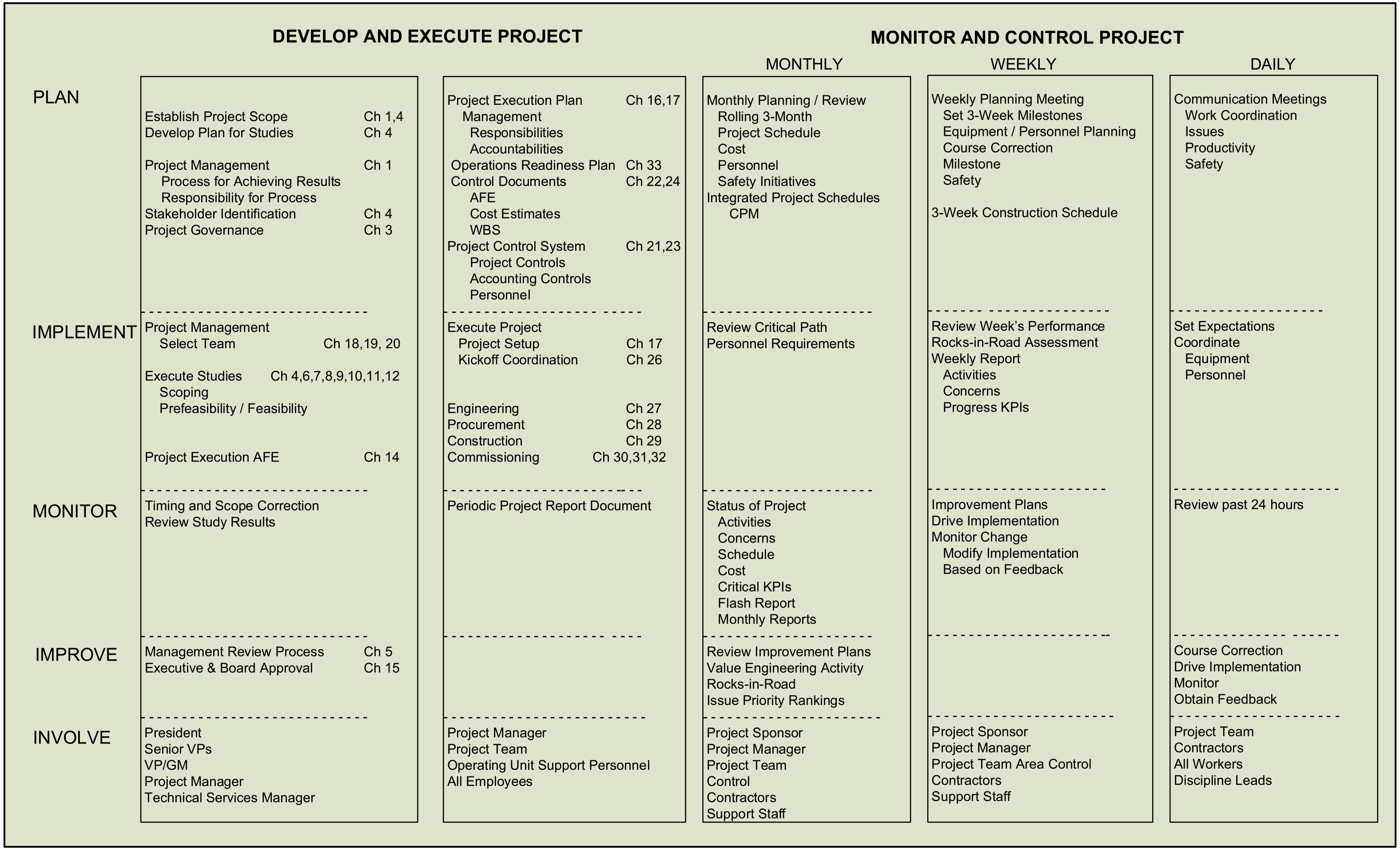
To ensure adequate control, all project areas have to be under a single point of responsibility, that is, under the project manager. The project manager is appointed by the mining company and should be independent of the EPCM *and* the Owner's future operations staff. The project manager is tasked with completing the project's defined scope within the approved budget and schedule.

The project manager assigns different levels of authority and responsibility to the other project team members to allow the work flow to proceed without unwanted interruption. Levels of approval for authorizing project expenditures and/or timing changes must be established. These delegations are set within the governance framework established for the project, and they need to respect the in-place company policies regarding delegation of responsibility.

Once the project scope is defined and the budgets and schedules are finalized, neither the Owner nor the EPCM contractor can be allowed to make *any* changes to the scope, budgets, or schedules without complying with the change control procedure. This change control procedure requires that all changes be approved by the project manager before implementation, and that only properly motivated changes can be considered for approval.

Similarly, the commitment of *any* funds for *any* project-related component must be approved by the project manager. **The project manager has full control, responsibility, and accountability for all project costs**. Thus, even the Owner team's portion of the project monies are controlled by the project manager, *not* by the Owner's operations staff. This is essential to ensure ultimate fiscal control.

If the project is divided into areas (as often happens on mega-projects), then from within the project management team a single project control specialist will be assigned to each locale as an area project controls manager. This individual is responsible for project controls within that area and will administer the controls for the project manager.



	DEVELOP AND EXECUTE PROJECT		MONITOR AND CONTROL PROJECT		
			MONTHLY	WEEKLY	DAILY
PLAN	Establish Project Scope Ch 1,4 Develop Plan for Studies Ch 4 Project Management Ch 1 Process for Achieving Results Responsibility for Process Stakeholder Identification Ch 4 Project Governance Ch 3	Project Execution Plan Ch 16,17 Management Responsibilities Accountabilities Operations Readiness Plan Ch 33 Control Documents Ch 22,24 AFE Cost Estimates WBS Project Control System Ch 21,23 Project Controls Accounting Controls Personnel	Monthly Planning / Review Rolling 3-Month Project Schedule Cost Personnel Safety Initiatives Integrated Project Schedules CPM	Weekly Planning Meeting Set 3-Week Milestones Equipment / Personnel Planning Course Correction Milestone Safety 3-Week Construction Schedule	Communication Meetings Work Coordination Issues Productivity Safety
IMPLEMENT	Project Management Select Team Ch 18,19, 20 Execute Studies Ch 4,6,7,8,9,10,11,12 Scoping Prefeasibility / Feasibility Project Execution AFE Ch 14	Execute Project Project Setup Ch 17 Kickoff Coordination Ch 26 Engineering Ch 27 Procurement Ch 28 Construction Ch 29 Commissioning Ch 30,31,32	Review Critical Path Personnel Requirements	Review Week's Performance Rocks-in-Road Assessment Weekly Report Activities Concerns Progress KPIs	Set Expectations Coordinate Equipment Personnel
MONITOR	Timing and Scope Correction Review Study Results	Periodic Project Report Document	Status of Project Activities Concerns Schedule Cost Critical KPIs Flash Report Monthly Reports	Improvement Plans Drive Implementation Monitor Change Modify Implementation Based on Feedback	Review past 24 hours
IMPROVE	Management Review Process Ch 5 Executive & Board Approval Ch 15		Review Improvement Plans Value Engineering Activity Rocks-in-Road Issue Priority Rankings		Course Correction Drive Implementation Monitor Obtain Feedback
INVOLVE	President Senior VPs VP/GM Project Manager Technical Services Manager	Project Manager Project Team Operating Unit Support Personnel All Employees	Project Sponsor Project Manager Project Team Control Contractors Support Staff	Project Sponsor Project Manager Project Team Area Control Contractors Support Staff	Project Team Contractors All Workers Discipline Leads

FIGURE 21.1 Project development and control process

The project controls manager has overall responsibility for providing control within the entire project. All project and outside personnel have to notify and get clearance from the project controls manager before committing any funds against the project. This person will generally be independent of any EPCM firm. It is extremely important that the project controls manager be given sufficient authority to not only question but also be the gatekeeper for the commitment of funds on the project.

The project controls team performs the following functions:

- Directs and assists in development of the project scope, estimates, and control documents.
- Establishes the appropriate project and accounting procedures.
- Monitors and evaluates each section of the project budget, including engineering progress, bid evaluation, procurement, scheduling, personnel, construction, precommissioning, commissioning, and start-up.
- Analyzes each aspect of the project and measures each item against the control estimate and schedules. The progress of the engineering, procurement, and construction functions are measured individually as well as in a weighted total project combination.
- Identifies variances that occur and assists the project manager in developing ways to compensate or correct such deviations to meet the project budget and schedules.
- Provides cost forecasting, contingency risk analysis, and final projected costs.
- Trends all activities, expenditures, contracts, and schedules, thus providing the keys to assessing where the project is heading and alerting the rest of the project team to areas that require attention.
- Establishes an auditing process for the engineering, procurement, and contracts functions located in the EPCM contractor's office. This could be achieved by assigning an individual from the mining company's controller department to the project.
- Assists in the review of bid packages and purchase orders on a daily basis.
- Determines and reports on the manner in which cost increase or decrease variances are drawn from or credited to project contingency.
- Ensures that a project completion audit is conducted within 6 months following project goals attainment.
- Provides management with an analysis of project compliance.

Team Mind-Set Regarding Controls

Less tangible, but just as important to the control system process, is the human attitude that underlies the whole project arena. People have to believe in the need for project controls for controls to truly be effective. The tenor of the control of execution stages within the project is set by the attention to the control philosophy displayed by the project team. For success, a positive attitude toward control functions has to be established and publicized at the earliest possible stage and maintained throughout the project life.

PROJECT CONTROL SYSTEM

A project control system is a complete and comprehensive process whereby all aspects of project execution are monitored and then reported against the originally approved SOW, budget, and schedule. The project control system provides the basis for decisions whereby the project manager receives timely data from his or her controls team for exercising the necessary control on the project activities to best achieve the desired project outcome. It is worth remembering that a project control system cannot by itself control anything; its purpose is to provide guidance to people who can take actions to improve the outcome.

The foundation of the project control system starts with the Project Execution Plan (PEP). It flows through the project control documents and project procedures manual (PPM) to the conducting of formal review meetings and the regular issuance of management reports. While the PEP, control documents, and management reports are the visible "hardware" parts of a control system, just as important but less visible are the project procedures. Furthermore, none of these will function effectively without the establishment of a communications system and a competent project controls team.

PROJECT CONTROL DOCUMENTS

Project Execution Plan

The development of the SOW, budgets, and schedules is ongoing throughout the study phases. The finalized SOW, budget, and schedule are captured within the PEP. The PEP thus becomes the primary control document against which the project execution stage is controlled. (See Chapters 16 and 17 for details on the PEP.)

The following list contains the other significant project control documents that belong with the PEP:

- Project goals and objectives
- Detailed SOW (derived from the feasibility study and the project Authorization for Expenditure (AFE))
  - Project schedule
  - Project critical path
- Key milestone dates
- Detailed cost estimate
  - Broken out per the WBS
  - Broken down into EPCM (direct and indirect), Owner's, and financing costs (see the "Cost Management and Control" section later in this chapter for an explanation on budget breakout)

Project Procedures Manual

The PPM is the primary complement to the PEP. (See Chapter 17 for details on the PPM.)

Key Documents Referenced in the Project Procedures Manual

Certain documents referenced by location within the PPM are needed for project control implementation:

- Engineering plan and schedule (broken down by engineering labor hours for each discipline)
- Construction (management) plan
- Commissioning and start-up plan
- Quality plan (applicable whenever project completion requires a quality component; e.g., a tankhouse's copper cathode specifications, a weighbridge's read-out accuracy)
- Project design criteria (These criteria are generally contained within a formal project design basis document and need to be developed with sufficient data, process flow

diagrams, and text support to allow scope to be truly fixed, and thus make scope change more difficult.)
- Final versions of the process flow diagrams

Management Reports

The final element in the project control system loop is the reporting system. (See Chapter 22 for content within the individual reports.) The suite of requisite project management reports and informational updates includes

- Weekly reports on activity and issues,
- Monthly flash report,
- Monthly status and progress report,
- Periodic project reviews,
- Field reports,
- Forecast updates, and
- Dashboard postings.

Monthly Project Review Meeting

Following issuance of the monthly status and progress report, a formal review meeting is held. Participants who should attend the meeting include

- The project manager,
- Senior Owner representatives from the business division and/or operating unit,
- A representative from the Owner's project management group (if such exists),
- The EPCM project sponsor,
- The EPCM project leader,
- The Owner's project team senior person,
- The project controls manager, and
- Other project team members (as necessary).

The purpose of the meeting is to apprise senior management of current progress and to handle any areas of concern that may be indicated from the management reports. The meeting would be chaired by the project manager. These monthly review meetings are sometimes conducted under the guise of steering committee meetings, but the intent is the same, that is, to formerly ensure that the issues affecting the project are being handled.

EARNED VALUE MANAGEMENT

Before the individual components of project control are discussed, the concept of EVM needs to be introduced. EVM has become *the* core methodology for measuring project progress objectively. And as Peter Drucker observed when he paraphrased Lord Kelvin and Galileo, "If you can't measure it, you can't manage it."

EVM is a project management technique for objectively measuring project performance and progress. EVM combines the measurements of scope, schedule, and cost in a single integrated system to provide key project trends and insight. EVM has numerous beneficial attributes that facilitate effective project management and meaningful project control:

- Use of EVM's process methodology forces an exact scope definition.
- Planning and control are significantly aided by EVM use.
- EVM measures true progress in an objective manner.
- EVM allows real-time analysis of overall project performance.
- EVM is able to provide accurate measurement (and forecast) of project performance problems, which are critical knowledge elements for effective project management.
- EVM can provide irrefutable data to help the Owner substantiate contract disputes.
- Studies show that the principles of EVM are positive predictors of project success.
- Implementation of EVM can be scaled to fit a project of any size or complexity.

EVM provides the project manager with a powerful tool to assesses project progress versus budget, and hence control spending. Information generated in the EVM status reports is used to spot potential problem areas early enough to be able to initiate effective recovery. Two components provide input to the earned value (EV) calculations: schedule and cost. In both instances, actual costs and durations are compared to the control budget and baseline master schedule, and then combined to produce the EVM updates.

The following are the essential features of any EVM implementation:

1. A project plan that identifies each element of the work to be accomplished
2. A valuation for each element of planned work; this is called the planned value (PV)
   - PV is the value that the control budget and baseline schedule is forecasting to be spent at a particular point along the schedule.
   - PV is also known as the budgeted cost of work scheduled (BCWS).
3. Predefined earning rules (i.e., metrics) that quantify the accomplishment of work. Work quantified as having been accomplished is called the EV. EV is also known as the budgeted cost of work performed (BCWP).

The most basic feature of an EVM system is that it quantifies progress by measuring an actual value or EV against the budgeted value or PV. EVM implementations for large, complex projects can include additional features, such as indicators and forecasts of cost performance (over or under budget) and schedule performance (behind or ahead of schedule).

Earned Value Management History

EVM emerged as a financial analysis program of the U.S. government in the 1960s and has since become a cornerstone of project management and cost engineering (Marshall 2007). The genesis of EVM began in industrial manufacturing at the turn of the 20th century, based largely on the "earned time" principles of Frank and Lillian Gilbreth, but the concept took root in 1967 when the U.S. Department of Defense established a criterion-based approach, using a set of 35 criteria, called the Cost/Schedule Control Systems Criteria.

EVM was first introduced to civilian projects in an article in *Public Works* magazine in 1979 by David Burstein, a project manager with Parsons Corporation, a U.S. engineering firm (Burstein 1979). This technique has been taught ever since as a core component of most project management training programs. By the late 1980s EVM had emerged as *the* project management methodology that had to be understood and used by managers and executives, not just EVM specialists. In the 1990s, ownership of EVM criteria (reduced to 32) was transferred from the U.S. government to industry with the adoption of the ANSI EIA 748-A Standard (ANSI [American National Standards Institute] 1998).

The use of EVM then quickly expanded beyond the United States as other industrialized nations began to use EVM in their own programs. An overview of EVM was included in the first *Guide to the Project Management Body of Knowledge* (PMBOK Guide) of the Project Management Institute (PMI) in 1987 and expanded in subsequent editions. The construction industry was an early commercial adopter of EVM. Closer integration of EVM with the practice of project management accelerated in the 1990s. Publicly traded companies started advocating the use of EVM in response to the Sarbanes–Oxley Act of 2002 (United States).

Project Tracking Without EVM

To explain EVM it is helpful to see an example of project tracking that does *not* include EV performance management (Wikipedia 2014). Consider a project that has been planned in detail, including a time-phased spend plan for all elements of work. Figure 21.2 Chart A shows the cumulative budget (cost) for this project as a function of time (the blue line, labeled PV). It also shows the cumulative actual cost (AC) of the project (red line) through Week 8. To those unfamiliar with EVM, it might appear that this project was over budget through Week 4 and then under budget from Weeks 6 through 8. However, missing from this chart is any understanding of how much work was accomplished during the project. If the project were actually completed at Week 8, then the project would be under budget and well ahead of schedule. If, on the other hand, the project was only 10% complete at Week 8, the project would be significantly over budget and behind schedule. A method is needed to measure technical performance objectively and quantitatively, and this is what EVM accomplishes.

Project Tracking with EVM

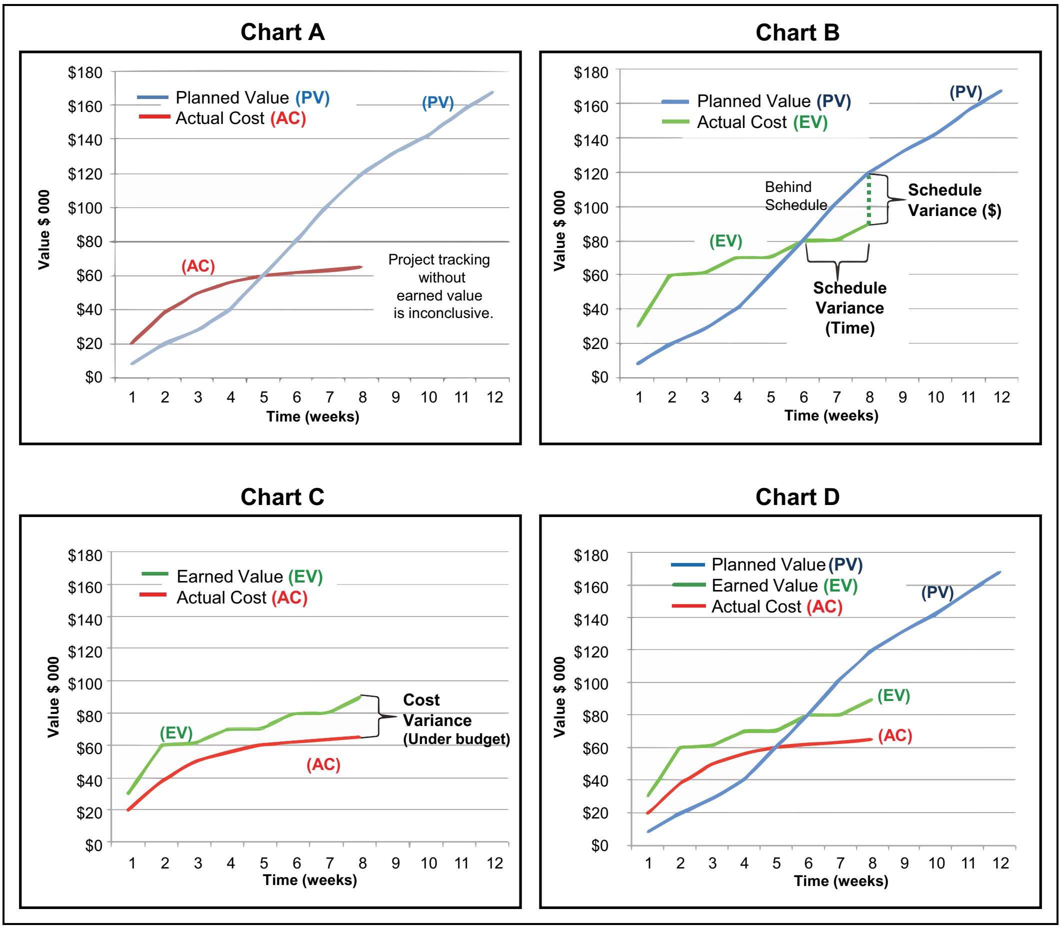
Consider the same project, except this time the project plan includes a predefined method of quantifying the accomplishment of work. At the end of each week, the project manager identifies every detailed element of work that has been completed, and sums the PV for each of these completed elements. Earned value (EV) may be accumulated monthly, weekly, or as progress is made.

$$\mathrm{EV} = \sum_{\mathrm{Start}}^{\mathrm{Current}} \mathrm{PV}\left(\mathrm{completed}\right)$$

EV can alternatively be calculated as EV = % complete × budget at completion (BAC). The BAC amount is the project total PV for an individual activity in the original control budget carried through to the end of the project. EV can be similarly calculated for the entire project by either methodology.

Figure 21.2 Chart B shows the EV curve (in green) along with the PV curve from Chart A. The chart indicates that technical performance (i.e., progress) started more rapidly than planned, but slowed significantly and fell behind schedule in Weeks 7 and 8. This schedule performance aspect of EVM is complementary to critical path or critical chain schedule management.

Figure 21.2 Chart C shows the same green EV curve with the AC data from Chart A in red. From the start, the project was under budget relative to the amount of work accomplished. This more correct conclusion could not be derived from Chart A.



Source: Adapted from Wikipedia 2014.

FIGURE 21.2 Earned value management three-line performance charts

Figure 21.2 Chart D shows all three curves—which is a typical EVM line chart. The best way to read a three-line chart is to identify the EV curve first, then compare it to PV (for schedule performance) and AC (for cost performance). It can be seen from this illustration that a true understanding of cost or schedule performance relies first on measuring technical performance objectively. This is the foundational principle of EVM.

Scaling EVM from Simple to Advanced Implementations

The foundational principle of EVM does not depend on the size or complexity of the project. However, most organizations establish an all-or-nothing threshold; projects above the threshold require a full-featured (complex) EVM system and projects below the threshold are exempted.

A more sensible approach is to scale EVM implementation according to the project at hand and the skill level of the project team (Sumara and Goodpasture 1997).

Simple EVM

Simple EVM emphasizes only technical performance (i.e., progress). There are more small, simple projects than there are large, complex ones, yet historically only the largest and most complex have enjoyed the benefits of EVM. Even so, lightweight implementations of EVM can be done by anyone with basic spreadsheet skills.

The first step is to define the work. This is generally done within the hierarchical arrangement of a WBS, although the simplest projects can use a task list. In either case it is important that the WBS or list be comprehensive. It is a requirement that the elements be mutually exclusive, so that work can be categorized in just one element.

The second step is to assign a value, called the PV, to each activity. PV may be in units of currency (e.g., dollars) or labor hours, or both. Assigning weighted values and achieving consensus on all the PV quantities yields an important benefit of EVM, because it exposes misunderstandings and miscommunications about the scope of the project, and resolving these differences can thus occur early. Those terminal elements that are not known (planned) in great detail up-front can be further refined at a later time.

The third step is to define the earning rules for each activity. The simplest method is to apply just one earning rule, such as the 0/100 rule, to all activities. Using the 0/100 rule, no credit is earned for an element of work until it is finished. A related rule is called the 50/50 rule, which means 50% credit is earned when an element of work is started, and the remaining 50% is earned upon completion. Other fixed earning rules such as a 25/75 rule or 20/80 rule are gaining favor, because they assign more weight to finishing work than to starting it, but they also motivate the project team to identify when an element of work is started, which can improve awareness of work in progress. These simple earning rules work well for small, simple projects because each activity tends to be fairly short in duration.

These three steps define the minimal amount of planning for a simple EVM. The final step is to execute the project according to the plan and measure progress. When activities are started or finished, EV is accumulated according to the earning rule. This is typically done at regular intervals (e.g., weekly or monthly), but there is no reason why EV cannot be accumulated in near real time, when work elements are started or completed. In fact, waiting to update EV only once a month (simply because that is when cost data are available) detracts from a primary benefit of using EVM, which is to create a current technical performance scoreboard for the project team.

In a lightweight implementation such as that previously described, the project manager has not accumulated cost or defined a detailed project schedule network (via use of a critical path or critical chain methodology). Such omissions would be inappropriate for a large mining project, but they are common and reasonable for small or simple projects. The point is that any project, even simple ones, can benefit from using EV to score real-time progress.

Intermediate EVM

Intermediate EVM integrates technical and schedule performance. For most projects, schedule performance (completing the work on time) has equal or greater importance than technical performance. Most project developments place a high premium for finishing on or ahead of schedule. Not that cost is unimportant; but finishing the work late may cost the company a great deal more in lost market value. These kinds of projects will never use the lightweight version of EVM described in the previous section, because there is no planned timescale for measuring schedule performance. A second layer of EVM skill is needed to manage the schedule performance of these intermediate-sized projects. The project manager has to employ a critical path or critical chain to build a project schedule model. As in the simple implementation, the project manager still defines the work comprehensively, via the WBS hierarchy, but a project schedule model is also constructed that describes the precedence links between the elements of work. This schedule model is then used to develop the PV curve (or baseline), as shown in Figure 21.2 Chart B.

Measuring schedule performance using EVM does not replace the need to understand schedule performance against the project's schedule precedence network model. However, EVM schedule performance, as illustrated in Figure 21.2 Chart B, provides an additional indicator—one that can be communicated in a single chart. While EVM schedule measurements are not necessarily conclusive, they do provide useful diagnostic information.

Although such intermediate implementations do not require units of currency (e.g., dollars), it is common practice to use budget dollars as the scale for PV and EV. It is also common practice to track labor hours in parallel with currency. The following EVM formulas are used for schedule management and do not require accumulation of AC. This is important because in these size projects true costs are often not available. For schedule variance (SV),

$$\mathrm{SV} = \mathrm{EV} - \mathrm{PV}$$

SV greater than 0 is good (ahead of schedule). The SV will be 0 at project completion, because by then all of the PVs will have been earned.

SV measured through EVM method is indicative only. For schedule performance index (SPI),

$$\mathrm{SPI} = \frac{\mathrm{EV}}{\mathrm{PV}}$$

SPI greater than 1 is good (ahead of schedule). However, to know the true amount of time that a project is behind or ahead of schedule, the project manager has to perform critical path analysis based on precedence and interdependencies of the project activities.

Advanced EVM

Advanced EVM integrates cost, schedule, and technical performance. In addition to managing technical and schedule performance, large and complex projects such as a major mining project require that cost performance be monitored and reviewed at regular intervals. To measure cost performance, PV and EV must be in units of currency, that is, the same units that actual costs are measured.

For large project EVM implementations, the PV curve is called the performance measurement baseline (PMB). Individual PMBs may be split according to the control accounts in the project's RASCI (responsible, accountable, supportive, consulted, informed) matrix or in accordance with the project execution work packages.

In addition to using the terms PV and EV, implementations often use the term *actual cost of work performed (ACWP)* instead of AC for actual cost. As stated earlier, the budget at completion (BAC) is the total PV at the end of the project. If a project has a management reserve, it is typically *not* included in the BAC or the PMB.

The cost variance (CV) formula is as follows:

$$CV = EV - AC$$

A CV greater than 0 is good (under budget).

The cost performance index (CPI) formula is as follows:

$$CPI = \frac{EV}{AC}$$

A CPI of 1 means the cost of completing the work is right on plan, that is, at budget cost (good). A CPI of less than 1 means the cost of completing the work is higher than planned (bad). A CPI of greater than 1 is usually good (under budget), but not always, as greater than 1 means the cost of completing the work is simply less than planned. Having a CPI that is very high (in some cases, very high is only 1.2) may mean that the plan was too conservative, and thus the CPI is being measured against a poor baseline. This is bad for the Owner because an overly conservative baseline ties up available funds from being channeled into other purposes.

Estimate at Completion

The estimate at completion (EAC) is the manager's projection of total cost of the project at the completion of an individual task or activity. The EAC can be similarly calculated for the entire project:

$$EAC = AC + \frac{(BAC - EV)}{CPI} = \frac{BAC}{CPI}$$

Estimate to Complete

The estimate to complete (ETC) is the estimate to complete the remaining work of an individual task or activity. The EAC can be similarly calculated for the entire project:

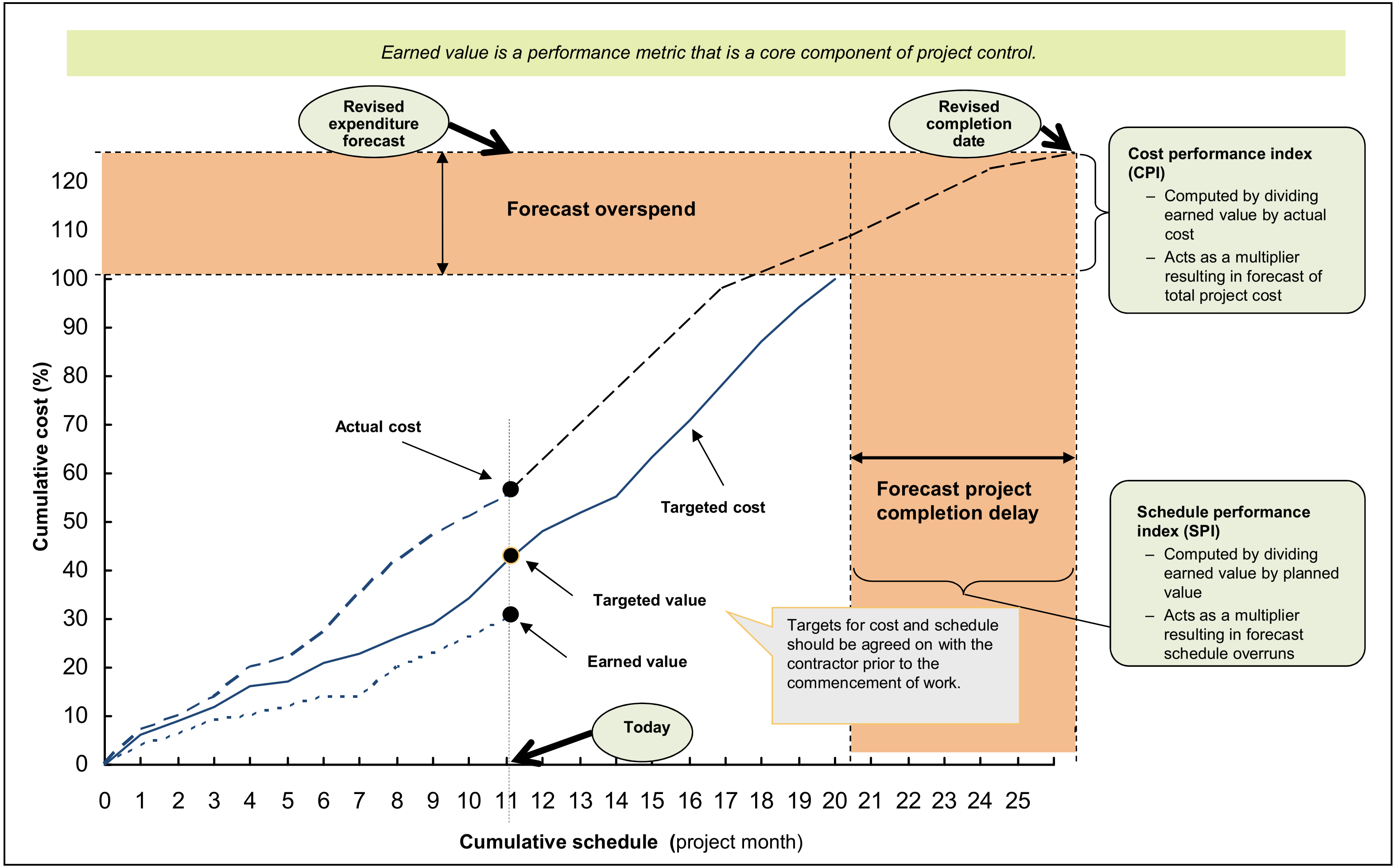
$$ETC = EAC - AC$$

Figure 21.3 is a generic example illustrating SPI, CPI, and EAC.

EVM Reporting

The preceding calculations are used in preparing an EVM report. The SV, SPI, CV, and CPI give a macro-indication of general project health. The remaining calculations are used to determine the magnitude of variance from the plan in either direction. EV reporting can be applied at any level of detail, from a project total down to individual drawing status, though most EPCMs track projects down to the billing group level.

EPCMs typically divide their projects by billing group. Billing groups are made up of logical groups of component activities that contribute to the completion of related project work and for which discrete deliverables are prepared. For example, project phases such as the feasibility study or the engineering work can be separate billing groups, each requiring significant work and design hours with multiple document and drawing deliverables. Project control deliverables, such as monthly reports and invoices, can be prepared at either the project or billing group level.



Source: Adapted from Fleming and Koppelman 2005.

FIGURE 21.3 Earned value: A project performance metric

Activity level reports roll up to the billing group and/or the project level for summary reporting. EVM reporting carried to a level lower than the activity (or task) is not useful and should not be pursued; it would require excessive project management time and cost. EVM reporting identifies trends in actual progress versus what was originally planned. When a task is identified as heading off-course, the project team analyzes this trend, determines the root cause and the mitigating action to be taken, and then the team calculates the cost or schedule impact.

If necessary, an action plan is prepared, and an estimate for the work required to mitigate the problem is calculated. The plan and cost are summarized on a notice of change (change order), which is submitted to the appropriate level for review and approval. The approved notice of change form is the documented backup required under the change control program and is tracked within the document control or document management system. A simplified notice of change form, as used by an EPCM firm, is included as a generic example in Figure 21.4.

EVM Limitations

While EVM is strongly advocated by the authors, there are inherent limitations to the concept itself (Schulze 2010). EVM has no provision to measure project quality, so it is possible for EVM to indicate a project is under budget, ahead of schedule, and with a fully executed scope, but still a poor-quality facility with an unhappy Owner and ultimately unsuccessful results.

EVM is not intended for nondiscrete (continuous) effort. Nondiscrete effort has traditionally been called level of effort (LOE) within the projects world. If a project plan contains a significant portion of LOE, and the LOE is intermixed with discrete effort, EVM results will become contaminated and hence unreliable.

Project accounting and project schedule management are prerequisites for achieving any benefit from EVM. If these prerequisites do not exist, EVM is a waste of time. Projects can be planned, but in execution they may not have access to true and timely actual cost data. The collection of true and timely actual data can be the most difficult aspect of EVM.

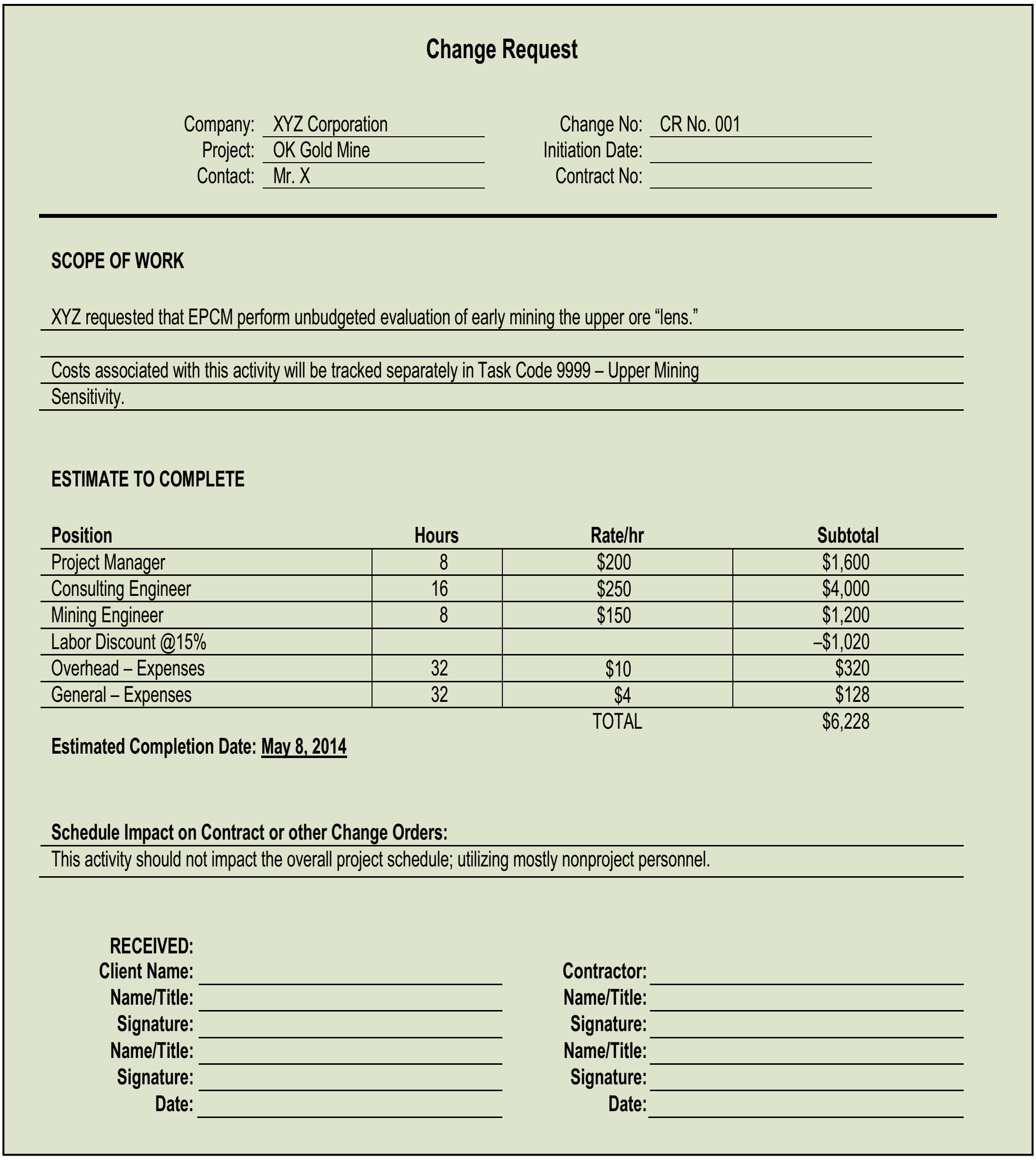
There is an inherent difficulty with periodic data gathering to synchronize the data timing of actual deliveries and actual invoicing with the date the EVM analysis is done. The data items are all independent; thus some items may have arrived on-site but their invoicing has not, and by the time the analysis is delivered, the data may be weeks behind actual events. This can limit EVM to a less definitive role for explaining project performance.

PROJECT CONTROL TOOLS

Effective project control is a set of proactive tools using current and historical data to provide a basis for forecasting and trending. The progress of the engineering, procurement, and construction elements is captured by critical EVM forecasting and trending techniques at regular intervals, each as a control subpart of overall project control to highlight potential problem areas before they happen, thus permitting corrective actions prior to occurrence.

Setting up the project control system starts at the idea stage and is continually developed through all stages of the project as more details are gathered. This process includes timely establishment of all the appropriate individual control procedures:

- Schedule control
- Cost management and control
- Quality control
- Scope control



Change Request

Company: XYZ Corporation
Project: OK Gold Mine
Contact: Mr. X

Change No: CR No. 001
Initiation Date:
Contract No:

SCOPE OF WORK

XYZ requested that EPCM perform unbudgeted evaluation of early mining the upper ore "lens."

Costs associated with this activity will be tracked separately in Task Code 9999 – Upper Mining Sensitivity.

ESTIMATE TO COMPLETE

Position	Hours	Rate/hr	Subtotal
Project Manager	8	$200	$1,600
Consulting Engineer	16	$250	$4,000
Mining Engineer	8	$150	$1,200
Labor Discount @15%			–$1,020
Overhead – Expenses	32	$10	$320
General – Expenses	32	$4	$128
		TOTAL	$6,228

Estimated Completion Date: <u>May 8, 2014</u>

Schedule Impact on Contract or other Change Orders:
This activity should not impact the overall project schedule; utilizing mostly nonproject personnel.

RECEIVED:
Client Name:
Name/Title:
Signature:
Name/Title:
Signature:
Date:

Contractor:
Name/Title:
Signature:
Name/Title:
Signature:
Date:

FIGURE 21.4 Notice of change

- Change management
  - Change orders
  - Major scope change control
- Contingency control
- Contracts control (i.e., contracts management)
- Accounting control
- Monetary control

All of the preceding individual project control procedures are required, as each parameter serves a unique purpose, but together they constitute project controls. The controls team thus requires personnel (preferably cost engineers) with project *and* accounting backgrounds.

SCHEDULE CONTROL

Probably the single element that has the most bottom-line effect on final cost is maintaining the project schedule. The cost outcome of major projects is very sensitive to schedule slippage. A first indication of a project slipping out of control is when a few small slippages start to appear in seemingly unimportant areas. Before long they turn into an avalanche, and there is a snowball effect of delays that throw the entire project into turmoil and over budget. The schedule control tools (critical path, etc.) need to be fully utilized to eliminate any knock-on effects of these initial small slippages. This will generally involve senior project staff going over the status of every element of the schedule in excruciating detail, but this effort will bring the right reward.

Schedule control involves defining and breaking down the project's master time schedule, then establishing and tracking against the project's significant milestones. Each project develops the schedules necessary for its particular complexity; schedules that will provide the level of control to adequately manage the schedule risk. Critical production milestone dates need to be agreed on by all parties, then established.

Through the engineering stage, most projects can get by with just the following schedules:

- Summary overall project schedule (to a Level 3 status)
- Key milestone dates list
- Detailed critical path method (CPM), logic-driven engineering, and procurement schedules. Before the engineering starts, the schedule must be fully resource loaded and leveled.
- Production start-up or ramp-up schedule and durations showing construction interfaces
- Production operations schedule (initial 5 years of operations by year, plus mine life)

The constraints of the project's master schedule and control budget schedule are all keyed in with these individual schedules.

During the detail engineering stage, prior to construction initiation, fully integrated, project execution schedules (for procurement and construction, each properly resource loaded and leveled, with companion CPM logic-driven schedules) are further developed and personnel-loaded to a Level 4 status to be ready for field usage.

And finally, for full project control during project execution in the field, the project's preceding suite of schedules would need to additionally include

- Three months' activities look-ahead,
- Three-week construction rolling horizon look-ahead Level 5 schedules,
- Personnel projections, and
- Progress curves.

After the establishment of the master (budget) schedule but before field construction initiation, an early-completion, aggressive schedule can be a useful tool to establish. This targets earlier milestone dates than in the master schedule. This early completion schedule is typically created by zeroing out schedule float and then adding in a greater degree of risk than would be contained within the master schedule. To be meaningful, the aggressive schedule needs buy-in from all parties, particularly the EPCM contractor and all affected field contractors and subcontractors.

If an early-completion, aggressive target schedule is additionally established by the project participants, then project progress tracking would take place against the budget master schedule *and* the early completion target schedule. From a control viewpoint, an early completion target schedule is always encouraged. Whenever an incentive or penalty is involved, contractors will focus more on the early-completion target schedule than on the project master schedule. From a control viewpoint, any such focus on early completion of schedule is good, as such focus by the project participants helps better ensure that the budget master schedule is attained.

The monthly report is the vehicle that tracks key variances to the project's control budget schedule, that is, the detailed master schedule, and communicates makeup methodologies for any deviations to project progress.

COST MANAGEMENT AND CONTROL

Project management is responsible for *all* project costs. Once approved, no project costs can be spent or reallocated without project management approval, nor can changes be made without going through the formal change order control process. Cost recording is not cost control (Guzman 2012a). Cost recording is accounting, a documentation of historical facts. Control can only be exercised *before* the cost is incurred.

The EVM system is the prime tool used to control project costs. Every major EPCM firm serving the mining industry comes with a project accounts database system robust enough to allow EVM reporting to be timely generated. With such a system in place, project activities can be controlled. EVM provides the project manager with the tools to assess progress versus spending and to spot potential problems early enough to initiate effective preventive measures.

For EVM to function, cost control has to have the WBS agreed to and in place prior to project kickoff, and have qualified cost engineers in place within the project controls team as soon as the project organization starts to function. The WBS apportions the project components into distinct controllable size elements and assigns a separate budget cost to each element. For control purposes on large projects, it is recommended to group these elements into three or four logical major breakouts within the total project budget. Figure 11.6 provides the major categories of a typical budget. A frequently chosen grouping of these budget elements for individual control purposes is very often the following:

- Facility (including EPCM, sustaining capital, and other) cost
- Owner cost
- Financing (and related) costs

Because cost areas are always very project specific, whatever budget breakout groupings are chosen to aid control, each chosen grouping will require meticulous definition. For best control, once the breakout has been designated, it is beneficial to assign a different individual to manage each defined breakout cost grouping. These individuals then need to report to the project manager.

Each activity element in the WBS is assigned a cost code and a provision for percentage completion as an input item in the EV progress-reporting system. By tying the cost codes to the schedule, direct costs can be entered as they occur. Most indirect costs are somewhat time related, so these can be apportioned and integrated. Project management software such as Ares

PRISM, Oracle's Primavera P6, or Meridian Systems' Prolog Manager, which can assimilate and properly adjudicate costs in a timely way, is essential for meaningful monitoring and analysis. This process in turn allows rapid identification of cost trends and the projection of possible schedule delays, which is absolutely essential if remedial action (cost control) is to be effective.

Facility Cost

The facility cost is composed of the capital cost for all the engineering, procurement, and construction activities (direct and indirect) to deliver the project facilities, including EPCM, sustaining capital, and any other cost groupings, but excluding Owner and financing costs. To arrive at this cost, the establishment of a firm schedule and personnel budget for the engineering, procurement and construction elements is required. Because the generation of this component of the project budget cost is typically contracted out to an EPCM firm, it is sometimes characterized as the EPCM cost rather than facility cost.

Owner Cost

The Owner cost essentially includes all non-finance-related items supplied by the Owner *not* included in the facility cost. This can cover things such as mining equipment, consumable and reagent supplies, warehouse inventory, land payments, insurance, government fees, taxes, permitting fees, Owner's support team expenses, working capital, start-up, and training costs. If the mine development or prestripping are performed by the Owner rather than a subcontractor reporting to the EPCM, then this activity would also be part of the Owner cost.

All areas of Owner cost must be developed to the same accuracy level as the facility engineering and construction budgets and schedule. Establishment of a firm scope, schedule, and personnel budget for Owner cost is a precursor to this cost establishment.

Financing (and Related) Costs

The financing costs, interest payments, due diligence fees, escalation allowance, and related costs are normally established by the Owner's corporate treasury and controller departments. Having a named contact individual within the treasury department to interface with the project is helpful in this regard. The Owner's treasury department must not be allowed to make changes in the project financing arrangements without notifying the project manager and project controls manager before the change implementation.

QUALITY CONTROL

Up-front establishment of the project quality criteria and plan and then monitoring against this plan constitute the hub of the project quality control function.

SCOPE CONTROL

Once the project scope is set and defined (typically within the PEP), the one thing that can best ensure achievement of the project budget and schedule goals is a focused adherence to project scope by all project parties. Only one person, the project manager, is allowed to approve project changes, scope or otherwise.

Successful scope control has one primary element: elimination of the desire or need for change. Scope changes in any project must be openly discouraged, and if allowed, then prominently displayed whenever possible with negative connotations. This is the best method of scope control, along with proper scope definition in the first place.

CHANGE MANAGEMENT AND CHANGE ORDERS

While change is never encouraged, the controlled allowance of changes *within* the project scope is a necessary part of project control. Change is inevitable; every project experiences it. Change can occur simply by the work progressing faster or slower than planned, or by an entity within the project team finding a better approach to project work. Changes such as design evolution, pricing update, budget shift between WBS elements, engineering development, quality change, facility relocation, utility alignment changes, and so on, can occur within any project. Not all such changes are bad; some can help the project.

Design changes or modifications are the most significant contributors to variations in engineering project cost or schedule. In many cases failure to freeze design concepts prior to detail design initiation is the root cause. But even if the Owner truly committed to freezing design concepts in basic engineering, some additional change is inevitable in detail engineering. Conversely, it is very likely that an EPCM reviewer will discover some design nuance that was overlooked and warrants a different approach, thus also constituting a change. In both instances, appropriate, organized action must be taken. A properly conceived and implemented change management procedure will help keep the project on track and provide documentation for those changes that do occur.

In essence, any change that bears a cost or schedule impact falls under change control. The most significant example is scope change. Any addition or deletion of significant work or task components (i.e., scope) *must* be approved by the Owner, with budget and schedule changes approved and applied before initiating the change. The project manager develops the associated cost and schedule impact estimate and submits it with the change request. Work on the changed scope should not start until the approvals are signed and returned by the Owner, though on occasion exceptions may be made in the interest of expediency.

Changes in cost or duration for specific tasks or task components usually have a small impact individually, but they occur more frequently. As a result, their combined effect can be as significant to the total project as that of a scope change. The root cause of these changes is usually related to budget estimate inaccuracy or productivity issues, and as such, they are generally provided for by project contingency.

If a task cost or duration change impact is less than the amount carried in project contingency for that item at the time of the change, then simple notification to the Owner and adjustment of the remaining available contingency is all that is required. If the impact of a task cost or duration change is greater than the amount carried in project contingency for that item at the time of the change, then the change control process to authorize schedule or cost extensions should be identical to that required for scope changes, that is, Owner approval even though no scope change will be involved.

This change control methodology follows the best practice protocol; that is, the project manager "owns" project contingency. Even so, the project manager should report project contingency status as part of each monthly report. The change procedure is outlined in the flow diagram in Figure 21.5. The decision path is designed to minimize internal and external approval chains, thus allowing the change authorizations to be reviewed, prepared, submitted, and authorized rapidly. Reducing the number of reviews and approvals speeds the change process, which helps limit the project's indirect costs.

The decision path shown in Figure 21.5 stipulates that a scope change of any kind must have Owner approval, whether or not it impacts project cost and schedule. The project manager

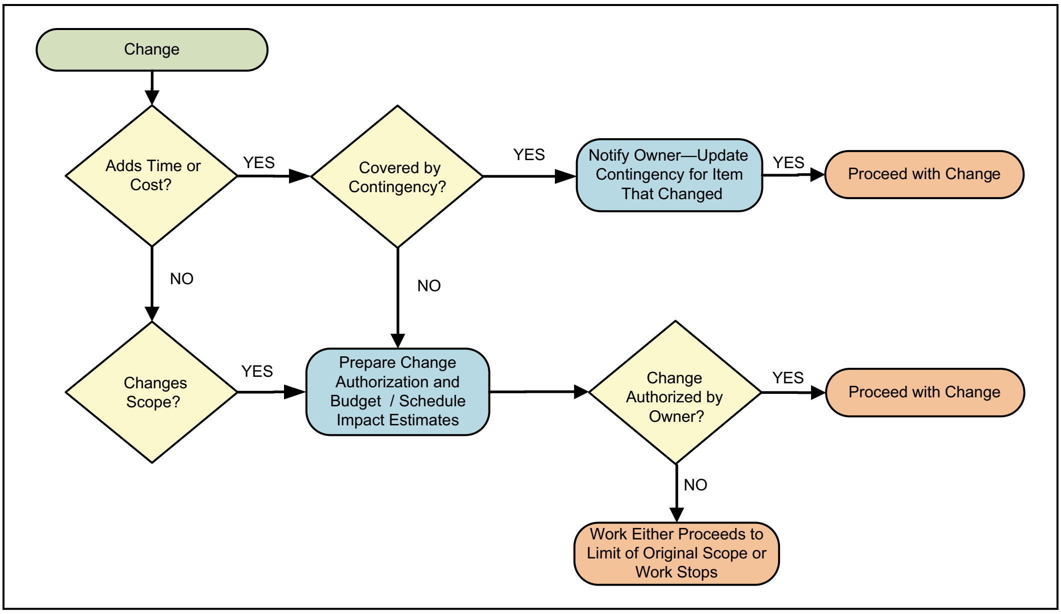


FIGURE 21.5 Change control procedure

should never make a change to the project scope without approval from the Owner, even for a cost- or schedule-neutral change. Scope changes in certain areas will often affect other areas, so it is important that all relevant parties are aware of the change and in agreement with its ramifications before the change is made.

A best practice is to capture any potential change on a Potential Deviation Notice (PDN) form as a "trend." Trends may or may not become changes and in turn change orders, but the PDN provides an early alert to all the project team members and facilitates timely remedial action. Each PDN is filed in a potential deviation log, and its consequences are highlighted within the monthly report.

Procedures for reviewing, approving, and recording in-scope, out-of-scope, and trend changes have to be installed within the project change management procedures. A detailed sequence for the handling of change orders according to their size and nature needs to be set. Particular scrutiny is needed for all major out-of-scope changes.

Changes have to be managed and controlled such that overall project scope and objectives are maintained. The EPCM firm and the construction contractor will typically tend to want to characterize any change (be it a routine pricing or quantity change, a normal design evolution change or a minor field relocation change) as a scope change, thus providing them with a valid reason for a change in their contract price (particularly if they have a lump-sum contract). However, while some of these changes may legitimately be characterized as scope changes by a constructor (in reference to their own contract), if such contractor scope changes are within the approved project scope and do *not* in any way change the project budget or completion schedule, they are *not* scope changes from the mining company's viewpoint. They are merely recordable as in-scope project changes with contingency drawdown (or contingency return, as the case may be) ramifications.

For example, movement of a primary crusher location from one side of a pit to the other could be a scope change for the construction contractor (and thus incur some contingency drawdown), but it typically would not change the mining company's defined project scope. Thus it would not be an out-of-scope change for the project or the Owner.

Out-of-Scope (Major) Change Control and Approval Procedure

The management of change that is *outside* of approved project scope is also a part of project control, but it is typically far from routine. Such changes are generally considered to be major scope changes and as such demand their own separate discussion. Major out-of-scope change control has a deliberately burdensome approval process.

Only major conceptual changes are classified as project scope changes from the mining company's viewpoint (e.g., increasing plant design throughput rate by 30%, adding a molybdenum recovery circuit to a previously approved copper-only circuit, or adding a solvent extraction and electrowinning facility to an existing mill installation). When such major, conceptual scope changes occur, then a supplemental AFE has to be prepared for senior management's approval—similar to the original AFE submittal process outlined in Chapter 14. Ideally, these instances are rare—and they will be if the proper preparation work has been done within the prefeasibility and feasibility studies.

A major out-of-scope change—real or potential (or any project change with the potential of exceeding or significantly reducing the allocated contingency)—needs to be communicated as soon as possible by the project manager to appropriate senior management in the Owner's company. Such changes could stem from changed subsurface geotechnical conditions, updated reserves information, new metallurgical data, enhanced safety requirements, new environmental mandates, and so forth. This direct communication to senior management is in addition to the normal highlighting of changes and contingency drawdown that will appear in the next monthly progress report.

The early communication to senior company management is for more than just damage control; it provides the best avenue for bringing into the project the additional resources necessary to alleviate or reduce the issue that is causing the potential project damage.

CONTINGENCY CONTROL

Contingency control, another parameter of project control, refers to the formal mechanism for drawdown of contingency, as well as the handling of savings amounts from discrete elements of the WBS. The contingency change protocol is specified in the contingency management procedures. As described in Chapter 12, from an Owner's perspective there are two fund sources to administer: contingency and management reserve. The project team manages contingency, but they cannot touch management reserve without specific senior management authorization from the Owner. The two funds are maintained as separate items.

Contingency Planning

Contingency planning is an integral part of project control and involves the development of action plans to be invoked in the event of specified risk events occurring. (See Chapter 9 for more details on managing risk.)

Contingency Management

Contingency is administered as a single item during project execution, rising and falling as changes occur. Contingency drawdown is only allowed for in-scope changes. Out-of scope changes need their own separate AFE submission, and, if approved by the Owner, come with their own contingency, which is then added to the single line-item contingency allowance pool. Contingency drawdown to cover negative variations is controlled and spent by a single person, the project manager. Similarly, any savings amounts from positive variations to the discrete elements within the WBS are handled by the same person.

Project cost decreases need to be identified in a timely way and made to flow back into the contingency account, not held in some secret slush fund. All WBS variances need to be documented properly and audited periodically, to ensure that contingency is not being misappropriated. The movement of contingency acts as a thermometer for the project. It is helpful from a control viewpoint to highlight such contingency movements within the monthly report. It works best to show the movements against an established drawdown curve, as either a plus or a minus.

CONTRACTS CONTROL AND CONTRACTS MANAGEMENT

Monitoring of the prime contractor and the subcontractors is necessary to ensure that performance and billing are as specified in the formal contracts and as required in the SOW. Contractor and vendor guarantees and warranties need particular attention to ensure their full and timely delivery. To encourage contractor performance, an incentive or penalty scheme is frequently established within the EPCM or contractor contract. (See the “Incentives and Penalties” section in Chapter 20.)

ACCOUNTING CONTROL

Accounting control provides a framework to ensure financial accountability. It supplies the accounting procedures and audit functions, as well as a historical record of project expenditure. Accounting control monitors what happened with expenditures versus budget and contract. While accounting control is an important part of the project control mechanism, by itself it is not enough, as it focuses on what happened *after* the fact.

Typically, three or four project accountants are required on a major project to handle the project accounting needs. Assigning a future operations accountant into one of these roles serves both the Owner and project well.

The financial audit function is part of accounting control and contracts control. Best practice requires that financial audits take place at selected intervals throughout a project life. On major projects, specialists from an outside accounting firm such as PricewaterhouseCoopers or Ernst & Young are typically hired to conduct the financial audit.

MONETARY CONTROL—CASH MANAGEMENT AND BANKING POLICIES

A banking plan determines how money is to be inserted into the project, then spent and controlled. This is critically important when dealing in multiple currencies. Accuracy of forecast minimizes cash accumulation and assists the Owner’s treasury department in reducing currency risk.

PROJECT AUDITS

A formal project review and oversight process needs to be used throughout the project life to ensure the project is being correctly managed and controlled. The project audit provides senior management with independent confirmatory evidence of project status. These ongoing project audits during a project's life are different from the financial audits by outsource accounting firms and are also different from the lessons learned audit that is conducted after project turnover and completion.

Project Audit Process

The project audit process is similar to most major mining companies' environmental audit process; that is, it applies a standardized approach using mainly in-house personnel to arrive at an objective rating of the project management process being practiced at the project.

The audit system must provide a process that evaluates the project for adherence to project management best practice. This process should have the ability to assess the complexity of a project and thus determine if all, none, or just selected components of the project management practices need to be adjusted at this particular location. The audit system must also provide a planned amount of oversight during the project life cycle, thereby providing a level of comfort to the Owner's senior management about the ability of the project team to successfully complete the project.

The audit system needs to be started early in the project life, no more than 90 to 120 days after project kickoff. Most avoidable costs can best be removed by the early, careful review and scrutiny that challenge why they need to be done in the first place. Subsequent audits need to be conducted a minimum of every 6 months after the initial audit.

To actually undertake the audit, checklists must be developed partly based on project size and partly based on project status, that is, the project life cycle point at the time of the audit. These audit checklists can, in large part, be taken from the checklists at the end of each chapter of this book.

A précised audit framework outline that was recently created by the authors for one of the large international mining firms is shown in Figure 21.6 for reader guidance.

Project Audit Personnel

The people hired to conduct audits will be drawn from

- Project management personnel at other ongoing company projects,
- Operations staff management slated for future project roles,
- The mining company's own project management group staff,
- Specialist project controls staff from outsource EPCM firms, and
- Specialist project audit staff from one of the major management consulting firms.

International firms such as PricewaterhouseCoopers, the Boston Group, the Westney Consulting Group, and IPA Management Consultants can provide project audit services at fairly short notice. The authors have participated in such audits with three of these named firms, both on the project side and on the audit side.

What stage is the project in?

Are all necessary resources in place?

Are the Owner or EPCM organization and interface responsibilities understood?

Is the project management team in place? The project manager? The controls manager?

The audit will consist of a review of each project component; using preset checklists to status the specific project stage and to record comments. The review must include the following.

1. **Project Scope**
   - Are all facility and infrastructure requirements through to product delivery defined?
   - Is a WBS in place? If not, what is its status?
   - All major project elements, equipment to be bought, etc., should be identified.
2. **Project Procedures and Criteria**
   - Obtain and review a copy of the project procedures manual.
   - Review the written procedures. Are they encompassing enough?
   - Record all goals, expected efficiencies, etc. These provide the control basis.
3. **Location of Work Components**
   - Visit the locales of the engineering, procurement, and construction activities.
4. **Design Parameters**
   - Obtain copies of any metallurgical test programs underway or completed.
   - List the design criteria for all areas of the project as presently defined.
   - Review existing plant P&IDs [piping and instrumentation diagrams], and PFDs [process flow diagrams] for water and materials balance.
   - Obtain and review existing general arrangement and detail design drawings.
5. **Engineering and Procurement**
   - List the status of all drawings and specifications (including infrastructure).
   - Summarize hours and costs to date for services in the engineering locations.
   - Obtain and review the latest equipment list pricing versus budget.
6. **Construction**
   - Summarize labor hours and costs to date for all field construction activities.
   - Obtain the latest forecast of remaining labor hours and cost to complete.
   - Conduct a field labor analysis using projected workforce load for the construction schedule along with the efficiency basis predicted to arrive at the project's future labor-hour requirements.
   - Considering the workforce in place. Is the workforce projection realistic?
   - Analyze the field materials and equipment needs to verify adequacy.
7. **Management and Supervisory Resources**
   - Are all the project management and controls teams in place?
   - Obtain an organization chart and review for sufficiency.
8. **Schedule**
   - Are a Master Schedule and an Execution Schedule in place? What level?
   - Obtain a copy of the current schedule along with history of schedule development.
   - Check the status of the key project milestones. Are they being met?

(Continues)

FIGURE 21.6 Project audit outline example

9. **Cost and Estimates**
   - Are the cost codes in place and being followed?
   - Is the control budget established? The latest capital cost estimate along with its basis needs to be obtained showing expenditure to date, open commitments, and forecast of yet-to-spend using the WBS to break down the costs by area.
   - Compare this latest forecast to the original approved project AFE budget.
   - Compare the latest operating cost forecast to the original budget AFE.
   - Analyze cash flow. Is the spending schedule and cash call forecast viable?
10. **Reporting**
    - Are the progress reporting systems (weekly, monthly, etc.) in place?
    - Are all requisite topics being covered, and are the right people receiving copies?
11. **Permitting, Licenses, Insurance, Bonding**
    - Are all environmental, building, import, and propriety licenses and permits in place?
12. **Project Controls**
    - Are the project management and controls processes in place and adequate?
    - Are performance measurements being properly taken?
    - Is earned value methodology being used? What are the CPI and SPI?
    - Are controls for accounting, audit, etc., in place?
    - Is an effective change control process in place? Is it being followed?
    - Are field trends being made? Are they useful? Are they realistic?
    - Complete a project controls summary and include controls report examples.
    - Review record keeping and document management and control. Are they sufficient?
13. **Delegation of Authority and Approval protocols**
    - Are change, work-hour, purchasing, travel protocols, etc., being followed?
14. **Contractual**
    - Are the commercial terms under which engineering, procurement, and construction were awarded being followed? Obtain copies of the contracts.
    - Review any partner, JV [joint venture], or financing considerations, if such pertain.

FIGURE 21.6 (Continued)

Project Audit Results

Audit results list the issues that the project needs to address, using an assigned, numerical risk assessment ranking attached to each issue (e.g., from 1 to 10). By giving a risk assessment to each concern, a priority is effectively given to the issues. This allows project management to focus on those individual concerns that have the greatest probability of negatively affecting the project. This critical rating of issues ensures that those matters that can provide the greatest return of value to the project are worked on first.

The audit team should be charged with recommending a course of corrective action for each issue that is given a risk assessment ranking value. Audits need to be much more than outsiders throwing negative darts at the project team. After some history has been gathered from several projects, a mining company can generally develop its own numerical scoring system for projects. The score for any particular project that is subsequently audited will then be based on the weighted compilation of issues catalogued in that company's risk assessment rankings.

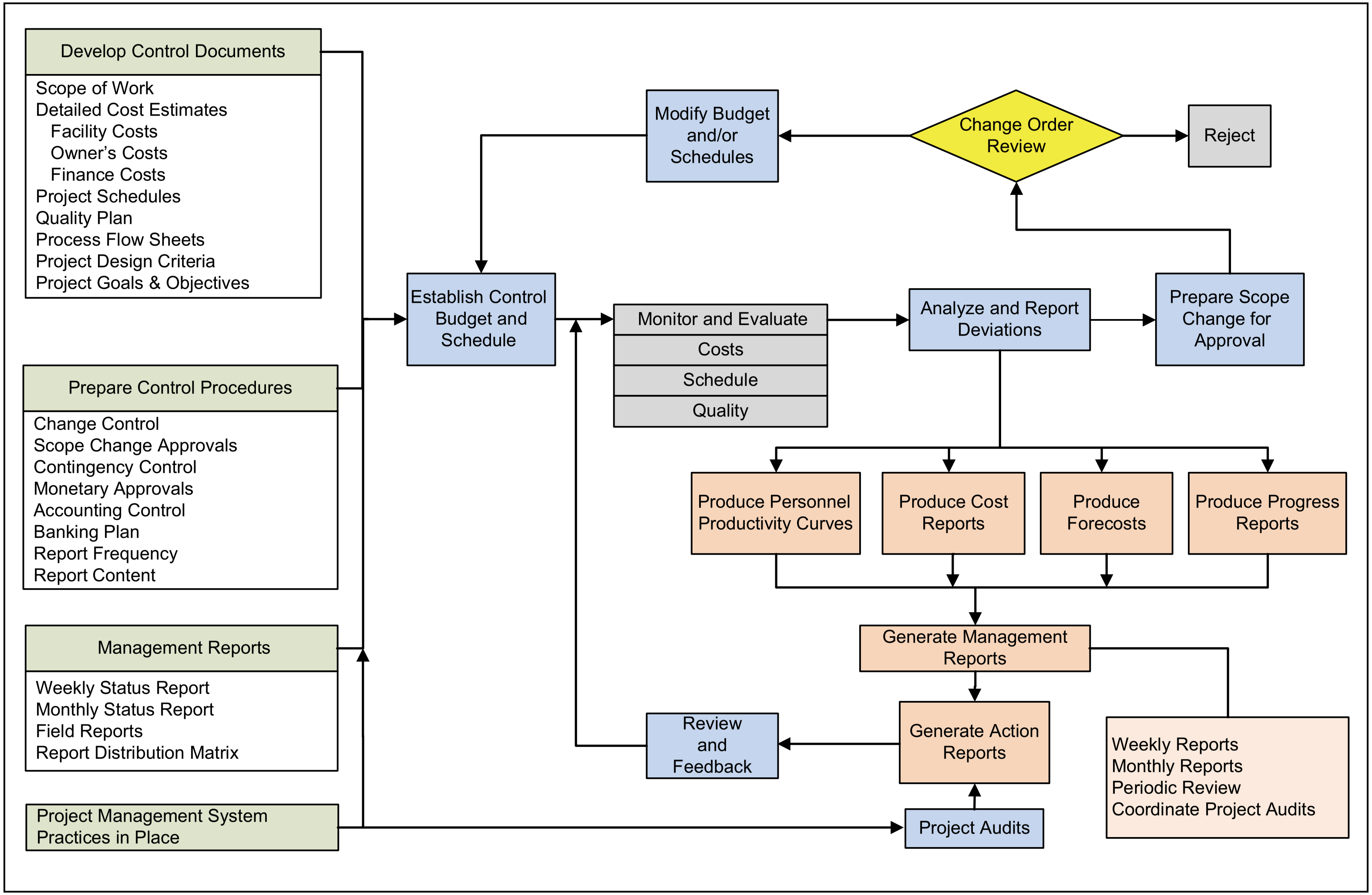
MANAGEMENT AUDIT

On occasion, a project manager, usually believing that he or she is pursuing the best course for the project, may initiate actions which can seriously jeopardize project outcome. To guard against this, a management audit conducted by a seasoned third-party project leader can be undertaken a few months after execution kickoff. This audit should report to the highest level of the Owner organization and should stand alone, that is, not be part of any routine project audit or financial audit.

CHECKLIST 21.1 PROJECT CONTROLS

No.	Item	Status	Date	Initials
1	Project management team—in place			
2	Project control management—in place (some may cover multiple duties)			
	A. Controls manager (person responsible for all project costs)			
	B. Estimator			
	C. Scheduler			
	D. Cost engineer (progress measurement, forecasting, etc.)			
	E. Accounting control staff (including audit function)			
3	Control documents—complete			
	A. Approved AFE			
	B. Scope of work—clearly defined and frozen			
	1. Owner's scope—determined			
	2. EPCM scope—determined			
	3. Construction contractor scope—determined			
	C. Project Execution Plan (PEP)—finalized			
	D. Project procedures manual (PPM)—assembled			
4	Project control system—developed			
	A. Work breakdown structure (WBS)—established			
	1. Task list and/or activities—completely defined			
	B. Project control budget (primary cost control document)—complete			
	C. Cross reference to assets code of accounts—created			
	D. Project baseline schedule—fully detailed and developed			
	E. Earned value management for measuring progress—utilized			
	F. Change management and control process—in place			
	1. Major scope change approval process—defined			
5	Project schedule control			
	A. Level 3 Project Coordination Schedule—complete			
	B. Critical path—determined			
	C. Project milestones—all set			
	D. Level 4 Execution Schedules (for engineering, procurement and all construction areas)—established			
	E. Operations start-up with construction interface—prepared			
	F. Production schedule (initial 3 years of operation)—produced			

No.	Item	Status	Date	Initials
6	Project procedures and policies—in place			
	A. Project administration			
	B. Accounting procedures—set with Owner			
	C. Contracts management			
	D. Project scope control policy			
	E. Engineering and procurement protocols and control procedures			
	F. Construction management procedures			
	G. Quality management (QA/QC) protocols			
	H. Workforce handbook			
	I. Environmental impact, permits, social acceptance, and sustainability policies			
7	Monetary controls:			
	A. Contingency management, control, and reporting—developed			
	B. Owner's (and financing) cost administration—in place			
	C. Monetary approvals (levels of authority)—established			
	D. Cash flow analysis—undertaken at defined intervals			
8	Management reports—defined			
	A. Report frequency and content—established			
	B. Weekly status, activity, and issues report—defined			
	C. Monthly flash and progress reports—defined			
	D. Periodic project reviews—set			
	E. Dashboard—functioning			
9	Field reports—in place			
	A. Field labor and materials status analysis			
	B. Progress, performance, and productivity measurement			
	C. Field trending			
	D. Personnel projections			
10	Control team functions—defined			
	A. Costs, schedule, quality—monitoring and evaluation			
	B. Trending of all activities—established			
	C. Forecast updates of project costs and schedule—determined			
	D. Owner and management reporting basis—set			
	E. Project compliance analysis—determined with Owner			
11	Audit processes—established			
	A. Project audits (for adherence to best practices)—set			
	B. Financial audits—frequency established			
	C. Project management audits—undertaken, if appropriate			
12	Recovery plan requirements—followed as necessary (see Chapter 25)			



FLOWCHART 21.1 Project controls

CHAPTER 22

Reports and Progress Reviews

> *What we've got here is a failure to communicate.*
> *— Paul Newman as Luke in* Cool Hand Luke*, 1967*

OBJECTIVE

This chapter clarifies the data and metrics needed within the suite of reports and progress reviews regularly undertaken during a project life for effective management and control of project execution progression. Effective reporting provides information and promotes understanding.

REPORT PURPOSE

A key element in organizing any successful project management effort is the early establishment of an effective information feedback system loop, that is, the reporting system. The purpose of all project reports is to provide timely, concise, unbiased information as to what is happening within the project to all those stakeholders who have a legitimate need to know.

Reports cascade in two directions from the project manager: upward with summary status information to the Owner's senior management team and board, and downward to functional project team members and consultants, providing key performance metrics for action interventions. Information similarly flows up from subordinates to the project manager, giving details on progress, and down from the company executives as they provide guidance on the broader issues. Reports enable information flow in multiple directions.

To be effective, the processes within the reporting systems must provide transparency in delivery of critical project information and maintain focus on the important project drivers. Reports are an important tool for accomplishing the project work. The procedures for writing, reviewing, approving, and implementing report results and recommendations need to be formalized and streamlined from project outset. The information technology (IT) system capabilities to support the reporting systems need to be established well before the project execution stage gets underway.

REPORTS FREQUENCY

The frequency and format of the project reporting are established by the end of the kickoff stage, along with the distribution list. Weekly activity, monthly status, and periodic review reports are always required, as are certain key field reports. And whenever project completion dates or project budgets are changed, for whatever reasons, formal forecast updates to senior management are mandatory.

WEEKLY ACTIVITY REPORT

A single-page flash report of the major activities and issues is required weekly from the project manager to keep project stakeholders adequately informed about project progress. This report, sent out at the latest on the Monday of the following week, needs to come from the project leader, because this is the best person to make sure that no important issue or activity is omitted. While a single-page report is always the goal, on occasion two pages can be tolerated—but never more than two, as most stakeholders stop reading after the first page.

Data are presented in bullet and table form:

- Work progress and accomplishments for the week, including key milestones met
- Changes in work scope (approved or requested)
- Project status
  - Overall project progress (percentage complete and dollars spent) versus the plan
  - Latest anticipated final cost versus approved budget
  - Forecast completion date versus master schedule completion date
- Issues and concerns

MONTHLY STATUS OR PROGRESS REPORT

A formal, written progress report is required on a monthly cycle. Generally, the cutoff date for the report is set by the Owner's accounting department to correspond with the corporate reporting system.

When an engineering, procurement, and construction management (EPCM) contractor is appointed, a decision has already been made as to whether a joint contractor–Owner report is produced or if separate independent reports will suffice. (Note: In most cases, a joint report is the superior document and as such is considered the best practice.)

The monthly report should contain the following information:

- Distribution list
- Introduction
- Executive summary
  - One-page flash report (similar format to the weekly flash reports)
  - Summary of the month's work effort with the overall project progress curve
  - Summary Master Schedule (Level 2) (Note: Although the monthly package includes a Level 3 schedule and the critical path is maintained at Level 3, in the executive summary, a Level 3 is too much detail.)
- Issues and concerns, coupled with a remedial-actions-and-needs log
- Safety and health statistics; including a project incidents-rate graph and table
- Activities during the month
  - Accomplishments
  - Activities missed during the month
  - Decision log
- Key events for next period
- Project cost summary (supported by tables and graphs)
  - Work breakdown structure (WBS) cost update
  - Accrued cash flow plan status
  - Cash flow variance report (table and curve)

  - Onshore and offshore breakdowns (if applicable)
  - Contingency variance graph and histogram
  - Contingency change log
- Workforce summary (plan vs. actual) shown on a one-page project life histogram
- Engineering status, including progress charts by discipline and by area
  - Home-office status report
  - If conducted in multiple offices, status at each office
  - Field engineering activity
  - Engineering drawings status
  - Vendor drawings status
- Procurement (sourcing, logistics, and materials management) status
  - Orders placed
  - Orders shipped (complete and partial shipments need to be broken out)
  - Orders received
  - Critical orders status
  - Expediting efforts and vendor inspections conducted
  - Logistics and traffic activities
  - Warehousing
- Construction activity, including progress charts by discipline and by facility
  - Contracts status
  - Owner's construction progress status (if applicable)
  - Installed quantity curves
- Commissioning activity
  - Finalized construction by system (one-page graph and table)
  - Precommissioned by system (one-page graph and table)
  - Ready-for-turnover by system (one-page graph and table)
- Quality management report
  - Quality assurance and quality control activities
  - Audits
- Project controls
  - Earned value analysis report with a one-page overall project progress table
  - Change management summary
    - Change order control log and status
    - Deviation log (current period and project to date)
    - Potential deviation log
    - Trend analysis
- Third-party progress reports and schedule
- Security and loss control report
- Regulatory activity
  - Permit status
  - Agency approvals
- Environmental update
  - Compliance activities (including spills and excursions, if any)
  - Hazardous waste activities, if any
  - Weather log

- Social acceptance and sustainability activities
    - Community relations
    - Governmental affairs
- Workforce analysis (including actual discipline-level personnel histograms vs. the plan)
    - Personnel additions and deletions
    - Hours expended (contractor [direct and indirect], Owner, and third parties)
    - Craft work productivity measurements (in tabular form)
    - Training status and operations workforce development
    - Recruiting activities
    - Camp update (if applicable)
- Project Coordination Schedule (Level 3)
    - Detail schedules (including Gantt bar charts and S-curves)
    - Critical path update
- Requisition items status—detail logs (optional)
- Site photos

The monthly report should be issued by the end of the second week of the following month at the latest; late reports lose their control effectiveness. The single-page monthly flash report is issued alone, ahead of the full monthly report distribution, as soon as the requisite data are available (typically within a few days of month close, but at least a week ahead of full report distribution). The flash report retains a fixed format, thus providing senior management a consistent basis for their project review.

PERIODIC PROJECT REVIEW

In addition to the monthly report, a periodic project review is produced every 6 to 12 months during the project life. This document contains an in-depth review of the project measured against the base control document and the project objectives. The document's purpose is to provide a comparison between the project, as originally described in the approved feasibility study and Project Execution Plan (PEP), and the configuration at the time of review, that is, scope, schedule, cost, goals, and so forth. It is not a rewrite of the feasibility study or a regurgitation of the monthly reports, but rather a discussion of the changes that have occurred in the project, along with current project status and expected outcome.

The periodic project review document (PPRD) provides senior management with a broad overview of where the project started, the major changes since project inception, where the project is today, and the risks remaining on the way to where the project is forecast to end. The report covers *all* aspects of the approved project. Thus the report's verbiage, tables, and schedules encompass all EPCM, constructor, Owner, regulatory, social, and financing activities. The objective is to provide the total project picture to the reader.

The PPRD is frequently the prime information source of the project's progress for senior management and the company's treasury department. They can then communicate that progress to outside parties (e.g., analysts, bankers). The PPRD needs to be extremely concise with very brief explanations and just enough detail for management to grasp the project's present status. The focus is on information that is new to management since the last PPRD. Total report length will depend on the amount of change since the last report, but brevity is always key.

The PPRD needs to contain the following items:

- **Executive summary:** review of originally approved goals and status of key project data
  - Summary highlighting the status of major project components, that is, schedule, expenditures, changes, risks, engineering, construction, and critical path problems
  - The likelihood of attaining project goals; that is, construction of a facility capable of producing *x* specified throughput rate on *y* date at *z* capital cost is stated
  - All major changes to scope, budget, key milestone dates, completion date, reserves, the 5-year production plan, etc.
  - Less than three pages of verbiage, plus a few select tables and graphs.
- **Scope changes:** review and explanation of all major changes within the project
  - Summary of changes by area, showing both cost and schedule impacts
  - One to two pages with a tabular listing and description of each major change
- **Schedule review:** update of project completion date and any changes to that date
  - Two-page update of critical path issues and milestones (met and unmet)
  - List of workforce requirements showing productivity (actual vs. expected)
  - Charts showing progress of each major area, percentage complete versus planned
  - Latest milestone schedule with completed and forecast dates, as well as the float time remaining
  - Schedule concerns ahead, including status of the major contractors
- **Capital cost review:** update of latest forecast capital cost versus approved budget
  - Summary by area, listing budget, forecast, spent and uncommitted totals
  - Summary of budget, spending, and forecast by quarter, from start to completion
  - Tabular summary of the total project costs by the major WBS areas
  - List of the committed funds and the confidence in the to-go forecast capital cost
  - Typically less than two pages of verbiage; data shown mostly in tables
- **Contractor's cost:** status by major WBS area. Discuss any contractor concerns.
- **Owner's cost:** review status by area. Highlight any scope changes and compare to feasibility study and/or PEP. Clarify any prior ill-defined areas.
- **Risk and contingency analysis:** review of commitments versus remnant contingency
  - Any variances to the risk summary table and confidence in the data provided
  - A table showing change in contingency by quarter
  - Typically one page of verbiage describing the vulnerable areas, plus the tables
- **Safety:** concise tabular review of project performance along with very brief comments
- **Reserves:** update of any work that redefines the feasibility study reserve base; requires a one-page table comparing any new reserve to the feasibility study
- **Mining:** update of the mine development progress, including any changes in mine plan
  - Modifications to the selected mining method, changes to the annual tonnage movements, changes to the equipment fleet, etc., captured and compared in tabular form to the feasibility study and/or PEP
  - No more than one page of verbiage plus a page of tables
- **Process system:** update on process flow, input parameters, or mass balance changes
  - Modifications to process equipment; items added or deleted to ensure project goals will be met; clarifications to prior ill-defined areas are described
  - Comparison of latest forecast production ramp-up in tabular form to feasibility study and/or PEP

  - Clarification of any scope changes and their process concerns and consequences
  - Two pages
- **Infrastructure:** update on any changes and field construction progress
  - A one-page update of the status of utilities (power, water, etc.), access road, etc.
  - Clarification of any prior ill-defined areas
- **Engineering:** update on progress to date versus budget and forecast; one table summarizing budget, latest forecast, and variance explanations
- **Procurement:** update on progress to date versus budget and forecast; one table summarizing budget, latest forecast, and variance explanations
- **Operations update:** latest forecast versus original scope; description on one page of any changes to the production plan, personnel, and operating cost that would materially change the original goals set for the project
- **Five-year capital expenditure forecast** for the project and operations on an annual basis
- **Cash flow update**

FIELD REPORTS

Field reports provide real-time information to project management. They need to be timely, short, and to the point, with a minimum of language and a maximum of pertinent data. Reports should cover, at a minimum, the following issues:

- Project oversight
  - Weekly report on progress of activities
  - Concerns and issues
- Scope: Change control report
- Schedule
  - Project critical path updates
  - Schedule progress and analysis
- Personnel
  - Workforce status
  - Performance productivity measurement
  - Workforce projections and requirements
- Costs
  - Daily time-card reporting system
  - Field labor and field material analyses
  - Cost estimates
  - Cash flow forecasts
- Forecast and trend analysis
  - Forecast to complete
  - Three-week look-ahead
  - Major change-effects summary

FORECAST UPDATES

On large projects that extend beyond a calendar year, it is sometimes necessary to update the project budget and/or schedule to reflect changes to the project environment, for example, reserve modifications, mining plan manipulations, scope changes, and product price fluctuations. These updates are called *forecasts,* and the project progress has to then be tracked against both the original approved budget and the latest forecast. The latest forecast will reflect the current reality for the project. However, the original approved budget is never lost; forecasts may be supplanted repeatedly by newer forecasts, but progress is always tracked against the original Authorization for Expenditure (AFE) budget. Without the discipline of retaining the original budget, project control is not meaningful.

MEETINGS

Subject-focused communication sessions in addition to the formal project review meetings listed in Chapter 17 are positive supplements to the reports listed here. The kickoff establishes the usefulness and frequency of such supplementary meetings. (See Chapter 26.)

DASHBOARDS

A project dashboard is a management information control tool that provides transparency on the critical economic and technical areas of project execution. The dashboard provides an online view of project status. The dashboard can be updated automatically as team members enter information, providing a real-time flow of critical project execution information, that is, an up-to-date view of the current health of the project while it is happening (Project Manager Online 2013).

To be effective, the dashboard needs to be an easy-to-read, single-page, real-time user interface showing mostly graphical snapshot presentations of the current status and historical trends of the project's key performance indicators in one place. Management needs this critical project information in an easy-to-discern format and a timely manner. Multiple pages, small type, and lists of information are less useful.

Dashboards are normally installed on the computers of all key internal and external stakeholders (Owner executives, Owner management, contractors, consultants, etc.), as well as on the computers of all project team members. The dashboard creates a common reference and a single source of truth across the project for all viewers.

Dashboard Elements

A project dashboard is a management summary of the project's key performance indicators (KPIs) that are informed by the full suite of project reporting elements. The KPIs most often displayed on the project dashboard are the following:

- **Critical project milestones**—A bar chart summary status of the key project milestones to allow a quick insight as to the overall project schedule status versus plan. If the dashboard is linked to support pages, these would typically be Gantt charts showing more schedule detail.
- **Cost outlook**—A histogram overview of the latest project spend and the forecast final project cost versus approved budget. If the dashboard is linked to support pages, these would show trends in change orders and claims, broken down by cost center.
- **Risk summary**—A succinct list of the most critical project risks, their potential cost, and schedule impact along with the status of any mitigation actions. Mitigation action status is typically color coded (green for on track, yellow for progress lagging, and red for not started).
- **Overall project progress**—A single graphical display of the earned value summary status of the whole project versus the plan.

- **Selected major stage (phase) or package performance**—Graphical illustrations of the status of individual project stages (e.g., feasibility, engineering, procurement, construction) or of key major work packages (e.g., civil works, electrical work). The focus in these displays is normally on percentage complete and schedule.
- **Program health indicators**—Numeric overview of selected key project metrics that have been deemed most relevant by management (project and/or Owner). Typically these would include
    - Workforce hires versus those planned,
    - Procurement contracts and purchase orders awarded versus those planned,
    - Safety performance statistics,
    - A summary of any environmental incidents and their severity, and
    - The progress of community initiatives and achievements against the plan.
- **Key decisions**—Some dashboards show a typed listing of key decisions to be made in the immediate future. This element does not lend itself to graphical display or easy linkage to support data, and it rarely changes from week to week; thus it is not particularly favored by most project staff.

Figure 22.1 depicts the typical KPIs chosen to create a project dashboard. Figure 22.2 is an example of a dashboard (using modified information commingled from two recent projects) to illustrate the kind of management data overviews normally desired by Owners and project managers.

Each dashboard is unique, created solely for the particular project at hand. It generally involves using a control model for collecting and consolidating the project data that recognizes cross-program linkages and interdependencies. The dashboard programs then feed the data into packages that display the selected project execution status indicators.

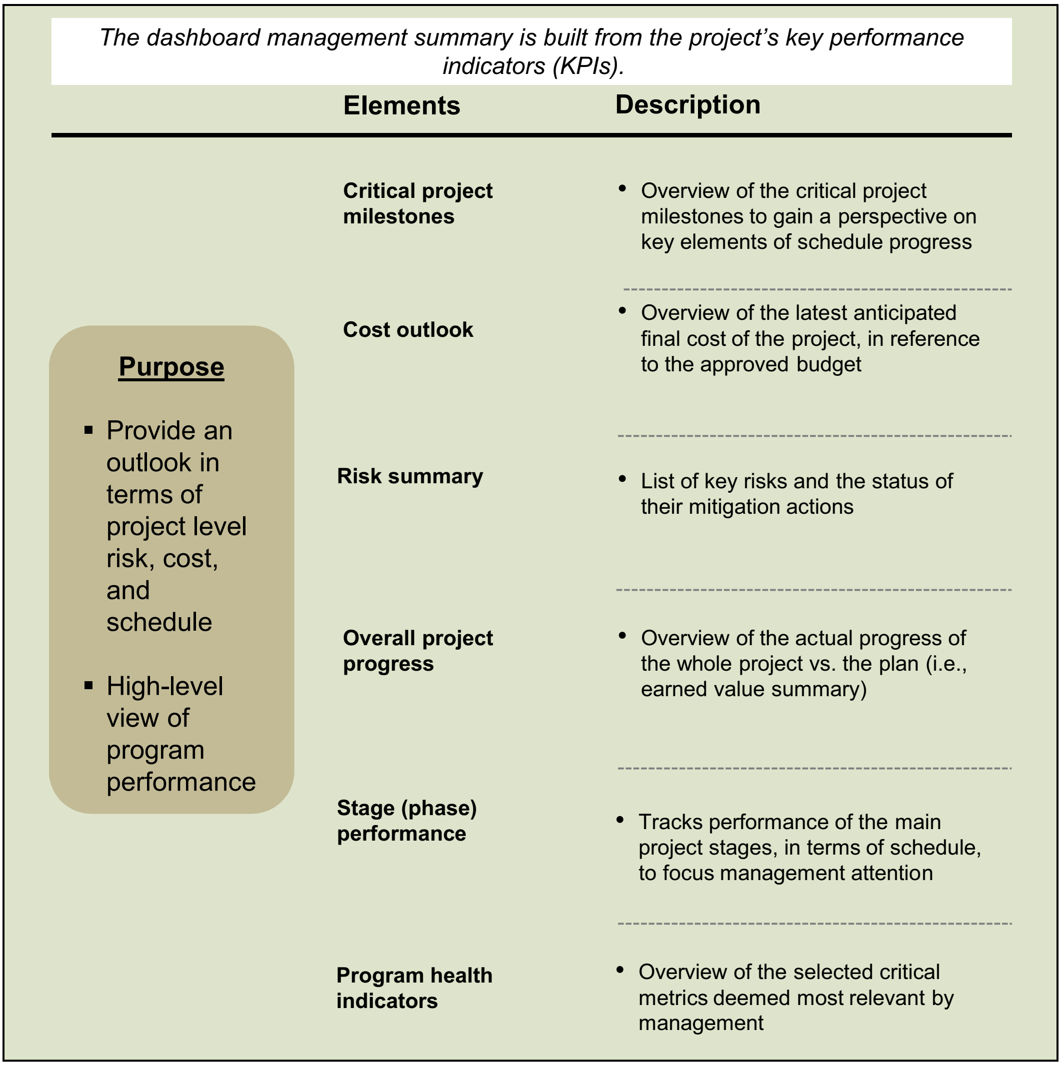
The dashboard establishes a forum and a format to surface and address problems. Using the dashboard, the viewer can see at a glance which of the project activities are on time, under budget, and destined for success, and which are behind. For those elements that are lagging, the viewer can use the dashboard's interactive software features to quickly drill down to try to identify the root cause of the problem. The dashboard thus enables a focus on the most important project areas for action and intervention.

Most dashboards can be customized. One can generally hide any one of the charts displayed to ensure that only pertinent information for that particular viewer is shown.

Dashboard Issues

Theoretically, the dashboard enables informed decisions to be made in a timely way by project team players in their efforts to actively manage project execution risks. Regrettably, however, the information displayed on dashboards has also been used as a "weapon" by senior management to aim unconstructive barbs at project management when project shortfalls appear rather than being used as a constructive tool to help fix an issue.

Consequently, a lot of project dashboards today are no longer updated automatically; they are only updated when the project manager approves the release of the new information. This is a shame, because more "eyeballs" on the problem (as long as they are attached to constructive minds) are generally a good thing for a project.



The dashboard management summary is built from the project's key performance indicators (KPIs).

Purpose

- Provide an outlook in terms of project level risk, cost, and schedule
- High-level view of program performance

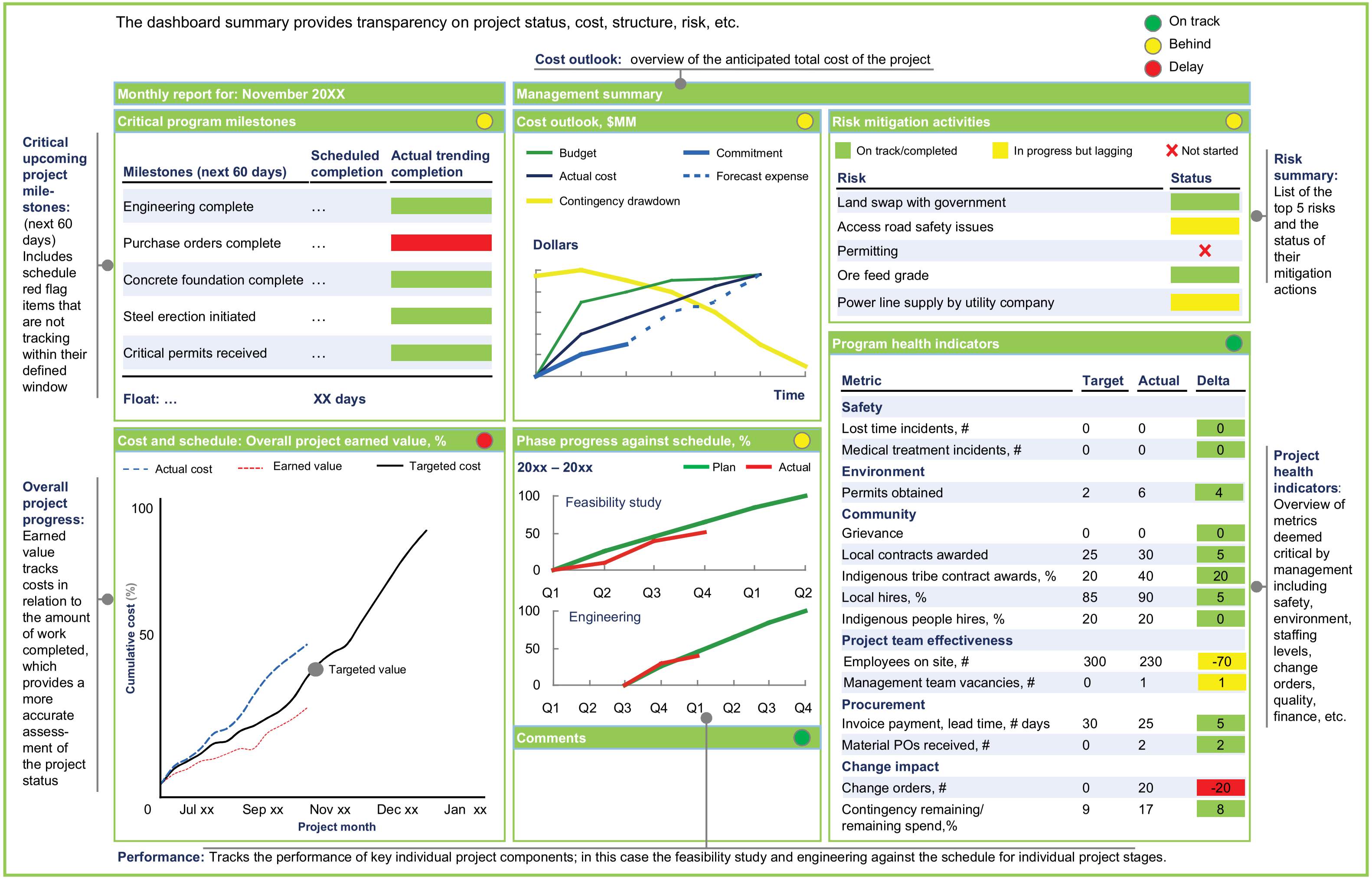
Elements	Description
Critical project milestones	• Overview of the critical project milestones to gain a perspective on key elements of schedule progress
Cost outlook	• Overview of the latest anticipated final cost of the project, in reference to the approved budget
Risk summary	• List of key risks and the status of their mitigation actions
Overall project progress	• Overview of the actual progress of the whole project vs. the plan (i.e., earned value summary)
Stage (phase) performance	• Tracks performance of the main project stages, in terms of schedule, to focus management attention
Program health indicators	• Overview of the selected critical metrics deemed most relevant by management

FIGURE 22.1 Key performance indicators for dashboard

COMMON PITFALLS IN PROJECT REPORTING

Common mistakes when establishing a project reporting structure include the following:

- Building in delays to the information-sharing process from the project manager and/or EPCM. This handicaps the ability to mitigate project problems with real-time responses and hinders rapid decision making.
- Disseminating incomplete information. It is difficult to act prudently or decisively when armed only with incomplete information.
- Lack of transparency and consistency in reporting. This can result in overruns not being timely addressed, or worse, not being disclosed until as late as final accounting.
- Generating reports with scads of extraneous information. Sifting through irrelevant data complicates and slows down management decision making.



The dashboard summary provides transparency on project status, cost, structure, risk, etc.

Monthly report for: November 20XX

Critical program milestones

Milestones (next 60 days)	Scheduled completion	Actual trending completion
Engineering complete	…	🟩
Purchase orders complete	…	🟥
Concrete foundation complete	…	🟩
Steel erection initiated	…	🟩
Critical permits received	…	🟩

Float: … **XX days**

Risk mitigation activities

🟩 On track/completed 🟨 In progress but lagging ✗ Not started

Risk	Status
Land swap with government	🟩
Access road safety issues	🟨
Permitting	✗
Ore feed grade	🟩
Power line supply by utility company	🟨

Program health indicators

Metric	Target	Actual	Delta
Safety			
Lost time incidents, #	0	0	0
Medical treatment incidents, #	0	0	0
Environment			
Permits obtained	2	6	4
Community			
Grievance	0	0	0
Local contracts awarded	25	30	5
Indigenous tribe contract awards, %	20	40	20
Local hires, %	85	90	5
Indigenous people hires, %	20	20	0
Project team effectiveness			
Employees on site, #	300	230	-70
Management team vacancies, #	0	1	1
Procurement			
Invoice payment, lead time, # days	30	25	5
Material POs received, #	0	2	2
Change impact			
Change orders, #	0	20	-20
Contingency remaining/ remaining spend,%	9	17	8

Critical upcoming project milestones: (next 60 days) Includes schedule red flag items that are not tracking within their defined window

Overall project progress: Earned value tracks costs in relation to the amount of work completed, which provides a more accurate assessment of the project status

Cost outlook: overview of the anticipated total cost of the project

Risk summary: List of the top 5 risks and the status of their mitigation actions

Project health indicators: Overview of metrics deemed critical by management including safety, environment, staffing levels, change orders, quality, finance, etc.

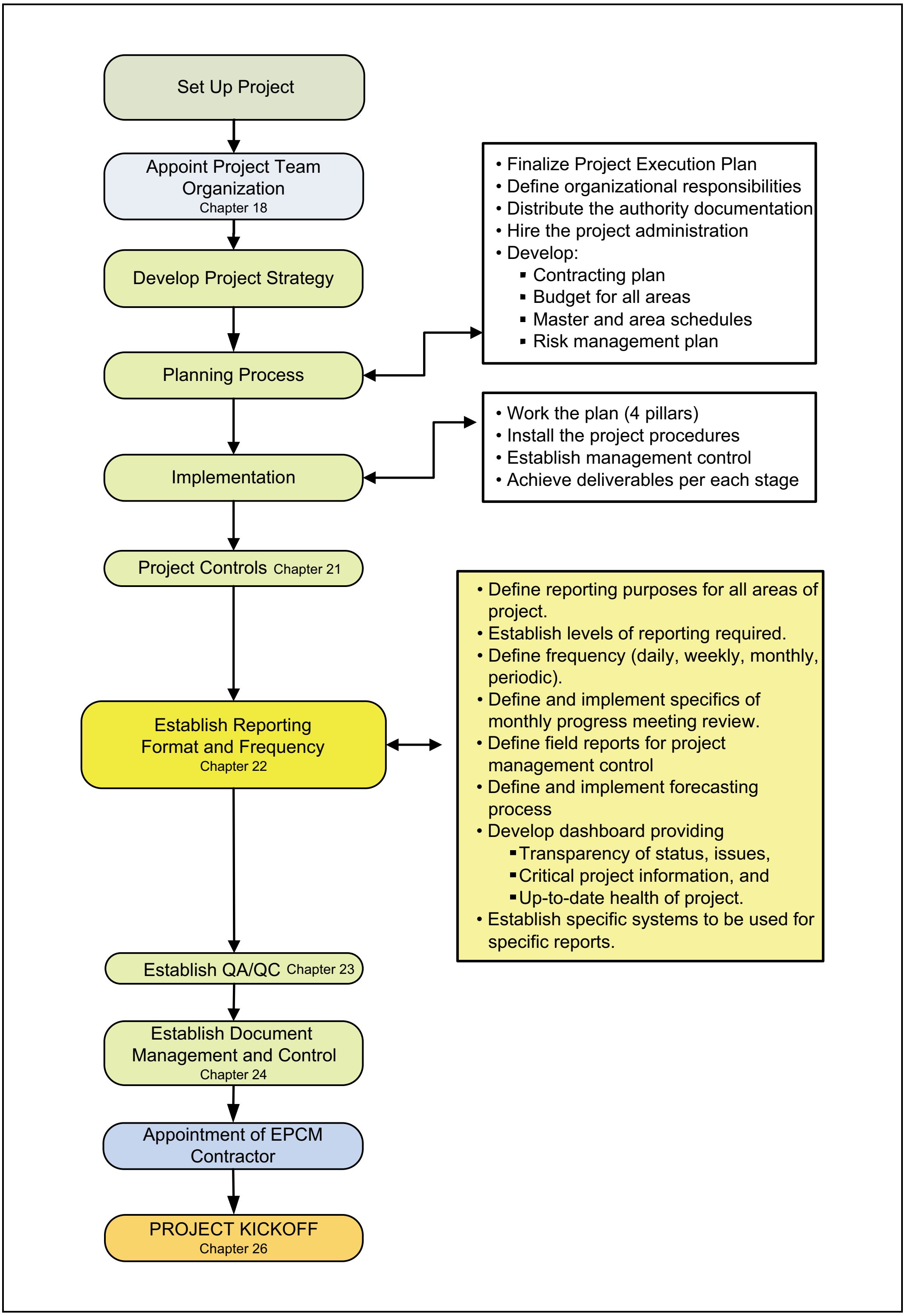
Performance: Tracks the performance of key individual project components; in this case the feasibility study and engineering against the schedule for individual project stages.

FIGURE 22.2 Dashboard management summary

- Not clearly outlining the reporting expectations or requirements for the EPCM or construction contractors at the time of contract award. Contractor reports lacking necessary information negate the report's utility and will in turn delay the project's own reports.
- Project management or EPCM tracking system not feeding smoothly into the Owner's enterprise or reporting system. Any lack of synchronization between the project and the Owner will add reporting burdens to the project (such as manual systems outside of the established structure) and will likely mean some information is either lost or delayed.

CHECKLIST 22.1 REPORTS AND PROGRESS REVIEWS

No.	Item	Status	Date	Initials
1	Reporting or information feedback system—established			
	A. Report purpose—individually defined			
	B. Individual report formats—specifics developed			
	C. Publication frequency—set			
	D. Key performance indicators (KPIs)—derived			
	E. Authorship responsibilities—assigned			
	F. Distribution list for each report—determined			
2	Project IT support system—in place			
3	Project management team (and controls personnel)—all hired			
4	Earned value management procedures—functioning			
5	Constructors reporting systems—in sync with project's systems			
6	Weekly activity flash report:			
	A. Author: project manager—identified			
	B. Issuance day: Monday of following week—agreed			
7	Monthly flash report:			
	A. Author: project controls manager—identified			
	B. Issuance day: within 2 days of month close—agreed			
8	Monthly status or progress report:			
	A. Author: project controls manager and staff—identified			
	B. Issuance day: within 2 weeks of month close—agreed			
9	Periodic project reviews:			
	A. Author: external project specialist—determined			
	B. Issuance: every 6 to 12 months—frequency set			
10	Field reports:			
	A. Author: project controls manager and field staff—identified			
	B. Issuance: weekly—agreed			
11	Forecast updates:			
	A. Author: project controls manager and staff—initiated			
	B. Issuance: annually and/or as necessary—outlined			
12	Dashboard—functioning			
13	Key attributes requisite from reporting system:			
	A. Delivery of critical information—timely			
	B. Transparency—achieved			
	C. Focus on project's value drivers—maintained			
	D. Information content—readably concise			
	E. Data presentation—predominantly pictorial			



FLOWCHART 22.1 **Report and progress reviews**

CHAPTER 23

Quality Assurance and Quality Control

> *Quality is never an accident; it is always the result of intelligent effort.*
> —*John Ruskin, 1819–1900*

OBJECTIVE

This chapter sets out the mix of quality assurance (QA) protocols and quality control (QC) reviews necessary within a project life to effectively ensure that the Owner's quality expectations will be met by the project deliverables.

QUALITY DEFINED

Quality is determined by the product end user, in our case the project Owner, not by society in general. Quality is not necessarily related to cost, and thus cost descriptors such as "high" and "low" are not applicable. Quality can be difficult to define within a project setting, but the McIntosh Engineering definition serves universally well: *quality* is "the extent to which the product delivered or the service provided conforms to the customer's expectations" (Dudson et al. 2007).

The quality of the service that an engineering, procurement, and construction management (EPCM) contractor offers is often the single most important factor in the Owner's choice on contractor selection and/or in the decision of an Owner who is considering offering an existing EPCM contractor the opportunity for additional work. When faced with poor quality, Owners seldom complain; they just switch providers. Poor quality within a delivered project is thus not just costly because of the payment of an insurance claim or redoing of faulty work; for the EPCM and the constructor, it generally results in the loss of a client.

EPCM's Definition of Quality

EPCMs will typically define quality on a professional performance basis, for example, as

- Conformance with industry standards;
- Meeting all applicable codes, laws, and standards;
- Suitable for intended usage (fit for purpose);
- Doing what the contract says;
- Conformance with requirements;
- Performing the work as well or better than the average competent EPCM; and
- Delivering a facility as per design.

Owner's Definition of Quality

For the Owner, quality is more than design excellence. Owners will likely measure the quality of a project in terms of impact to the schedule, the adherence to budget, and the deliverables of the project. The quantifiable aspects of project quality for the Owner relate much more to outcome than to the performance standards used for project execution.

But it is the softer, less easily defined aspects of project delivery that tend to cement the image of quality achieved or not achieved for the Owner. It is the promise not kept, the communication not delivered, or the milestone date that was ignored that leads to the perception of poor quality in the mind of the Owner. An Owner sees quality being delivered when the EPCM (or the constructor) understands the Owner's problems, develops creative solutions to project road blocks, and eliminates hassles from the Owner's life.

Consequently, the Owner's requirements and expectations must be clearly identified upfront whenever the Project Execution Plan is put together. Given that many problems relate to the working relationship between the EPCM and the Owner, both parties need to focus on this aspect of the project. An Owner needs constant assurance that all personnel charged with delivering the project truly care about the project.

The Project's Definition of Quality

The first step in delivering quality is for the project manager to meet with the Owner and develop a detailed list of the Owner's expectations regarding the project. The critical success factors in the Owner's mind each have to be translated into some form of quantifiable performance measure:

- If the Owner wants a *highly automated process plant*, this needs to be translated into, say, "a process plant that can be controlled by one person."
- If the Owner wants *adequate parking*, this needs to become, for instance, "space for 120 cars."
- If the Owner wants *minimal change orders*, this needs quantifying as, say, "totaling less than 2% of the capital cost."

The point is that the quality expectations of the Owner have to be determined before kickoff, and then documented and accepted by the full project team. Everyone on the team is then accountable for maintaining the quality standards, and the project manager has to reinforce them with his or her own actions.

QUALITY ASSURANCE

QA within a project encompasses the planned and systematic activities that ensure that the quality requirements for the project will be fulfilled.

QA requires systematic measurement of the process. It relies on comparison with standard, monitoring processes and associated feedback loops that prevent error. This is in contrast with QC, which focuses on process output.

QA activities for a project include items such as

- Management of the quality of services related to design;
- Surveillance of off-site and on-site assembly of materials and equipment;
- Management of the quality of delivered materials;

- Oversight of the services related to engineering, procurement, and construction;
- Conduct of the monitoring and inspection processes; and
- Achievement of the specified quality in the operations output products.

Implementation steps for quality assurance are as follows:

1. **Incorporate QA into the project budget.**
   - Include QA as a line item in the project budget.
   - When properly applied, good QA reduces overall cost.
2. **Make realistic assignments.**
   - Assign responsibilities to individuals who can handle them. Match employee capability to task.
   - It is not always possible to have the perfect employee available for every task. Project managers have to be aware of the limitations and strengths of team members and compensate, where necessary, with a higher level of supervision.
3. **Consider project complexity.**
   - Complex or long-duration projects invite error as a result of coordination difficulties. Team turnover on a long project can hinder communication, and a small, undetected mistake can magnify the consequences over time.
   - Each engineering discipline must be responsible for its individual subarea of QA. The project manager has to assign that responsibility to a team member with the knowledge and support to ensure quality within the disciplines.
   - When information is shared among disciplines, the project manager has to ensure that each team member is aware of the level of detail involved and the impacts from the tasks of others.
4. **Develop realistic schedules.**
5. **React quickly to symptoms and problems.**

QUALITY CONTROL

QC for a project embraces all the techniques and activities (including simple observation) that fulfill the project requirements for quality.

Historically, QC has been mostly focused on the checking procedures that verify the quality of the various elements of project scope being delivered. But checking quality at the end of a process does not reduce the chances that errors are being made during the process. When the checking is done only at the end, any errors made during the process can only add cost (and probably delay) to the project.

QA activities, on the other hand, reduce the potential for error during the different project execution steps so that the chance of a poor-quality product is substantially reduced. QC procedures are thus, in one sense, a late-stage but integral element of QA.

ENGINEERING QUALITY PLAN

It is always best to address quality up-front, in the engineering phase where quality can be designed in, rather than downstream in the construction phase where quality activities tend to be more involved with correction than in prevention of errors. QA is therefore where most of the engineering quality effort is focused, as this is the much more cost-effective way to accomplish quality than is QC.

Conformance to the International Organization for Standardization's 2008 version of ISO 9001 *Quality Management Systems* is quite commonly a component of the quality plan, particularly for the EPCM firms and the major mining companies. But no matter how well it is set up, every design project will at some point introduce errors and omissions. The purpose of quality management within the engineering phase is to try and prevent these errors from occurring in the first place (the QA component), and then if they do occur, to find and correct the errors before the design goes to the field (the QC component).

An engineering QA/QC plan has to answer the following questions:

- Which documents should be reviewed?
- Who should review them?
- When should they be reviewed?
- What kinds of errors will be sought?
- What is the budget allotted for review?
- What are the schedule and budget allotments for corrections?

Reviewers receiving engineering documents need explicit guidance as to what kind of review is expected. The different types of reviews commonly conducted within an engineering quality plan are listed as follows:

- **Conceptual review**—An evaluation of the basic concepts on which the project is based is done to ensure that the facility will function properly given the project's budget and schedule constraints and any Owner corporate image concerns.
- **Intradisciplinary review**—An independent, experienced person from each engineering discipline checks the applicable calculations, drawings, and specifications produced by that particular discipline.
- **Interdisciplinary review**—One or more individuals perform a detailed inspection to ensure consistency and identify interferences between engineering disciplines.
- **Drawing-specification cross-check**—This check is conducted by a specialist who reviews the specifications page by page to identify information that needs to appear on the drawings, and looks for inconsistencies between the drawings and the specifications.
- **Multifacility cross-check**—On projects involving multiple facilities, this review will identify inconsistencies between buildings located in the same complex. For example, a pipe shown leaving one building as 8 inches in diameter should not be found entering another building as 6 inches in diameter.
- **Vendor review**—Equipment and material suppliers are asked to identify equipment incompatibilities, out-of-date specifications, and/or inappropriate materials.
- **Constructability review**—A technically correct design may be difficult or impossible for a contractor to construct. A constructability review is conducted by an experienced field construction contractor to identify and remove these problems during design.
- **Operability and maintainability review**—This evaluation should always be conducted by an Owner employee responsible for operating and maintaining the completed facility. The purpose is to identify aspects of the design that will make the facility difficult to operate or maintain.

The project manager determines at which stage of document completion the reviews will be conducted. For small, simple projects, one review near the end may be enough; for large, complex designs, multiple reviews are necessary to avoid extensive design rework.

ENGINEERING QUALITY ASSURANCE

Engineering QA encompasses the management measurement processes that ensure the quality of the products of engineering (designs, drawings, calculations, specifications, etc.) as well as the services and inspection processes related to the engineering output. The two key principles of QA are (1) *fit for purpose,* meaning that the product should be suitable for the intended purpose, and (2) *right first time,* meaning that mistakes should be eliminated.

Engineering QA mostly relies on monitoring, measurement, and comparisons to standard processes, along with feedback loops to confer the desired error prevention. QA forms need to be created that list what to look for and what to measure for. The completed forms then identify any nonconformance.

ENGINEERING QUALITY CONTROL

An engineering QC program requires independent review of all the project documents. The quality reviewer has the responsibility for ensuring that the engineers comply with the verification activities and design reviews stated in the engineering procedures and deliverables plan. Ideally, the QC reviewer should be an autonomous peer or supervisor with no previous connection to the project. On large projects, QC reviews may be conducted by a review panel. The QC review focuses on four primary areas:

1. **Quality assurance confirmation**—Prior to design completion, before any initial submittals to the project manager and the Owner, the engineering QC reviewer should first confirm that all in-house engineering office checklists (including those specially prepared or edited for the project) have been checked off by the designers and that any comments made by the design staff have all been appropriately dealt with. The reviewer should then add his or her initials and date to each checklist item.
2. **Consistency**—The reviewer should cross-check all plan sheets and reports for consistency and then cross-check the documents to verify that all recommendations have been followed. If they have not, an explanation must be contained in the reviewer's project submittal report. To accomplish the consistency review, the reviewer must be provided with the complete package of engineering documents.
3. **Detail**—While the engineering staff will usually catch most of their own mistakes, over time the staff can become too familiar with the project drawings and documents and may miss minor errors that may have crept in. It is the responsibility of the QC reviewer to see that all inadequacies in this area are caught.
4. **Understandability**—The QC reviewer should read the engineering plans with the following question in mind—"Can a construction person unfamiliar with the project tell what is intended to be built?"—but at the same time must recognize that the QC review purpose is suitability for use, not perfection.

Time for the QC reviews has to be incorporated into the project schedule and monies allocated within the project budget. The schedule and budget should also allow time for the additional work that may result from the reviews.

Engineering Drawings

From a QC viewpoint, drawing reviews should verify the following factors:

- The scope of the drawing is satisfactory, and all intended work has been included.
- The facility structures and equipment have been examined from an overall operational standpoint, and all necessary components are included.
- Results from engineering studies and calculations have been properly incorporated into the design criteria.
- Department drawings are interfaced correctly with other department drawings.
- Previous comments on check prints are incorporated into the completed drawings.
- The design conforms to the applicable codes and standards.
- Constructability of the item and potential interferences have been considered.
- Where applicable, provisions have been made for keeping existing facilities operational during construction.
- Accessibility for maintenance, repair, and in-service inspection has been considered.
- Material selection is verified as proper:
  - Materials specified on the drawing agree with those selected by the designer.
  - Materials selected by the designers will perform adequately in service.
  - Materials and/or equipment required to be specified on the drawings are so noted.
- Dimensions are correct and consistent.
- Drafting practices conform to drafting standards.
- Drawings are legible and can reproduce satisfactorily.
- Title block information is correct and complete.
- Drawing numbers and titles agree with the drawing list.
- The designer, drafter, and reviewers have personally initialed the drawings.
- Revisions are adequately identified as to what has been changed, and the correct revision number and date of approval by the project manager are all properly shown.

Engineering Calculations

To achieve a suitable level of QC in the engineering calculations, the following must be done:

- Know the design capability of the person making the calculations.
- Have an experienced lead person check the design criteria for completeness and accuracy before design begins. Checklists need to be used to avoid omissions.
- Require approval of the basic design before detailed calculations commence.
- Set up standard design procedures as guides.
- Establish format requirements for calculations:
  - Transcribe all calculations neatly and legibly.
  - List all design assumptions.
  - List all formulas and define symbols.
  - Place the calculations in the project file and provide a subject index for quick reference.
  - Set up procedures for checking calculations.
  - Thoroughly check any special, intricate, or unusual designs.

Engineering Specifications

To achieve a suitable level of QC in the engineering specifications, the following tasks must be accomplished:

- Start specifications early in design. Do not wait until the last week of the project.
- Draw from the engineer's master guide of standard specifications for this new project. Do not use specifications from similar or past projects.
- Do not insert any manufacturer specifications that are not understood.
- Do not specify untried or untested materials without research.
- Draft technical sections for each discipline using engineers from that discipline.
- Mandate that the discipline's lead engineer review the final technical specifications.
- Require that the project manager coordinate compilation of the specifications.
- Evaluate all proposed substitutions for acceptability.

Engineering Quality Control Reports

A written report of each QC review, typically a project memorandum, is prepared by the reviewer and provided to the project manager, with a copy sent to the head of the engineering company's quality department and then placed in the project file.

The project manager assigns but does not conduct reviews. The project manager may accept or reject the recommendations of a QC review. The project manager's actions or inactions on the QC recommendations need to be noted as a separate memorandum and provided to the reviewer and the head of the engineering company's quality department.

The engineer will not only be concerned that the quality of the project work delivered is technically correct and fulfills contract obligations, but the engineer will also need to know that the work meets the engineer's internal professional standards and thus sustains the engineer's liability loss-prevention objectives.

Quality Sufferance from Late Design Changes

The fundamental engineering QA/QC approach is to provide quality professional design services on time and within budget. While it is a project reality that some changes will be required during the design process (for Owner concept change, revised assumptions, etc.), the later those changes occur, the greater the likelihood that quality will suffer. And the later in the design process that changes are made, the more costly those changes will be. A change made before the 30% engineering review mark might have an associated cost of $4,000, but the same change made at final review could easily cost $20,000, and if changed during construction, it could top $100,000. Changes require redrafting, which entails multiple drawings and affects many disciplines.

Costs for design changes at the conceptual design stage and at the 30% design review stage can generally be acceptably absorbed by a project (and possibly even at the 60% design review stage). However, requested design changes identified at the 90% or 100% reviews, or by the Owner after the plans have been released, should wherever possible be rejected and termed unacceptable if the project is to remain on schedule and in budget.

Worst of all from a project budget and/or schedule standpoint are crucial design changes that stem from problems discovered by the contractor on the site. This reflects unacceptable QC during the engineering stage.

PROCUREMENT QUALITY

As with engineering, procurement is mostly focused on QA, invoking processes that make sure the product that goes to the field meets project requirements. Procurement personnel have to pay special attention to harmonizing process- and materials-related requirements and standards with a vendor's product features.

Similar to engineering, QA forms are created for the procurement process listing what to look for and what to measure for while procuring goods for the project site.

Procurement documentation that is sent out with requests for qualifications and/or request for proposals typically demand the following types of quality criteria coverages from vendors and suppliers (Vadatech 2013).

Purchase order errors or inconsistencies—Supplier shall review purchase order requirements prior to starting work. If errors or inconsistencies are noted within the purchase order, the supplier must immediately notify the buyer. Product will not be accepted by the buyer until the purchase order documentation properly describes the product delivered.

Nonconforming material or product—Supplier shall submit a deviation or waiver request to buyer to report any departure from drawings, specifications, or other purchase order requirements. Supplier cannot ship a discrepant item without the buyer's concurrence.

Changes in process or materials—Supplier shall not change any process and/or material that will effect fit, form, or function without prior approval from the buyer and/or the regulatory agency as appropriate.

Corrective action request—When a quality problem exists with the supplier's product, the project's QA manager will require analysis for the cause of the problem, containment methodology, statement of any actions taken, and effectiveness of the actions. If the corrective action is being required for materials mandated by a permit or regulatory agency (e.g., a pond liner), then the supplier will need to coordinate such action with the regulatory agency representative assigned to the project.

Limited shelf-life items—Materials with limited shelf life (paint, adhesives, etc.) must show the date of manufacture, lot number, and applicable specification on their containers. The time between the manufacturing date and the date of scheduled receipt by the buyer shall not exceed one-fourth of the material's shelf life.

Prohibited practices or unauthorized repairs—Supplier may not repair parts damaged or found to be faulty during fabrication. Defects in product shall not be repaired by any method unless authorized in writing by the buyer. Note: this is a particular problem for large castings originating in developing countries (e.g., China, Brazil, and Korea).

Notification of facility change—Supplier shall not relocate any manufacturing facility during the performance of a purchase order without affording the buyer an opportunity to examine such facilities for compliance with quality system requirements.

Improper resubmittal—Items rejected by the buyer and resubmitted shall be clearly identified as resubmitted items on seller's documentation with a statement that they are either replacement or reworked items.

Certification of conformance—Certification that the material shipped meets all requirements of the purchase order shall be included with each shipment.

Review of quality or inspection—The supplier's quality system and manufacturing processes are subject to review by the customer or regulatory representative upon notification.

Right of entry—Representatives shall be afforded the right of entry to verify at the supplier's premises that the material or products adhere to specified contractual requirements.

Control of records—Supplier shall maintain quality records within its quality system for a minimum of 7 years. Electronic media backup will be performed to prevent document loss.

Nonconformance forms drawn up by the quality management team should be used to record any noncompliant test conducted or inspection performed. The forms identify the equipment or material involved, the location and functional description of the item, the acceptance criteria that were demanded, and any action taken from the unsatisfactory results incurred.

Supplier shop inspections are usually performed by personnel from the EPCM design engineering group, as they are generally best qualified to do this work. It is too disruptive to the project to have key project management team members away from site, traveling to faraway manufacturing locales.

Responsibilities of Quality Management in Procurement

The prime quality management responsibility for QA/QC in the procurement function is in administering the vendor or supplier inspection and surveillance functions:

- Review project specifications and purchase orders for quality conformance.
- Ensure that contract inspection activities are in compliance with project requirements.
- Evaluate supplier quality programs.
- Review and approve vendor and supplier inspection test plan proposals.
- Perform random audits of vendor and supplier systems.
- Conduct shop surveys and inspections.
- Prepare nonconformance reports and manage resolution of nonconformance issues.

CONSTRUCTION QUALITY

Most of the efforts for quality in the construction phase are concerned with QC rather than QA. Nevertheless, QA still has a role in the construction phase, particularly in the calibration of instruments that measure the constructors' work output.

CONSTRUCTION QUALITY ASSURANCE

QA forms need to be created for the construction management team that list what to look for and what to measure on-site during the calibration instrument activities of project execution. Such forms need to include the following information:

- Location identification
- Functional description
- Calibration procedure
- Calibration interval
- Acceptance criteria
- Action for unsatisfactory results

CONSTRUCTION QUALITY CONTROL

QC is always a concern for the project manager in the field (Hendrickson and Au 2008). Defects or failures in constructed facilities can result in large costs; reconstruction may be required and facility operations impaired. Failures may even cause personal injuries or fatalities. Indirect costs of insurance, inspection, and regulation will all likely increase from each construction quality shortfall. The answer is to get the job done right the first time.

Conformance: The Quality Focus of Construction

The important decisions regarding the quality of a project facility are made during the design and planning stages rather than during construction. It is during engineering that component configurations, material specifications, and functional performance are decided.

QC during construction thus largely consists of ensuring conformance to the original design and planning decisions. Quality conformance activities mostly involve field inspection and testing to ensure that the on-site work meets the requirements of the approved quality manuals, relevant codes, technical standards, and contract documents.

While conformance to design is the primary focus of QC during the construction phase, there are other occasions where quality concerns come into play:

- Field changes needed due to improper design, changes desired by an Owner, and even unforeseen circumstances can all provide opportunities to improve quality during the course of construction. While these changes may be motivated by the concern for quality, they will likely require reevaluation of design decisions and some measure of redesign—activities that will add unbudgeted cost.
- Some engineering designs rely on informed and appropriate decision making during the construction process. For example, some tunneling methods entail that decisions are made about the type of support required at different locations along the tunnel based on observation of ground conditions during the tunneling process. Since such decisions are based on better information concerning actual conditions, the facility design will be more cost-effective as a result (but not necessarily on budget.)

With conformance being the prime measure of quality during the construction process, the specification of quality requirements in the contract documentation is important. The quality requirements need to be clear and verifiable, so that all parties can understand the level of work involved. QC records gathered during the conformance inspections have to be distributed to garner action. Prompt and decisive corrective action to resolve items of nonconformance is essential for effective management of the QC program.

Organizations Responsible for Quality Control in Construction

Ensuring QC during construction is the responsibility of the project manager in overall charge of the project. That said, each party directly concerned with the project—including the Owner, the EPCM, and the individual construction contractors—may have its own quality inspectors. These inspectors are frequently subcontractors from specialized quality management companies.

Governmental inspectors to ensure compliance with regulatory requirements will also be involved. Common examples are inspectors from environmental agencies, from the local government's building department, and from occupational health and safety agencies.

While the construction effort will always require the services of inspectors for QC, quality management needs to be a primary objective for all personnel on the project. Employee participation in QC should be sought and rewarded. Quality improvement can serve as a catalyst for improved productivity. Owners should promote good QC and seek out contractors who maintain such standards.

In addition to the prior mentioned organizational bodies involved in QC, issues of QC arise in virtually all the functional areas of the construction activities:

- Testing of material samples by specialized laboratories to ensure compliance
- Accurate recording of information for work completed on-site
- Document control (including changes during construction), procurement, field inspection, and final checkout of the facility

Work Quality and Material Specifications

Specifications for on-site work quality are an important feature of facility design. Specifications will include references to generally accepted construction standards.

General specifications of work quality are available from organizations such as the ASTM International, the American National Standards Institute, or the Construction Specifications Institute. Specifications are formalized for particular types of construction activities, such as welding standards issued by the American Welding Society, or for a particular facility type, such as the *Standard Specifications for Highway Bridges*, issued by the American Association of State Highway and Transportation Officials. These general specifications will always need modifications to reflect local conditions, policies, available materials, and local regulations. A few specifications will even contain prohibitions for specific circumstances.

Some specifications require judgment in application since some items are not precisely specified. For example, excavation must extend a “sufficient” distance to permit inspection and other activities. Obviously, the term *sufficient* may be subject to varying interpretations. In contrast, a specification that tolerances be within plus or minus a tenth of a foot is subject to direct measurement. Writing specifications requires a trade-off between assuming reasonable behavior on the part of the parties concerned in interpreting words such as “sufficient” and the effort in attempting to prespecify all situations.

In recent years, performance specifications have been developed for some construction operations. Rather than specifying the required construction process, these specifications refer to the required performance or quality of the finished facility. The exact method by which this performance is obtained is left to the construction contractor. For example, traditional specifications for asphalt pavement would specify the composition of the asphalt material, the asphalt temperature during paving, and compacting procedures. In contrast, a performance specification for asphalt details the desired performance of the pavement with respect to impermeability, strength, and so forth. How the desired performance level is attained is left to the paving contractor.

Traditional Statistical Methods for Construction Quality Control

Theoretically, the ideal QC program would test all materials and/or work on a particular project. For example, nondestructive techniques such as X-ray inspection of welds would be used on all welds throughout the facility. On-site inspectors would witness the appropriateness and adequacy of construction methods at all times. But exhaustive or 100% testing of all materials and work by inspectors is exceedingly expensive. In many instances, testing requires the destruction of a material sample, so exhaustive testing is not even possible. As a result of these limitations, small samples are used to establish the basis of accepting or rejecting a particular work item or shipment of materials. Statistical methods are used to interpret the test results from the samples to reach a conclusion concerning the acceptability of the entire batch of materials or work products.

Two types of statistical sampling are commonly used for the purpose of QC in batches of construction work or materials:

1. The acceptance or rejection of a lot based on the number of defective (bad) or nondefective (good) items in the sample. This is *sampling by attributes*, a procedure intended to determine whether or not a particular batch of materials or work products is acceptable. Sampling by attributes is applied by testing a predefined number of sample items from a lot. If the number of defective items is greater than a trigger level, then the lot is rejected. Otherwise, the lot is accepted. Developing this type of sampling plan requires understanding of probability, statistics, and acceptable risk levels on the part of the supplier and consumer of the lot.
2. Instead of using defective and nondefective classifications for an item, a quantitative quality measure or the value of a measured variable is used as a quality indicator. This testing procedure is referred to as *sampling by variables.*

Whatever sampling plan is used in site testing, it is always assumed that the samples are representative of the entire population under consideration. Samples are expected to be chosen randomly, so that each member of the population is equally likely to be chosen. Convenient sampling plans such as sampling every 20th piece, choosing a sample every 2 hours, or picking the top piece on a delivery truck may be adequate if pieces are randomly mixed in a stack or in use. However, some convenient sampling plans may be inappropriate. For example, checking only easily accessible joints in a building structure is inappropriate, since joints that are hard to reach may be more likely to have erection or fabrication problems.

Another assumption implicit in statistical QC is that the quality of materials or work is expected to vary from one piece to another. This is certainly true in the field of construction. While a designer assumes that all concrete is exactly the same in a building, the variations in material properties, manufacturing, handling, pouring, and temperature during setting will result in concrete that is actually heterogeneous in quality.

Reducing such variations to a minimum is the goal of quality construction. Ensuring that the materials achieve some minimum level of quality with respect to either average properties or to the fraction of defectives is the task of QC.

Total Quality Control in Construction

QC in construction typically involves enforcing compliance with minimum standards of material and workmanship in order to ensure the performance of the facility according to the design. Examples of such minimum standards are described in the previous section, "Traditional Statistical Methods for Construction Quality Control." For the purpose of enforcing compliance, random samples and statistical methods are used as the basis for accepting or rejecting work completed and batches of materials. Rejection of a batch is based on nonconformance or violation of the relevant design specifications.

An implicit assumption in these traditional QC practices is the notion of an acceptable quality level, which in turn means that there is an allowable fraction of defective items. Materials obtained from suppliers or work performed by a constructor is inspected and passed as acceptable if the estimated defective percentage is within the acceptable quality level. Problems with materials are corrected after product delivery.

In contrast to the traditional approach of QC is the goal of *total quality control.* In this system, no defective items are allowed anywhere in the construction process. While zero defects can never be permanently obtained, it is a worthy goal. This approach to QC was first developed in manufacturing firms in Japan, but has since spread to many construction companies. The best known certification for quality improvement is the ISO 9001 standard, which emphasizes good documentation, quality goals, and a series of cycles for planning, implementation, and review.

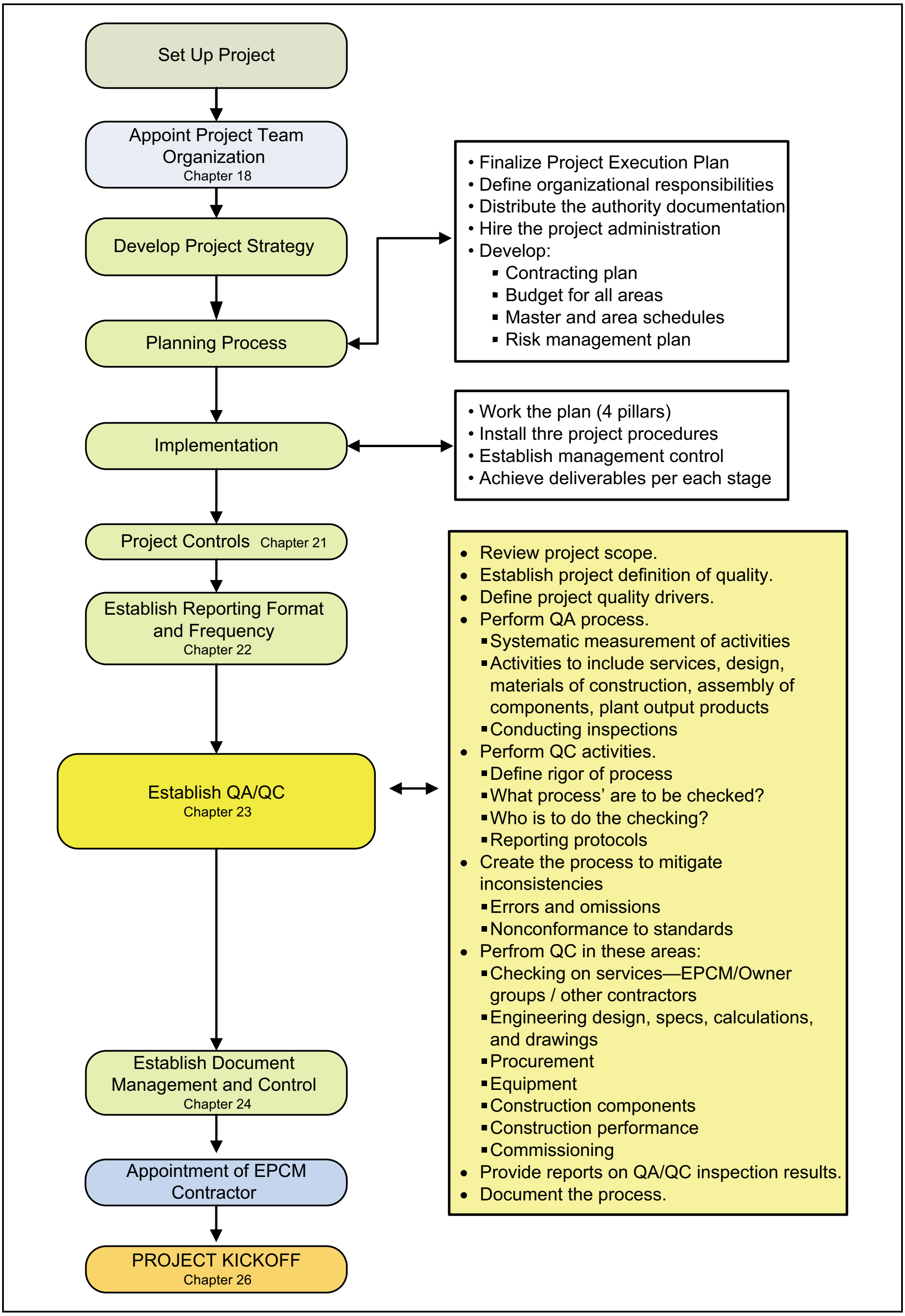
Total QC is a commitment to quality expressed in all parts of an organization and typically involves many elements. Design reviews to ensure safe and effective construction procedures are a major element. Other elements include extensive training of personnel, shifting the responsibility for detecting defects from QC inspectors to workers, and continually maintaining equipment. Worker involvement in improved QC is often formalized in “quality circles,” in which groups of workers meet regularly to make suggestions for quality improvement. Material suppliers are also required to ensure zero defects in delivered goods. Any materials delivered with defective items are returned.

Companies have found that a commitment to total QC can deliver benefits. Expenses associated with inventory, rework, scrap, and warranties are reduced; worker enthusiasm and commitment are improved. Owners appreciate the higher quality work and will pay a premium. As a result, improved QC is a competitive advantage.

The concept of total QC is not easy to apply in construction. The unique nature of each facility, the variability in the workforce, the multitude of subcontractors, and the cost of making necessary investments in education and procedures make programs of total QC a challenge. Nevertheless, a commitment to improved quality and an endorsement of the goal of zero defects can pay dividends in the construction arena.

CHECKLIST 23.1 QUALITY ASSURANCE AND QUALITY CONTROL

No.	Item	Status	Date	Initials
1	Project Execution Plan—finalized			
	A. Definitive scope of work—set			
	B. Owner's requirements and expectations—identified			
	C. Owner's perception of quality—understood			
2	Project management team—in place			
	A. Quality manager—appointed			
	B. Organizational responsibilities—defined			
	C. Levels of authority—in place			
3	Project quality drivers—defined			
4	Quality management plan—produced			
	A. ISO 9001 quality conformance standards—adopted			
5	QA systematic measurement processes—established			
	A. Design error elimination protocols—published			
	1. Right the first time philosophy—adopted			
	B. Engineering quality monitoring services—provided			
	1. Fit-for-purpose philosophy—adopted			
	C. Purchasing QA specifications—prepared			
	D. Supplier quality monitoring services—engaged			
	E. Off-site assembly of materials and equipment—inspected			
	F. On-site assembly of materials and equipment—monitored			
	G. Nonconforming goods inspections—conducted			
	H. Field construction QA measurement services—provided			
6	QC verification processes—established			
	A. QC measurement rigor—in place			
	B. Work scope elements to be checked—determined			
	C. QC checkers—assigned			
7	Engineering QC activities—established			
	A. Design and engineering reviews—conducted			
	B. Vendor equipment reviews—undertaken			
	C. Operability and maintenance reviews—required			
	D. Constructability reviews—performed			
8	Procurement QC activities—established			
	A. Document errors and inconsistency reviews—undertaken			
	B. Nonconforming goods inspections—conducted			
9	Construction and commissioning QC activities—established			
	A. Facility installations in conformance with design			
	B. Performance practices in conformance with standards			
10	QC mitigation processes—established			
	A. Errors and omissions—corrective procedures conducted			
	B. Nonconformance—corrective procedures undertaken			
11	QA/QC reporting processes—established			
	A. QA/QC reports—properly documented			



- Finalize Project Execution Plan
- Define organizational responsibilities
- Distribute the authority documentation
- Hire the project administration
- Develop:
  - Contracting plan
  - Budget for all areas
  - Master and area schedules
  - Risk management plan

- Work the plan (4 pillars)
- Install thre project procedures
- Establish management control
- Achieve deliverables per each stage

- Review project scope.
- Establish project definition of quality.
- Define project quality drivers.
- Perform QA process.
  - Systematic measurement of activities
  - Activities to include services, design, materials of construction, assembly of components, plant output products
  - Conducting inspections
- Perform QC activities.
  - Define rigor of process
  - What process' are to be checked?
  - Who is to do the checking?
  - Reporting protocols
- Create the process to mitigate inconsistencies
  - Errors and omissions
  - Nonconformance to standards
- Perfrom QC in these areas:
  - Checking on services—EPCM/Owner groups / other contractors
  - Engineering design, specs, calculations, and drawings
  - Procurement
  - Equipment
  - Construction components
  - Construction performance
  - Commissioning
- Provide reports on QA/QC inspection results.
- Document the process.

FLOWCHART 23.1 Quality assurance and quality control

CHAPTER 24

Document Management and Document Control

> *When the weight of the project paperwork equals the weight of*
> *the project itself, the project can be considered complete.*
> *— Paraphrased from George Washington's Farewell Address, 1796*

OBJECTIVE

This chapter attempts to clear up the confusion between the encompassing term *document management* and the much more rigid discipline of *document control*. Document management has become a default term for any task that that deals with document handling—regardless of the instance in which the documents are used. This is not strictly correct, and this chapter will explain why. The objective is to lay out the suite of document management policies and document control protocols necessary within a project life to provide effective records management.

Projects extend over many years, and a large number of people are involved for short periods of time. These short tenures can lead to a lack of identification and loyalty with the Owner's goals. This necessitates a need for a comprehensive document-handling system to be developed early and then implemented at all levels of the project organization.

IS DOCUMENT MANAGEMENT THE SAME AS DOCUMENT CONTROL?

While the terms *document management* and *document control* have similarities, and both essentially deal with document handling, the two disciplines are not the same. The two areas comprise different aspects of document handling, with each having specific uses and characteristics and each playing a different role. Given the superficial sameness of terminologies, it is easy to see how the terms can be confused. But it is important to properly understand the difference between the two disciplines. Knowing the differences between a document control system and a document management system will help the project manager better define the project's needs and will ultimately save time and money.

DOCUMENT MANAGEMENT

Document management is the storage and retrieval of documents. A project document management system encompasses the safe electronic storage, indexing, access, search, retrieval, archiving, version control, and deletion of all documents and records. Usually a document management system allows users to scan and convert hard-copy documents into a digital electronic format, primarily with the aim of reducing printing costs and making the management of documents hassle-free. Project progress must never be held up over paperwork.

An appropriate document management system can handle a large volume of everyday short-life-span documents, such as e-mail, letters, and meeting notes—most of which have just a single-version existence. Some projects use a *shared environment* document management system, which allows permitted users to modify as well as access documents (Wacker 2013), but in the authors' opinion, this element is better retained within the document control system.

While document management systems began as a simple way of scanning documents into microfiche so they could be stored, indexed, and easily retrieved, today's systems are typically complex umbrella systems that cover the electronic management of any type of information (Stainow 2009), thus blurring the lines between content management (Web pages) and knowledge management (unstructured data).

Desirable Elements of a Document Management System

- The system can handle hundreds of documents daily, in multiple styles and sizes. Vendors, consultants, engineers, and regulators rarely use similar document types.
- The system is capable of electronically digitizing all the project's paperwork, for example, engineering documents, Authorizations for Expenditure, accounts payable, human resource records, purchase orders (POs), vendor invoices, internal communications, reports, permit records, manuals, contracts, and so forth.
- The system must contain robust Internet access software, including an Internet portal.
- The system is capable of working with a number of servers and a variety of software.
- Revisions saved as unique versions in the same file allow easy tracking and comparison.
- Distribution of documents is through a password-secure hyperlink.
- Keyword or phrase search engines are used. Use of key fields allows indexing to narrow document searches and minimize time spent.
- Full-text search (i.e., saved data images) appear in full text when stored files are viewed.

Benefits of a Document Management System

- Documents are stored centrally and indexed.
- Easy document search-and-retrieval facility is enabled.
- Paper-based documents can be converted into electronic versions for easier access.
- Singular version control is possible for each type of project document.
- The system enhances communication and collaboration among members of the project organization.

DOCUMENT CONTROL

Document control is the controlled management of documents through their entire document life cycle. Document control is far less generic and much more prescriptive than document management. A document control system demands a much higher degree of reliability for security, version control, review cycle, visibility, and availability than does a document management system. It is very important that the document control system provide a controlled audit trail.

A project document control system covers the control of documents that are essential to the project execution, particularly those documents that frequently morph into different versions over the long term within a project life. These include documents that have been put together for a specific use (e.g., engineering drawings) and those that have been released with intention and have even gone through a solid approval process for relevancy and accuracy (e.g., specifications, POs, and contract agreements). When documents of this nature need to be modified, all changes and the reason for such changes must be identified, along with the person making the changes and the modification date. Modified versions have to be kept separate from earlier versions to prevent confusion. Access to these documents has to be regulated so only the latest version is used. Outdated versions are archived to keep an auditable paper trail. This audit trail of events in the life of a document is a crucial document control tool.

These "essential" multiversion project documents have a far longer life span than the single-version documents that are the prime concern of the document management system; they reflect the changes that take place within a project life, with each version representing a change. Previous versions need to be accessible to show the natural progression of the document and to serve as a template to use when updating the current version.

Elements of a Document Control System

- Controlled flow of documents is essential between all the project players, that is, project management, EPCM, Owner, contractors, subcontractors, materials management, vendors, and so on.
- Each document's movement is tracked up to and including the final as-built drawings from field engineering.
- All the original records are filed as part of quality control; only duplicates get distributed.
- All letters, e-mail, and telephone conversation memos are filed for retrieval. This normally means saving a PDF version, including all e-mail threads.
- All project drawings (except for field sketches) should be created electronically.
- Only standard drawing sizes should be chosen and used.
- Standard layering specifications need to be adhered to for all electronic drawings.
- The drawing numbering system must not allow any drawings with the same number.
- Revised and/or obsolete drawings are placed in a file that disallows printing.
- Vendor information, that is, vendor drawings and vendor data requirement (VDR) sheets are tracked via the originating PO number. Document control is responsible for notifying procurement when conflicts arise between PO information and VDRs.
- Vendor operations and maintenance manuals are assembled and compiled as complete sets by document control.
- Document control serves as a support to the project's quality management functions.

Benefits of a Document Control system

- Strict version control ensures that only the latest live version is available for use.
- Documents can be analyzed via application of reporting tools.
- A complete audit trail is created for easy tracking of the document life cycle.
- There is a high level of security and control specific to the requirements of regulatory compliance.
- Centralized, electronic storage is based on organization hierarchy and document type.
- Web-based access and control of documents and processes enable sharing and consistency.

DOCUMENT CONTROL AND/OR DOCUMENT MANAGEMENT?

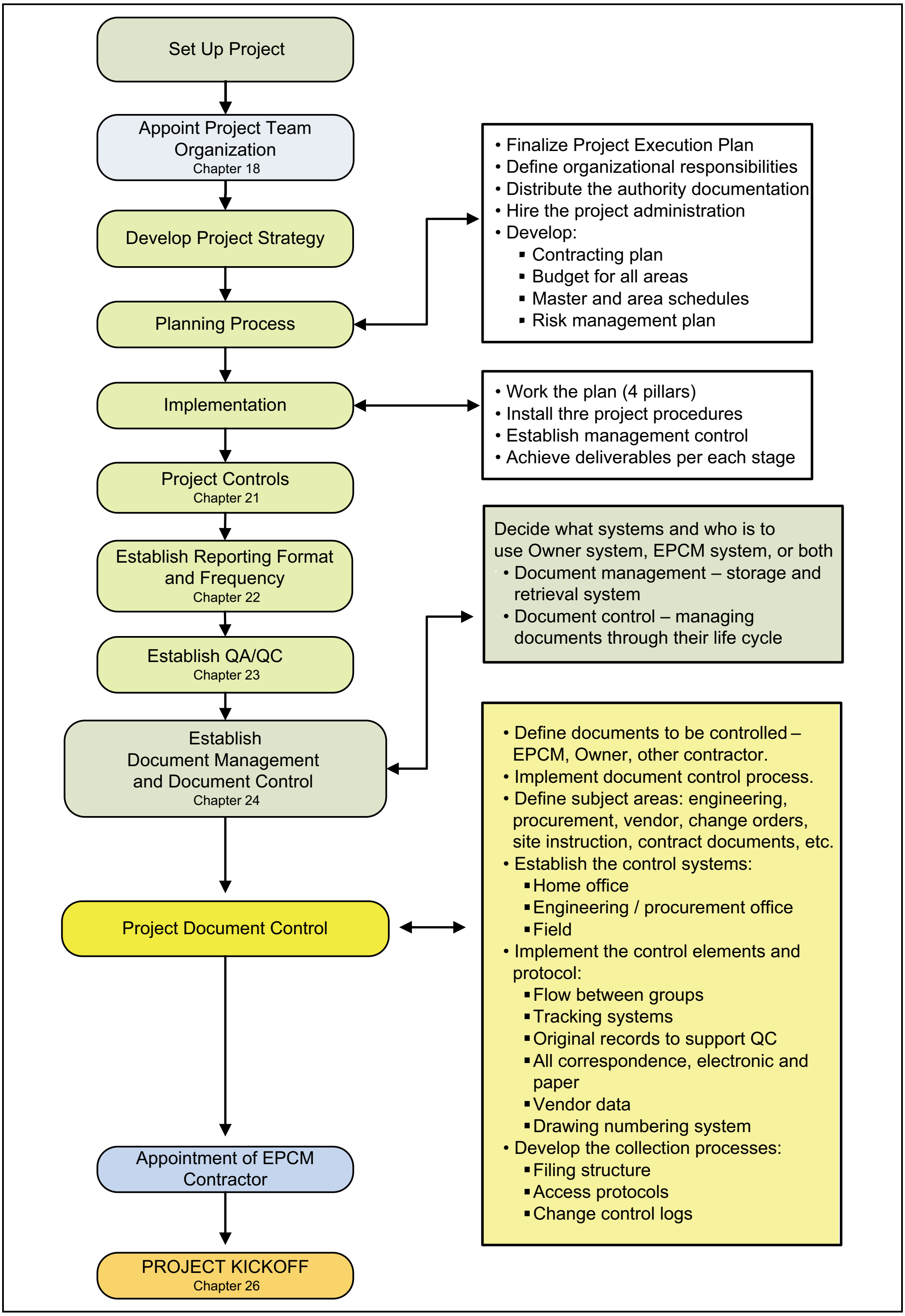
Both document control and document management systems have their own use and their own direct benefits for any project. The question to ask is, "Are both needed and/or useful for this specific project?" A few companies, mostly for cost reasons, elect to use only a document control system, but most large mining corporations deploy both within their projects to properly cater to the multiple needs of the different project entities.

Bottom line: *All* projects need a document control system. *Most* projects additionally need a document management system.

Generally speaking, it is possible that a document control system could take on the role of document management, but only on a project where the number of transient documents is not large. While it is true that document control systems have been used as document management systems on certain projects (primarily heavily regulated ones), document control systems are generally not robust or flexible enough to handle the large volumes of project data that can be handled by a document management system, notwithstanding the sales pitches for document control systems claiming they have most of the benefits of a document management system. And it is equally true that very few off-the-shelf document management systems have the prescriptive aspects in place to act as an effective document control solution. Hence this book recommends employing both systems.

CHECKLIST 24.1 DOCUMENT MANAGEMENT AND DOCUMENT CONTROL

No.	Item	Status	Date	Initials
1	Project Execution Plan—finalized			
2	Project team—appointed			
	A. Capable personnel to manage document handling—hired			
	B. Organizational responsibilities—defined			
	C. Levels of authority—set			
3	Robust Internet access, including an Internet portal—installed			
	A. Web-based access and control—established			
4	Document-handling systems choices—investigated			
	A. Owner's system, EPCM's, or new?—decision made			
5	Document management system—in place			
	A. Documents to be controlled—cataloged			
	1. Owner			
	2. EPCM			
	3. Other			
	B. Filing structure—set			
	C. Subject areas—defined			
	D. Document collection process—established			
	E. Centralized storage and retrieval system—established			
	F. Electronic digitization capability—functioning			
	G. Keyword or phrase search engine—provided			
	H. Password access protection—adopted			
6	Document control system—in place for complete document life cycle			
	A. Control protocols—established			
	B. Project drawing sizes—standardized			
	C. Unique document number system(s)—adopted			
	D. Project's essential key documents—identified			
	E. Document tracking (though final field as-built)—in place			
	F. Flow between project entities—controlled			
	G. Original records storage—in place			
	H. Strict version control—in use			
	1. Change control logs—established			
	2. Obsolete documents—usage disallowed			
	I. Regulatory compliance requirements—functioning			
	J. Audit trail—established			
7	All correspondence (electronic and paper)—filed for retrieval			
8	Vendor data—compiled and recorded			



- Finalize Project Execution Plan
- Define organizational responsibilities
- Distribute the authority documentation
- Hire the project administration
- Develop:
  - Contracting plan
  - Budget for all areas
  - Master and area schedules
  - Risk management plan

- Work the plan (4 pillars)
- Install thre project procedures
- Establish management control
- Achieve deliverables per each stage

Decide what systems and who is to use Owner system, EPCM system, or both

- Document management – storage and retrieval system
- Document control – managing documents through their life cycle

- Define documents to be controlled – EPCM, Owner, other contractor.
- Implement document control process.
- Define subject areas: engineering, procurement, vendor, change orders, site instruction, contract documents, etc.
- Establish the control systems:
  - Home office
  - Engineering / procurement office
  - Field
- Implement the control elements and protocol:
  - Flow between groups
  - Tracking systems
  - Original records to support QC
  - All correspondence, electronic and paper
  - Vendor data
  - Drawing numbering system
- Develop the collection processes:
  - Filing structure
  - Access protocols
  - Change control logs

FLOWCHART 24.1 Document management and document control

CHAPTER 25

Project Pitfalls

> *The greatest glory in living lies not in never falling, but in rising every time we fall. — Nelson Mandela, 1995*

OBJECTIVE

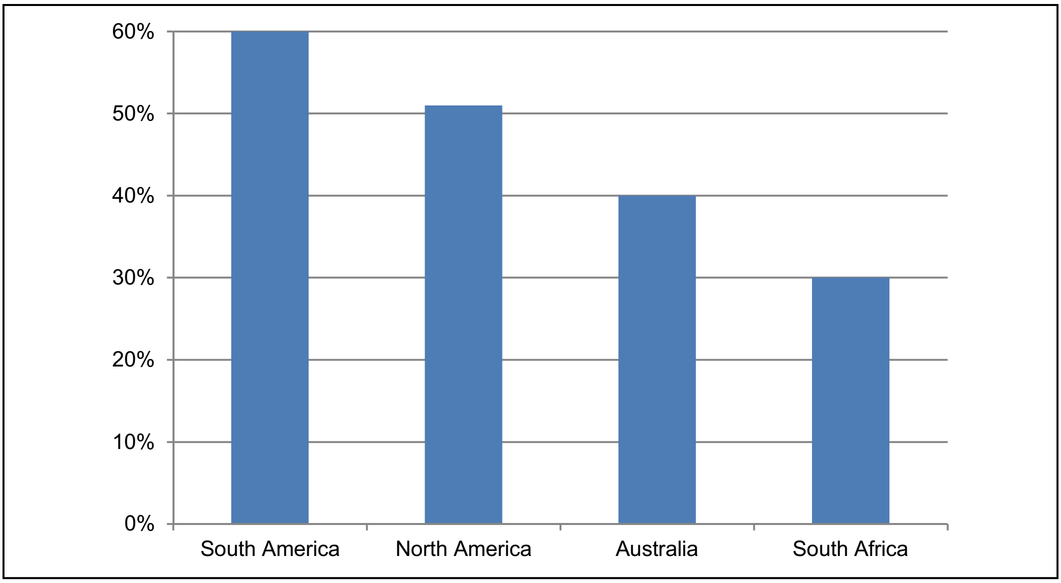
The objective of this chapter is to highlight the maladies that all too frequently befall mining projects and then to offer some basic remedies. Achievement of this objective requires an understanding and an awareness of the relationships that exist among the various elements that are in play during the execution of a mining project. Recovery methodologies are discussed for those instances where project objectives (budget, schedule, quality) are being compromised or lost.

HISTORICAL PROJECT PERFORMANCE

The industry does not have a stellar record in delivering projects that meet the physical and financial parameters forecast in the approved feasibility study. Delays and cost blowouts in projects have been prevalent for decades. In their 2003 seminal analysis of 258 completed infrastructure mega-projects (including mining), undertaken in 20 countries on five continents in the 70 years from 1927 to 1998, Flyvbjerg and colleagues from the Department of Development and Planning at Aalborg University in Denmark show that significant cost overruns occur in almost nine out of ten projects (Flyvbjerg, Skamris Holm, and Buhl 2003). Actual costs were an average of 28% higher than forecast, with projects outside of Europe and North America coming in at a hefty 65% over budget. This study shows that there is an 86% likelihood of a mega-project having costs higher than forecast. This likelihood stayed constant during the 70-year period studied.

Mega-project schedule performance has been no better than cost performance. A more recent study by Seung Han and colleagues from the Department of Civil and Environmental Engineering at Yonsei University in Korea shows that for 36 mega to medium sized projects undertaken since 1990 with more than 5 years' budgeted duration, the average duration extension was 2.6 years, precipitating an average cost overrun of 50% (Han et al. 2009). Other mega-project information available to the authors for recent projects shows similar dismal results, with 77% missing their specific deadline date and 60% suffering sizable schedule overruns.

Probably even worse, from a mining company's viewpoint, 75% of the built projects fail to meet their quality or functionality specifications after they become operational. It is fashionable today to claim that similar poor performance in the mining world is a temporary aberration, an outgrowth of an unusual, escalating cost environment caused by the large number of



Source: Adapted from Harcus 2013.

FIGURE 25.1 Average mining project cost overrun for 2012

projects in the construction pipeline and a scarcity of competent resources to staff the projects. However, this claim ignores reality: Examination of mining project performance over the past 100 years shows similar dismal results, decade to decade.

A 1970s analysis published by the U.S. Bureau of Mines detailing mining project performance for the first 60 years of the 20th century revealed that 60% of all U.S. mines failed to yield any return to the original developer, and that only 1 in 10 mines delivered forecast returns. A review by the authors of additional studies by minerals industry writers from 1980 through 2013 shows that the weighted average capital overrun of more than 220 mining projects from around the globe in the 40 years from 1965 through 2004 was 26%, with less than 10% achieving the commercial prediction of their feasibility study (Bullock 2011a; Bullock 2013; Gypton 2002; Hickson 2000b, 2000c; Humphreys 1999; McCarthy 2013; Yearley 1998).

A June 2013 Deloitte and Metals Economics Group follow-up review of ongoing major mining projects revealed that capital overruns have worsened, not improved, since 2004 (Harcus 2013). Figure 25.1 shows the percentage of overruns for these projects, broken out into the four main mining regions of the world: North and South America, Australia, and South Africa.

The problem is real; it is absolutely *not* hypothetical. One of the goals of this book is to provide a better understanding of the causes for this underachievement in project outcome, in order to then lead to a turnaround in project management performance.

ROOT CAUSES OF PROJECT FAILURE

Examination of more than 10,000 projects from the last half century by a bevy of modern-day management consultants reveals a striking consistency in the reasons that projects fail (Grenny 2006). These consultants found that projects rarely fail due to any lack of technical competence or management sophistication. The concerns that cropped up and were addressed were not the problem. It was the issues that were not addressed, problems that were overlooked (deliberately, by incompetence or unintended oversight), situations that project participants for whatever reason chose to remain silent about that repeatedly precipitated project failure. The following, in order of frequency of occurrence, were found to be the major root causes of the failures:

- **Denial:** 82% of the projects that failed had leadership who would not admit there were problems within the project.
- **Failure to "get real":** 80% of the projects were set up to fall short because deadlines and resource limits were set with no consideration of reality.
- **Absent sponsors:** 77% of the projects had sponsors who did not provide the leadership, political clout, time, or energy to address project problems.
- **Unwillingness to "rock the boat":** 70% of the failed projects were unsuccessful because no one said anything when they saw something going wrong.
- **Team breakdown:** 62% of the failed projects involved team members who were unwilling or incapable of supporting project goals.
- **Power play:** 61% of the failed projects were subject to individuals using their influence to subvert or manipulate project priorities for their own advancement.
- **Morale damage:** 54% of the unsuccessful projects had teams in which morale was reportedly damaged by a culture that discouraged speaking about negative issues.

HOW TO PREVENT PROJECT FAILURES

Paying attention to proper project management processes, installing good tools and techniques, implementing meaningful project progress scorecards, and creating effective project governance will help reduce the likelihood of project failure, but the real solution is just to use plain common sense.

Stop building unfeasible projects. Overcome the desire of leaders to get "their" project built on "their" shift even when, objectively, it is doomed to failure. It generally requires an external peer review to fully achieve an objective view of any proposed project. Insiders become caught up in the excitement of creating something new and forget it should only be done if it makes business sense. While it was okay for Walt Disney to say, "It's kind of fun to do the impossible," this mind-set will get a mining company into trouble.

The reality is that not all opportunities will turn out to be feasible projects. As John Marsden, 2014 SME president, pointed out in his inaugural interview: projects today are challenged with increasingly stringent regulations, social and political pressures, declining availability of skilled tradespeople and technical expertise, and a threefold increase in capital costs over the past 10 years (Marsden 2014). These combined headwinds will inevitably cause certain marginal projects to fail to meet their investment hurdles.

Sir Robert Wilson, former executive chairman of Rio Tinto, had it right when he stated to one of the authors in 2002 that it was "investment folly" to ignore net present value (NPV) analysis and blindly pursue lower cash costs without addressing capital usage. As he said, "If you're not rejecting more than you build, you're kidding yourself."

Get the right leadership people in place at the head of the project team with the acumen to recognize problems and the capabilities to get them fixed. Then foster a culture that allows personnel to speak up and act, so that the issues are addressed in a timely way.

Do not go for industry-leading output in a single step. George Mealey and Milt Ward drove Freeport Indonesia's $5 billion expansion from 9,000 tons per day to 230,000 tons per day in a dozen increments over a 22-year period from 1983 through 2005. Each project successfully reached its output goal—on budget and on time. This phenomenal record was achieved despite the remote island mountain terrain with 400 inches per year of rainfall. Each project was a manageable chunk that built on the success of the preceding step. Freeport-McMoRan's corporate management listened and adsorbed the feedback from the project teams; the project teams listened and bought into the expansion goals of corporate management. Thus, the issues being faced with each new project could be properly planned and realistically budgeted.

An enabling, supportive culture of communication must be in place between mining company leadership and the project team. If people are afraid or discouraged from bringing up issues, then a crucial component of what drives project success is missing. The onus is on project management to skillfully create a project culture where it is safe to broach negative issues.

PITFALLS WITHIN PROJECT MANAGEMENT

Eight prime project management pitfalls have been identified that can derail a project and thus mar the success of project outcome (Guzman 1998; Hickson and Owen 1997; Hickson 2000a, 2000b, 2000c, 2001a, 2001b, 2002):

1. Failure to sufficiently plan up-front
    - Lack of attention to the fundamentals of project management
    - Insufficient development and implementation of an approved plan
2. Poorly defined scope, budget, and/or schedule
    - Inaccurate gathering of project requirements
3. Inadequate project controls
    - Lack of control and/or improper management of change
    - Lack of understanding and acknowledgment of the effects of change
4. Unclear and/or inaccurate portrayal of assumptions to the project decider
5. Deficient communication and/or lack of trust among participants
6. Loss of project focus
    - Loss of emphasis on overall project objectives
    - Lack of focus on value
7. Ill-qualified project leadership personnel
8. Inattention to safety and quality

Failure to Plan

The prime cause of problems in project execution is the failure to properly plan the project up-front and a subsequent lack of focus on the project goals. Both of these causes are symptomatic of insufficient attention to the fundamentals of project management. Projects can be large or small in scope and cost, but whatever their size, they are almost always complex in execution. Thus, it is absolutely essential that a detailed plan for conducting the scope of work be developed at an early stage. Once this has been created, careful and diligent management to the plan is required. Given that change is inevitable, a process to control and manage change must be implemented at the earliest possible time in the project life.

Lack of planning can be categorized by one of the following phrases:

- Lack of…
- Poorly developed…
- Inattention to…
- Delay in…

Poorly Defined Scope

The project manager must firmly understand what the project aims to achieve. While project requirements are often difficult to uncover and gather due to diverse stakeholder agendas, the goals must be clear to the project team, as it is these goals that allow project scope to be set (Fister 2013). Project scope cannot be allowed to subsist in a nebulous state of flux. Project budgets and schedules get overrun when the scope of the project is not adequately set in the beginning and/or is permitted to change without sufficient control.

Inadequate Project Controls

Control and management of change require that all direct and indirect effects of change be carefully considered prior to the change being made. Even a seemingly minor change can often have a chain influence that negatively affects other downstream project tasks. Change control can only be successfully applied if a clearly defined and well-understood scope is established early, and a project control system is in place and functioning to assess the impact of that change.

Unclear and/or Inaccurate Portrayal of Assumptions

A deficiency within some project studies is that too little attention is given to clearly and forcefully describe for the project decider the assumptions made in reaching the study's key outputs, that is, the suppositions behind the capital cost estimate, installation and start-up schedule, operating cost analysis, return on investment, and so forth. Too often the assumptions are buried or glossed over such that the ultimate project decider does not ever realize the true risks involved or that he or she is looking at a sales brochure rather than an impartial study.

The project manager must have the skills to uncover, analyze, and integrate the various assumptions in the overall study analysis. Further, the project manager must have the fortitude and ethics to clearly and accurately describe the assumptions in sufficient detail so that the decider has a clear understanding of the undertaking and its inherent risks.

Deficient Communication

Any lack of communication among study team, engineer, construction team, and eventual operations team will lead to difficulties in executing the project cycle. Project participants must communicate effectively for change control to function. The building and maintaining of relationships among the various parties is a time-consuming exercise requiring a great deal of emphasis from project management. Primary responsibility for this rests firmly with the project manager, who must actively and consistently foster an environment where open communication can occur. This can only be achieved by maintaining a broad view of project development, understanding the role and responsibility of all participants, and strongly encouraging active participation.

Loss of Project Focus

A project needs a destination statement, a clear understanding of what the ultimate goal is; and the statement needs to be prominently displayed so that no one on the team forgets. By ensuring that contractually and philosophically all participants are focused on the overall project objectives, the fundamental basis of success can be established.

Project management must continually reinforce the objectives, maintain a bottom-line mentality for getting there, and anticipate problems that may affect project participants. A partnering application of team alignment is a good avenue to obtain this goal.

Ill-Qualified Project Leadership

Like most human endeavors, the influence and importance of appropriate personnel are paramount. No project can be effective and successful without the right individuals striving together toward the project goals. Selection of the right person to be project leader is the single, most important decision for project success.

Similarly, the key personnel working with the project leader need to be carefully selected. And while professional competence is important, it can be overshadowed and disrupt a project development effort if the personalities of these individuals are not conducive to working together. Disruptive, disgruntled, and incompetent personnel need to be replaced.

Inattention to Quality and Safety

When management focuses solely on beating the schedule and budget, the inevitable result is a deliverable that does not meet the rest of the project goals, and accidents will happen, leading to undesirable consequences for people and machines. Project leadership must pay constant attention to all the elements that define success to ultimately deliver a successful project.

LACK OF QUALITY STANDARDS FOR PROJECT STUDIES

An issue that has confounded mining project evaluators for decades is the complete absence of any industry or regulatory quality standards as to what comprises a valid mining project study, be it scoping evaluation, prefeasibility, or feasibility (Crawford, Pollack, and England 2007).

There is no published, accepted minimum standard for the level of effort or for a minimum percentage of engineering or for any requisite accuracy that should go into any one of these studies. This utterly mystifies the authors of this book. The situation needs to change, now.

The Canadian Securities Administrators came up with National Instrument 43-101 in the late 1990s as a standard for defining geological resources and mining reserves. NI 43-101, along with the comparable Joint Ore Reserves Committee (JORC) Code in Australia and the South African Mineral Resource Committee (SAMREC) Code in South Africa, have greatly contributed to the elimination of shoddy work and the minimization of fraud and error in the reporting of resources and reserves (JORC 2012; SAMREC 2007). But there has been no similar effort for project characterization. One can legitimately ask, "why not?"

As Graham Lumley (2012) of GBI in Australia observed regarding the advent of NI 43-101, and the JORC and SAMREC codes, "We have effectively moved the point of deception from geology to [project/engineering] planning."

The only weapon that the project manager and Owner have to overcome this issue is to enforce their own standards. They can and should require a minimum level of engineering along with a mandated accuracy of estimate at a defined level of confidence for each of their projects, similar to those advocated in this book.

DESIGN ERRORS: WHY THEY OCCUR

Errors creep into a project design for a number of reasons: some project related, others management related, and some from budget constraints.

Project-Related Factors

Project factors that should signal the potential for design issues include

- Complexity of the project,
- Multiplicity of disciplines required, and
- Information inadequacy.

Errors are avoidable. To ensure deliverable quality, management must insert proper quality assurance protocols up-front to prevent project-related factors from creating errors.

Project Management Factors

Poor personnel management practices can lead to design errors. Poor management practices need to be corrected whenever discovered, for example,

- Inefficient scheduling of work activities;
- Work flow not well coordinated, interfaces with gaps, and responsibilities not defined;
- Insufficient or inappropriate staff for the work to be performed;
- Poor communication, and information flow not being properly managed;
- Project controls insufficiently established or used;
- Inadequate or nonexistent review and/or checking procedures; and
- Time constraints (poor scheduling).

Pressure for Profit

Errors can sometimes stem from the pressure for making a profit. Engineering, procurement, and construction management (EPCM) fee budgets can be set too low if the economic pressure of competition pushes the EPCM to propose an artificially low budget to satisfy a price-driven Owner. This could stem from the Owner not understanding the magnitude of the scope or simply not trusting the EPCM's estimate.

Even the best planned budgets can become stressed near project end, when internal and external pressures vie for the remaining fee dollars. Wherever the budget pressure comes from, the project manager cannot afford to skip the cost of assuring quality. The avoidance of such cost is never worth the potential legal, financial, or professional consequences.

PROCESS PLANT FAILURES: WHY THEY OCCUR

A study revealed that 27% of the causes behind mining project failure stem from bad or erroneous process plant input data (McCarthy 2013). The following list describes the key issues:

- Incorrect interpretation of metallurgical results (lack of understanding or deliberate)
- Unrepresentative metallurgical testwork. This covers a host of sins:
  - Metallurgical domains within the deposit mischaracterized or misunderstood

  - Testing performed on unrepresentative samples
  - Failure to identify process contaminants
  - Process water chemistry differing from the laboratory water used in tests
- Improper scale-up
- Incorrect plant equipment design
- Inability of plant design to handle ore types delivered by the actual mining schedule

The key to eliminating these process failures is to gain a fundamental understanding of the deposit domains and the chemistry of the system *before going forward with plant design* (Hickson 2000b). This requires a focused technical characterization up-front, prior to completing the feasibility study. By conducting a suitable suite of tests on appropriate deposit samples, meaningful results can be derived that will permit proper assessment of risk before making the project commitment.

OVERRUN CAUSES

There will be occasions when a project will find its budget and/or its schedule being threatened with an overrun and thus in need of a recovery plan. The overrun threat can have several causes, but the more common ones can be categorized by five reasons: faulty estimate, change of scope, poor execution, owner-introduced issues, and changes in project environment, described in the following sections.

1. Faulty Estimate

- Inadequate project scope definition at the time of estimation—number-one cause of a faulty estimate (Scope can only be defined with complete plans and specifications.)
- Insufficient engineering in the feasibility study and/or prior to construction start
- Omission of required major facilities (particularly with infrastructure items)
- Deliberate “lowballing” (low estimating) of a project’s cost or schedule by the engineer and/or the construction contractor to gain approval to perform the work (The engineer or contractor then relies on change orders to recoup their monetary or time shortfalls.)
- Lowballing of a project’s cost or schedule within the feasibility study by the project advocate to gain approval to proceed (also known as bias underestimating)

Lowballing by Owner personnel is more prevalent than the reader might imagine. The authors have come across project advocates at the corporate president level, division vice president level, country manager level, and future general manager level who deliberately omitted items from a board submittal to gain project approval. These items were absolutely necessary to have a viable operation, and the advocate fully intended to have the engineers design them in once approval was attained.

Each time the authors’ challenged a project advocate as to why needed items were excluded, the universal answer was essentially some version of the following response: “The board would never approve the project if they knew the true cost and return, but this organization really needs the project to go forward, so I did what was necessary to make it happen. If I’d included everything, the bottom line wouldn’t have come out okay.”

Other problems that contribute to faulty estimates include the following:

- Faulty technical assumptions
  - Inadequate assessment of true geotechnical and/or ground conditions on-site
  - Misstated ore reserves (generally due to insufficient and/or unreliable data)
  - Overestimation of mining recovery and underestimation of mining dilution
  - Incorrect metallurgical recovery (usually a result of unrepresentative samples)
  - Incorrect climate ranges used (temperature, rainfall, and wind load on buildings)
  - Improper earthquake zone category selected for design
  - Insufficient infrastructure to achieve design operations output
  - Schedule optimism, rather than reality
  - Lower construction productivity than predicted
  - Overoptimistic mine design productivity
  - Plant availability and reliability misstated, insufficient downtime allowance
- Overemphasis on low cost, overlooking intangibles
- Too much assuming, too little planning
- Faulty economic inputs, particularly prevalent in times of high inflation
  - Understated capital and/or operating cost
  - Underestimated wage rates (construction workers and operators)
  - Underestimated construction labor turnover (adds training cost and schedule delay)
  - Missing construction support items (roads, fuel tanks, camp, spare parts, etc.)
  - Owner cost and/or working capital omitted, assessed improperly, or set too low
  - Permit, royalty, license, insurance, and financing costs wrongly omitted
  - Usage of higher commodity price(s) than the trend price
  - Overestimation of the marketability of the mineral products
- Inadequate contingency in the approved project budget due to the Owner (and/or project manager) not understanding the feasibility study accuracy level and/or a lack of awareness of the true project risks; including inadequate recognition of country risk
- Technical fascination; desire for leading edge ideas overruling proven concepts
- Underestimation of project complexity
  - Poor mix or alignment of technologies.
  - Trying to do too much—not keeping it simple wherever one can
- Too little effort to get it right and learn from the errors of the past
  - Insufficient meaningful benchmarking of industry best practices
  - No update of items during the three study phases pre-approval submission
  - Omission of major capital items (e.g., power line upgrade, land acquisition)
  - Constructability not built into design
  - Overoptimistic development and start-up schedule
  - Insufficient allowance for operator training prior to commissioning
- Lack of awareness of the real project environment (e.g., lack of knowledge of the logistics, infrastructure, labor rates, and quality of supervision in a new or remote area)

2. Change of Scope

- Direct result of initial poor project definition
- Improper and/or inadequate control of change

  - Late changes by Owner in engineering causing schedule drift and creating general havoc
  - Lack of future operator involvement during project definition
- Insertion of commercially untried, technological innovation during detail engineering (e.g., novel design, materials, or scale not previously attempted), which ultimately prove unfeasible

3. Poor Execution

- Failure to have a construction-driven project once field mobilization initiates
- Lack of adequate project controls either at project outset or during project execution (Lack of scope control during project engineering and/or construction is the prevalent culprit for overrun, but inadequate cost control and insufficient schedule control during execution can cause equivalent damage.)
- Insufficient up-front planning and/or untimely implementation of the approved plan
- Late, misaligned, or untested systems and procedures
- Failure to commit to the Project Execution Plan (PEP), and wrongly trying to maintain flexibility
- Attempting to manage a project with either an understaffed or underqualified team
- Hiring an organization to execute the project rather than individual people
- Lack of sufficient qualified project controls staff within the project team
- Loss of focus on the original approved project objectives (e.g., not following the approved PEP or approving project purchases of unbudgeted items)
- Turnover of key project personnel
- Lack of experience on the part of the Owner and/or EPCM in developing a project in this locale; engagement of a contractor incapable of performing
- Poor contracting strategy selection (e.g., lump sum with a still-developing scope)
- Project leadership arrogance—unwilling to seek advice for unfamiliar issues
- Delivery organization complexity
- Lack of commitment or follow-through by project team leadership
- Failure to stretch; too much groupthink and "not invented here" mentality
- Detail engineering initiated prior to receiving vendor-certified drawings
- Equipment delay from insufficient expediting of manufacturer and customs agencies
- Insufficient logistics support to allow field contractors to construct as per project plan
- Introduction of fast-track process—with all its negatives
- Poor contractor labor productivity during engineering and/or construction
- Inept, unqualified, and/or insufficient construction field supervision
- Not paying sufficient attention to quality assurance and quality control (QA/QC) or safety during project execution
- Incompatible project participants—not working as an aligned team, no real partnering
  - Lack of cultural alignment between Owner and contractors
  - Lack of a common understanding
- No meaningful communication between entities, but belief that there is
- Conflict-generating terms within the contract documents (e.g., inconsistent or unfair terms and conditions, price squeeze for one of the parties)
- Risk/reward not balanced among project players

- Stakeholders overlooked
- Lack of cultural awareness (in either domestic or foreign projects); mismanagement of community and/or native tribe issues

4. Owner-Introduced Issues

- Lack of interest or commitment to the project from Owner corporate leadership
- Lack of support from Owner corporate leadership; nonalignment with project team
- Unrealistic expectations of a company leadership unfamiliar with project complexity
- Increased risk aversion—adding layers of review, schedule delay, and capital expenditure
- Owner team too large—interfering unnecessarily
- Owner team too small—underrepresented in design, operability, and maintenance
- Meddling or intimidation by Owner corporate departments in power plays
- Uninformed people without relevant project experience forcing poor processes
- Inability to live with the decisional pace of an ongoing project
- Unfamiliarity with the constant change of projects versus operations
- Unrealistic demands for continuous real-time project status communication and updates
- Saving a modicum of money at the expense of a successful project and good operation
- Underestimation of time the Owner takes to review engineering and procurement submittals
- Underestimation of time to obtain permits and raise financing
- Owner partner disagreements, ego conflicts, or misalignment of Ownership interests
- Stopping and starting project for non-project-related reasons (e.g., cash flow)
- Changing direction for unrelated reasons, such as a better return from another project
- Lack of Owner preparation and/or insufficient training of operations staff for start-up (see Chapter 31)

5. Changes in Project Environment

- Unanticipated external forces impacting the project's performance
    - Worse-than-anticipated weather conditions
    - Acts of God (earthquakes, drought, snow, floods, wind events, etc.)
- Worse-than-anticipated ground conditions (regarding geological reserve, geotechnical strength, or soil composition, etc.)
- Inadequate risk assessment and/or a deficient risk mitigation plan
- Unidentified environmental issues discovered by construction
- Newly mandated government regulations (e.g., new environmental protection requirements or new labor, economic policy, or recently enacted political restrictions)
- Construction cost inflation between feasibility publication and construction execution
- Labor shortages due to competing mega-projects in the vicinity
- Inability to hire engineers or a construction staff with the skill competencies forecast
- Labor interference to the project's timely execution (disputes, slow-downs, strikes)
- Less competition from merged equipment suppliers—higher pricing than estimated
- Unanticipated social demands from local communities and stakeholders
- Activities of groups (e.g., nongovernmental organizations) obstructing project activities
- Acquisition to demands from construction workers for better camp conditions

- Civil unrest in the project host country
- Change in government (at any level: federal, state, or local)
- Supplier bankruptcies and manufacturing company closures
- Change in exchange rates between mining company's home country and project site
- Tax changes in the project host country and/or in the Owner's host country

RECOVERY PLAN

With the exception of a faulty estimate, most of the other potential compromises to project cost and schedule once the project is underway can be managed and generally overcome. The project may not emerge totally unscathed, particularly if external forces have changed the project environment, but if recovery plans of sufficient size are put in place early enough, the project damage will be greatly reduced, sometimes even completely eliminated.

Key Elements

Keys to a successful recovery plan are the following:

- Early recognition of the problem, that is, awareness that the project is stressed—This requires competent, adequate project staff in place from the outset.
- Timely, honest, comprehensive, unbiased, project progress reports—If project management buries the project stress signs and reports only the good news, then no recovery plan will ever get initiated.
- Quick identification of the underlying issues to the problem—This requires attention to detail by the project team and sufficient qualified controls staff and systems within the project.
- Mature, rational management response within the Owner's upper echelon—If the Owner reacts negatively toward project staff whenever being apprised of items of concern, then the typical project reaction is to stop reporting the bad news. Again, if stresses are not reported, recovery plans never get initiated.
- A competent project leader with sufficient pertinent background expertise *and* an aligned project management team in place to quickly fashion a viable recovery plan—When cost or schedule stresses emerge, the project leader's best defense is to highlight the stress in a nonthreatening fashion to key project participants and then allow those people to work together to find the best and quickest solution.
- Adequate available resources (people, technology, and contingency money)—The recovery plan solution may involve any number of options, for example,
    - Inserting savvy operations personnel into the engineering office,
    - Hiring a subcontractor to catch up the behind-schedule engineering,
    - Placing EPCM procurement staff onto a supplier's factory floor (the squeaky wheel gets the grease),
    - Adding expeditors to shipping ports,
    - Erecting additional off-site fabrication facilities,
    - Placing more cranes on the construction site,
    - Adding trainer craftspeople into an underperforming constructor crew, and
    - Providing funds to the permit agency to accelerate permit reviews.
- Swift removal of the impeding negative element—Replace nonperformers who do not respond to notice of performance shortfalls.

Implementation

A recovery plan will generally require the insertion of resources (money, technology, and people) to repel the project threat. Funds inserted, when employed in a timely and focused manner, will generally save the project more money than would be incurred if the recovery plan was not initiated. A recovery plan provides a chance of turning a negative situation into an acceptable scenario. Ignoring the threat merely guarantees a negative result.

Most times, a recovery plan will require both adding resources *and* drawing down contingency. It is an unfortunate reality, however, that if contingency was not properly calculated initially, or if the project team cannot locate sufficient backup resources in a timely way, then the schedule or cost threat may not be fully alleviated.

Recovery plans sometimes fail to quickly produce the desired result, and the recovery plan cost may be more than initially expected. This is generally because the recovery plan started too late and an element of panic has set in. The plans in these instances tend to focus on the schedule, and the cost element becomes incidental. The tendency is to throw resources at the problem area without adequate planning and supervision. This is wrong. A recovery plan should be seen as a project within a project and the controls, and attention should be at least the same, if not more focused, to achieve the desired result.

The recovery plan obviously requires strong senior management support, but that support must not override the project manager. Because project threats and stresses come in a myriad of forms, there is no one answer or response that can be characterized or advocated as *the* perfect project recovery plan. The major components of a successful recovery plan are, however, as previously described.

CHECKLIST 25.1 PROJECT PITFALLS

No.	Item	Status	Date	Initials
1	Project management—competent team appointed (see Chapter 18)			
2	Project controls—staff and systems timely installed (see Chapter 21)			
3	Project scope—definitively defined up-front (see Chapter 16)			
4	Project scope control—in place (see Chapter 21)			
5	Project goals and objectives—clearly set (see Chapter 17)			
6	Project plan—prepared in detail prior to execution (see Chapter 16)			
7	Project procedures—established (see Chapter 17)			
8	Schedule realism—developed (see Chapter 10)			
9	Budget estimate accuracy—determined (see Chapter 11)			
10	Contingency appropriateness—calculated (see Chapter 12)			
11	Environmental protection—achieved (see Chapter 8)			
12	Social acceptance—gained (see Chapter 8)			
13	Risks—Properly understood (see Chapter 9)			
14	Communication—inclusive plan adopted (see Chapter 17)			
15	QA/QC processes functioning effectively (see Chapter 23)			
16	Information adequacy—timely reporting provided (see Chapter 22)			
17	Control team functions—defined (see Chapter 21)			
	A. Trending of all activities—undertaken			
	B. Forecasting of all project costs—produced			
18	Project audit process—set (see Chapter 21)			
19	Recovery plan requirements—implemented, as necessary			

Execution Stage

CHAPTER 26

Kickoff Coordination

> *While our business is generally based on sound scientific principle, there is still considerable "art" to the work we do. The art is the exciting part.*
> *— Scott L. McIntosh, CEO, McIntosh Engineering, June 8, 2000*

OBJECTIVE

The kickoff is a critical point in the project: when all the team members have been appointed; the contractor(s) have been selected; and all the activities relating to project engineering, procurement, and construction are about to begin. A formal kickoff session ensures a shared commitment by the project's key players to make use of the best possible resources to produce a value-engineered, efficiently constructed project that meets or exceeds the stated project goals.

This chapter covers the key issues needed to initiate the project execution stages, including development of an alignment (or partnering) concept, setting of the roles and responsibilities of key players, establishment of the project reporting hierarchy, and implementation of the full suite of project execution procedures.

ASSEMBLE THE TEAM

The project team is brought together for the project engineering and construction effort. This team is composed of the key project management personnel listed in Chapter 18 and the discipline skills listed in Chapter 17, along with the specialty skills requisite for the project control team described in Chapter 21. This bringing together takes place in a kickoff session arranged by the project leader specifically to confirm and solidify an alignment of objectives and an agreement on project scope. The kickoff session typically lasts 1–2 days and generally takes place in or near the engineering, procurement, and construction management (EPCM) or engineering company's location.

KICKOFF MEETING

The kickoff meeting establishes team focus, roles, and relationships. It is the initial assembly of project team members and key stakeholders to ensure that everyone has one central focus for completing the project on time and within budget. It centers attention on the best use of the available technical and human resources, clearly identifying all roles and responsibilities, such that everyone becomes aligned on delivering a project that will fully meet the stated goals.

Specific items on the agenda for the kickoff meeting include the following:

1. **Recap** of the present situation
   - What has already been established, where the project is currently
2. **Establishment** of a common approach for going forward
   - Agreement and context for project success
   - A forward focus mind-set
   - Commitment for action
3. **Substantiation** of the project tools to be provided and used
4. **Confirmation** of project scope and the commitment of all stakeholders
5. **Alignment** of the team, during which team spirit is developed and individual styles are clarified for one another such that individuals are able to ascertain how they can best work with each other
6. **Setting** of the project performance measurements

Any lingering project issues or questions should be resolved at the kickoff meeting. If there are any "soft performance" measures that the Owner wants to attain in addition to the stated goals, this is the time to get them out into the open.

At this point, the project has been awarded to the major contractors, the EPCM is in place, and the contract language has been negotiated. Now it is time to get going and start delivering results.

PROJECT VISION

The project vision provides a minimum expected standard of performance for the project team and its relevant stakeholders to strive for as they collectively progress the project. A group creation of the project vision is typically the starting exercise in the initial project partnering, alignment, and team-building session held as a key component of the formal kickoff process. It is the first step in getting agreement on outcomes.

Figure 26.1 presents a pithy Project Vision Statement from a 2011 Canadian project. Figure 26.2 is taken from a 1997 project in the United States that embraced a more encompassing statement. What matters is that the vision has the team's commitment, it is suitable for public display, and it fits on one page with a large font.

PARTNERING

Partnering, or alignment (as it has become to be known), is a best practice for projects, particularly for large, complex ones. Today, most major mining companies use a formal alignment process at the front end of their project execution stage. Partnering is the bringing together of project-related personnel to obtain joint buy-in of the project development process and responsibilities. The intention is to end up with a focused team with a common goal, for each team member to understand his or her role, and for a system to be installed whereby decisions can be made to achieve that goal.

Unfortunately, in the past, some mining organizations have deliberately fostered adverse relationships between themselves (the Owner) and the project contractors. A better practice is to drop this confrontational mind-set. To avoid inherent bias, the alignment sessions are best facilitated by a professional partnering or team-building facilitator from an independent organization, skilled in accomplishing the partnering goals.

Deliver a project that is an industry showcase of development and operating excellence.

Involves: People, processes, technology, and management systems

Engages: Highly skilled and valued workforce

Requires: Timely decisions and seamless transition from development to operations

Assures: A safe, sustainable, environmentally responsible workplace, and a valued community partner

Delivers: According to plans and budgets

Results: Project meets board and stakeholder expectations

FIGURE 26.1 Project Vision Statement—Example 1

The project team is charged to develop a world-class project that achieves

- **Safest performance**—0 lost-time accidents and 0 citations
- **Best value in all activities**—for engineering, procurement, construction, and commissioning
- **Full attainment of project goals**—start-up on time, in budget
- **Operation's goal**—forecast production at unit cost by end of ramp-up Zero surprises for Owner's board
- **Full project control**—cost, schedule, and risk management
- **Highest standard of quality**—in every aspect
- **Maximum respect for each other**—EPCM, contractor, owner

These goals will be achieved within a culture that

- Follows high standards in every aspect of the work;
- Teaches and practices teamwork among all parties;
- Promotes effective communication among all employees and contractors;
- Clearly defines each person's responsibilities and expectations;
- Holds employees and contractors accountable to fulfill their responsibilities;
- Assists employees and contractors in exceeding their expectations;
- Fosters mutual respect for each other;
- Commits to following all company rules;
- Is committed to talking to each other about problems;
- Discourages the need or desire for scope change;
- Mandates that unsafe acts will not be tolerated; and
- Respects and protects the environment and our neighbors.

FIGURE 26.2 Project Vision Statement—Example 2

Partnering Participants

Once the partnering facilitator has been chosen, the kickoff alignment session can take place. To be effective, the alignment process should comprise no more than 30 key people. The relevant parties that should participate include the following:

- Project management team
- Key Owner personnel and operators
- Project stakeholders
- Major construction contractors
- Key members of the EPCM firm
- Specialist commissioning entity
- Crucial specialist consultants and/or vendors

Partnering does not diminish each party's responsibility to make their own area perform correctly and to stand behind their section and strive to make it function whenever difficulties arise. Thus, the EPCM team for a major project still has an overall engineering responsibility for the full system to function correctly, even though others (e.g., the material handling equipment supplier, a tailings dam engineer) may undertake parts of the specialized design.

Government Regulators as Partnering Participants

On rare occasions, a project regulator might be invited to a partnering session. This was done successfully with the lead regulator of the Bureau of Land Management for a gold mine in California in the 1980s and with a local mine inspector for a Utah longwall coal mine project in the 1990s.

However, the frankness of discussion needed for successful partnering can be compromised by the presence of regulators; thus, as a general rule they do not belong at these sessions. The interests of the partnering participants and the regulators unfortunately are too frequently opposed. If this is *not* true of the case at hand, then inclusion of a regulator may be viable, but this is an issue that should be handled with caution and generally with guidance from the company's legal and environmental affairs departments.

Partnering Alignment Deliverables

The outcome of the partnering sessions is a project charter, that is, a signed commitment to the project objectives by all participants. Other alignment deliverables include the following:

- Project goals and objectives
- Chain of command
- Roles of all key players and stakeholders
- Individual accountability assignments
- Measurement criteria for monitoring achievement of the consensus agreed-to goals
- Common project terminology
- Reporting requirements, reporting frequencies, and report recipients
- Precommissioning, commissioning, and start-up requirements
- Project management battery limits

Certain soft deliverables should also come out of an alignment session:

- An understanding of the culture of the stakeholder companies
- Development of rapport with and respect for fellow team members

- Sharing of stakeholder expectations
- An understanding of the decision-making process
- Better understanding of the business drivers behind the project vision
- Establishment of informal communication and information flow networks

TEAM BUILDING

Motivating and aligning the team are vital. The project manager cannot complete the project alone. Assembling the team early on, in a facility close to the site, will facilitate bonding between team members and will allow the members to participate in the process of establishing project procedures and controls together. Transparent, open sharing of information is a key component for building trust between team players.

Certainly, each individual within the project team must have defined responsibilities, set deliverables, and the authority to achieve the desired results. Further, if each individual has established a positive relationship with the other team members, and if each person understands the other members' responsibilities, then they are each much more likely to beneficially intercede on their fellow team members' behalf when difficult issues are encountered.

It is the project manager's job to assist team members in meeting expectations. The project manager must be the first to recognize achievements, publically whenever possible. Conversely, if an individual does not fit into the desired team relationship environment, it is the project manager's job to replace him or her. Having a team member with lesser skills is a better solution than tolerating someone who is going in the opposite direction to the project goals. If the project manager is honest and keeps relationships friendly but professional, it will be easier to make and survive the tough personnel decisions.

CONFLICT RESOLUTION

Handling conflict is a subject typically covered in the kickoff meeting. Conflict exists in many forms, and all conflicts must be treated seriously. Each must be addressed, and the best time is immediately.

Project Team Conflicts

Team member disputes occur whenever the project goals and team member responsibilities are not well defined. The project manager has the capability to eliminate this issue. Misunderstandings from a breakdown in communication are the leading cause of conflict. The project manager must meet privately with the disputing members to settle the conflict. Listening to and understanding the other person's concerns will fix most of the problems, but as a final resort, the project manager must rule.

Remember, projects are not run by committee, nor are they a democracy. In the end the project manager must make the final decision—the decision that is best for the project.

External Conflicts

Conflicts may also arise from contract disputes, claims, strikes, and so forth. They must also be settled as quickly as possible, but these external conflicts will likely necessitate the input of key Owner personnel and/or other stakeholders. Delaying disagreements to the end of the contract or the end of the month will only escalate the problem.

PROJECT PROCEDURES IMPLEMENTATION

By the end of the kickoff stage, the project procedures will have been reviewed and exact mechanisms agreed to and implemented. It is vital that all these key project procedures be in place and functioning immediately after the kickoff session ends:

- Reference to location of the Project Execution Plan (PEP; Chapter 16)
- Organization chart of the project management team (Chapter 18)
- RASCI (responsible, accountable, supportive, consulted, informed) chart of roles, responsibilities, and accountabilities (Chapter 18)
- Project control tools and procedures (Chapter 21)
- Engineering protocols and control procedures (Chapter 27)
- Procurement procedures (Chapter 28)
- Construction management plan (Chapter 29)
- Reference to when the commissioning plan will be complete (Chapters 30 and 31)
- Environmental impact and permit management requirements (Chapter 8)
- Social acceptance and sustainability considerations (Chapter 8)
- Project administration (Chapter 17)
- Insurance mandates (Chapter 20)
- Communications coordination plan (Chapter 17)
- Project audit protocol (Chapter 21)
- Reporting requirements (Chapter 22)

ENVIRONMENTAL IMPACT, PERMITS, AND SOCIAL ACCEPTANCE MANAGEMENT

The one project procedural area not likely managed by the project team is environmental impact, permits, social acceptance, and sustainability. The kickoff meeting thus needs to identify for the meeting participants exactly who has the management responsibility for ensuring that environmental and social acceptance issues are being covered. That is, who is responsible for environmental management; who has the continuing permitting responsibilities; and who is working with the local communities on social and sustainability issues? Typically, these activities are reserved for an environmental and social affairs person from the Owner's company seconded into the project organization, holding a dual reporting relationship to the project manager and to the Owner's corporate management.

REPORTING

The frequency and final format of the project reporting is established by the end of the kickoff stage, along with the distribution list. Monthly and periodic review reports are always required, as are certain critical field reports. Content details of these reports can be found in Chapter 22.

Weekly Activity Report

The weekly report is a concise, single-page flash report of the project's major activities and issues.

Monthly Status Report

The monthly report should be issued by the end of the second week of the following month. It contains the following information:

- Executive summary progress report and schedule update
- Issues, concerns, and remedial actions
- Safety and health statistics
- Activities during the month and key events for the next period
- Project cost and cash flow summary reports (including contingency change log)
- Workforce summary (one-page histogram depiction of plan vs. actual)
- Engineering, procurement, construction, and commissioning activity status
- Quality management report
- Project controls (including earned value analysis and change order control log)
- Third-party progress report updates
- Environmental impact, permitting, social acceptance, and sustainability activities update
- Workforce analysis (including discipline-level staffing histograms)
- Project master schedule and key detail schedules (including critical path update)

Periodic Project Review

The periodic project review document contains an in-depth review of the project measured against the project objectives and is produced every 6–12 months during project life.

Field Reports

Field reports provide real-time feedback to project management. Field reports highlight the progress of current activities, issues, schedule, costs, personnel, trends, and forecasts.

Forecast Updates

Re-forecasts of the original approved budget and/or schedule are produced as necessary to reflect changes in the project environment. New forecasts allow project reality to be properly reflected. Actual project status can be additionally tracked against the updated latest forecast, but the project always continues to track against the original approved Authorization for Expenditure and PEP. This project discipline never goes away.

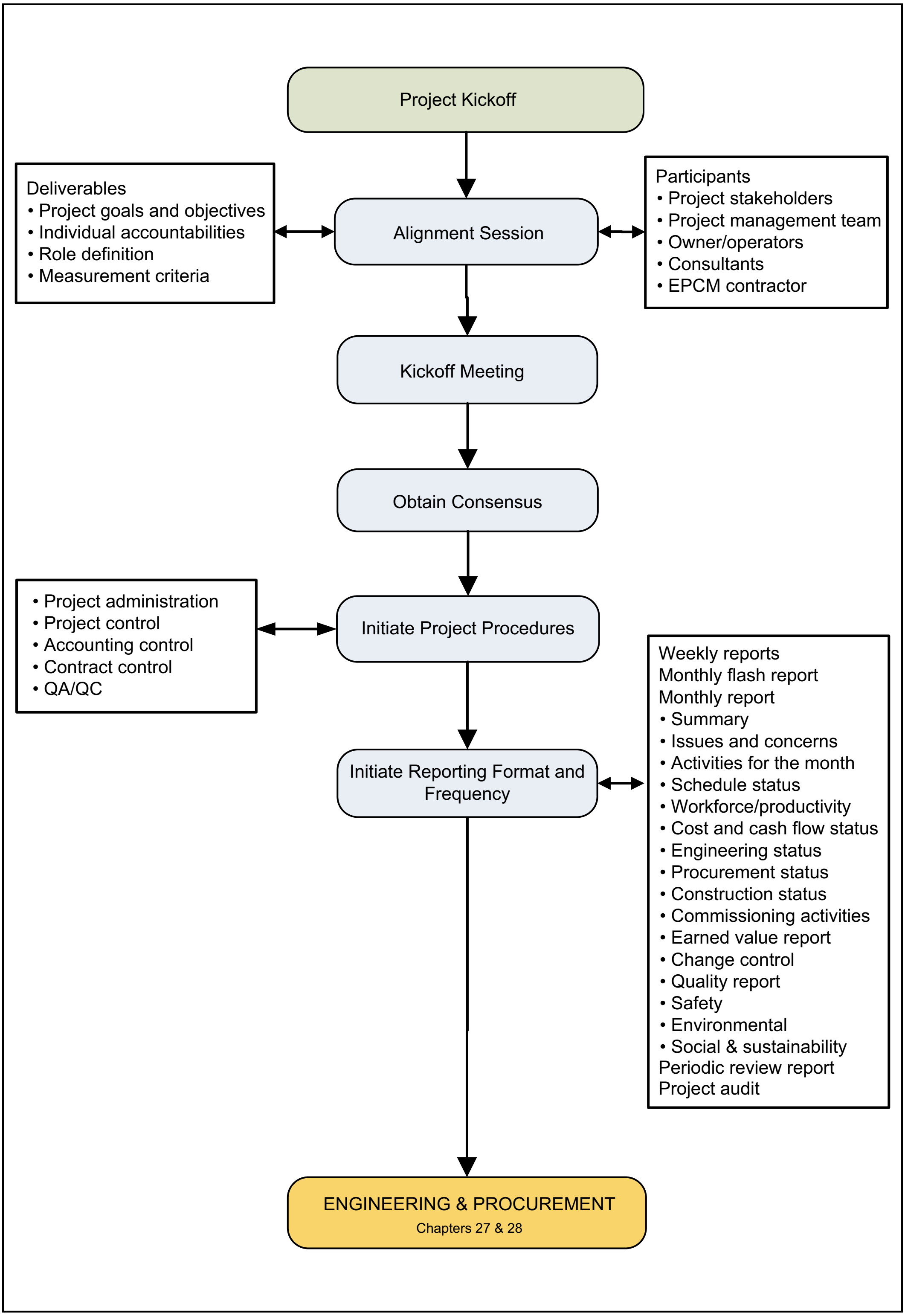
MEETINGS

The kickoff session establishes the type and frequency of meetings necessary for effective project management (see Chapter 17). The established meetings should include

- Daily line-up meetings,
- Weekly look-ahead meetings,
- Monthly progress review meetings,
- Senior management update meetings, and
- Subject-focused supplementary meetings.

CHECKLIST 26.1 KICKOFF COORDINATION

No.	Item	Status	Date	Initials
1	Project team—assembled			
2	Preparation for kickoff and alignment session—complete			
	A. External facilitator—engaged			
	B. Agenda for kickoff meeting—published			
3	Relevant attendees—identified by name			
	A. Project management team			
	B. Project stakeholders			
	C. Key Owner personnel and operators			
	D. Key EPCM members (including sponsor)			
	E. Major construction contractors			
	F. Commissioning team leadership			
	G. Crucial specialists, consultants, and vendors			
4	Partnering or alignment session—held per guidelines			
	A. Project vision statement—produced			
	B. Project charter—produced and signed by all			
	C. Project goals—consensus achieved			
	D. Individual roles and responsibilities—defined			
	E. Alignment deliverables—identified			
	F. Conflict resolution—addressed			
5	Partnering session feedback—incorporated into PEP			
6	Project procedures—implemented			
7	Environmental and permitting requirements—understood			
8	Social acceptance and sustainability needs—understood			
9	Reporting requirements—documented			
10	Meetings purposes and frequency—established			
11	Audit program—initiated			
12	Follow-up alignment sessions—dates established			



FLOWCHART 26.1 Kickoff coordination

CHAPTER 27

Engineering

Scientists investigate that which already is;
engineers create that which has never been. —*Albert Einstein, 1921*

OBJECTIVE

The myriad activities that compose the engineering phase of the project are delineated within this chapter. It is generally accepted that each project is unique, but even so, most projects share a number of common decision points. This chapter identifies these common elements within the engineering phases and provides direction for the project manager in accordance with recognized best practices and typical mining company procedures. The formal hazard and operability (HAZOP) review and the fatal-flaw analysis take place at this stage, before initiation of any field construction activity.

ENGINEERING MANAGEMENT ORGANIZATION

Certain decisions made at or before project kickoff impact how the engineering stage of the project is managed and administrated, such as

- Appointment of the engineering contractor (denoted herein as the "Engineer"),
- Selection of the contract type (which affects the project controls methodology), and
- Setting of the key schedule milestones.

Much of what is expected of the Engineer should already be in hand from the bid documentation prepared for the selection and appointment of the engineering provider. (See Chapter 19.) The scope for the Engineer needs to be reconfirmed before initiating engineering. Required interfaces with affected areas of the mining company must be identified and implemented; for example, the Owner's purchasing department for procurement and the Owner's operations technical services departments for design criteria.

Typically, the entity selected as the engineering contractor is also appointed to perform the procurement function, as these two project components are significantly intertwined. Figure 27.1 illustrates the linking mechanisms between the engineering and procurement functions. In recognition of this, going forward, this book generally assumes that an engineering, procurement, and construction management (EPCM) contractor provides the core services, as its name implies, for project execution.

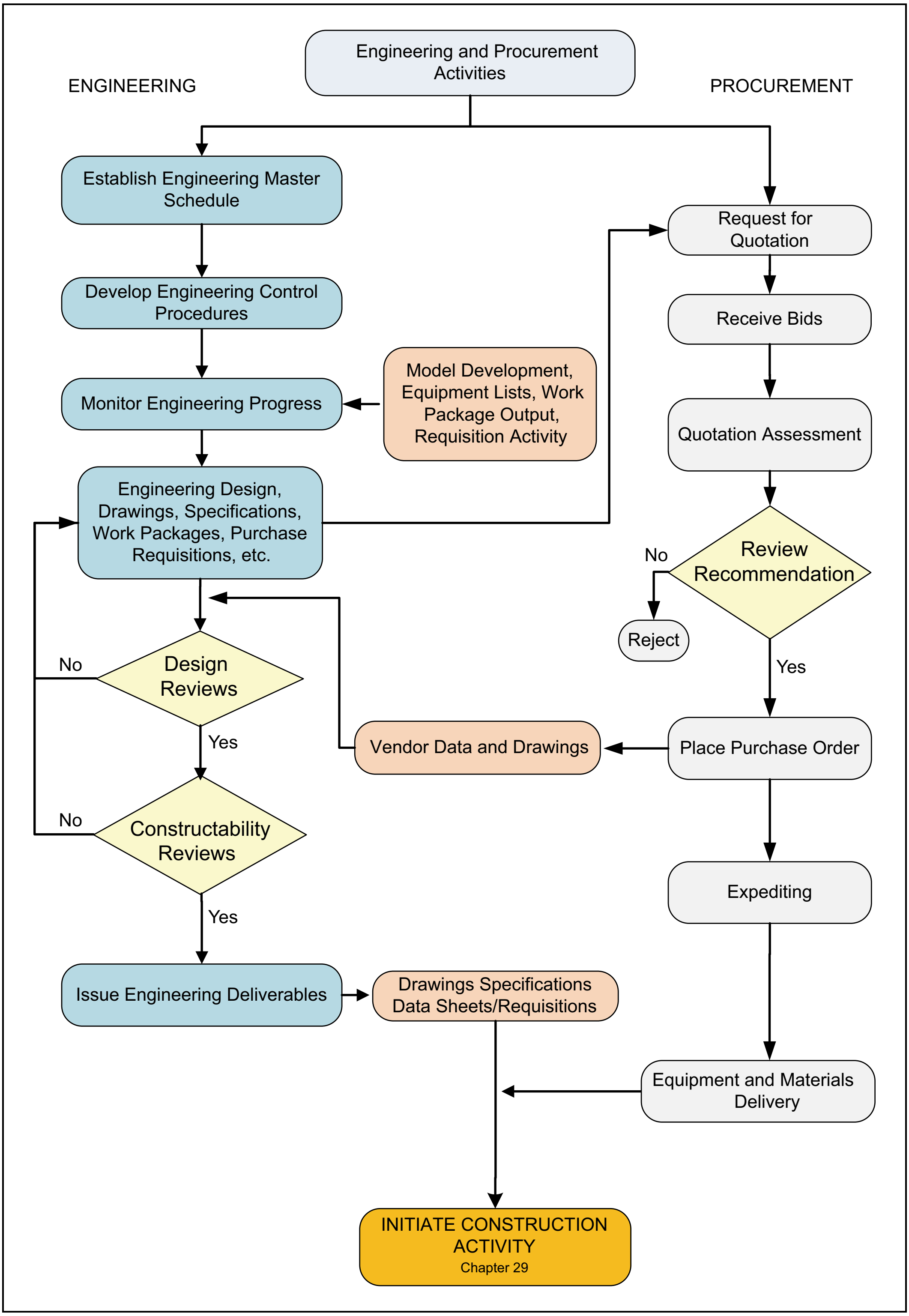


FIGURE 27.1 Engineering and procurement activity flow diagram

DRAWING IDENTIFICATION PROTOCOL

This is a convenient juncture for a discourse on the identification protocols used on drawings issued by engineering firms. A drawing protocol needs to be established, understood, and then followed on all projects.

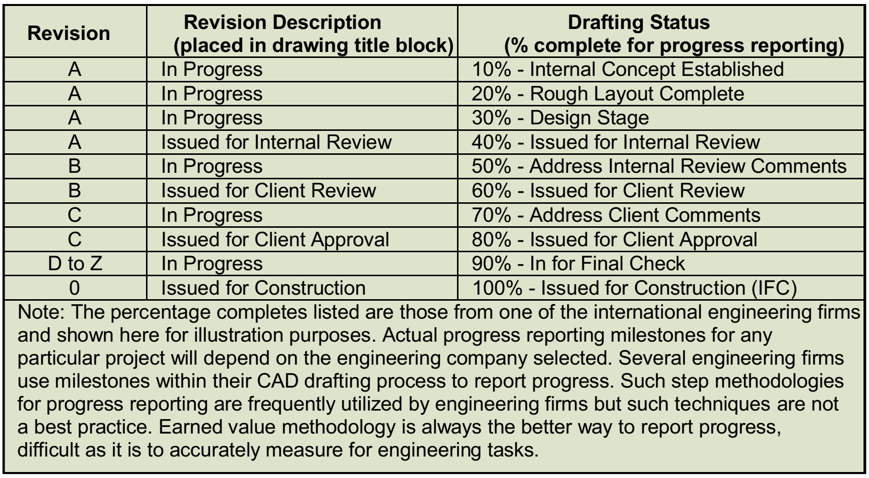
Drawing Identification Format—Lettering and Numbering Sequence

Issued drawings by engineering firms typically have a single alphabetical character with a hyphen followed by a number. In this convention the first component of the sheet identification format, the alphabetical character, is known as the discipline designator and denotes the category of subject matter contained on the drawing (National Institute of Building Sciences 2011). The following discipline designators are currently recognized by the U.S. National CAD Standard (Version 5):

G = General
H = Hazardous materials
V = Survey or mapping
B = Geotechnical
C = Civil
L = Landscape
S = Structural
A = Architectural
I = Interiors
Q = Equipment
F = Fire protection
P = Plumbing
D = Process
M = Mechanical
E = Electrical
W = Distributed energy
T = Telecommunications
R = Resource
X = Other disciplines
Z = Contractor or shop drawings
O = Operations

While not all engineering firms use all the preceding discipline designators, the main designators A (architectural), C (civil), S (structural), M (mechanical), and E (electrical) are fairly universally used.

Following the hyphen after the discipline designator is a unique number for each drawing. The drawing numbers can mean many things. Sometimes the initial number designates a sheet type. For example, 1 could be a plan, 2 could be an elevation, and 3 could be a section. Sometimes the initial number designates an area of the facility. For example, 1 could be the leach pad, and 2 could be the crushing plant. Sometimes, however, the numbers mean nothing more than the date order of the drawing initiations within each discipline. The point here is that there is a logic behind each engineering contractor's drawing numbering sequence; thus it is useful for the project team members to become familiar with the numbering protocol.



Revision	Revision Description (placed in drawing title block)	Drafting Status (% complete for progress reporting)
A	In Progress	10% - Internal Concept Established
A	In Progress	20% - Rough Layout Complete
A	In Progress	30% - Design Stage
A	Issued for Internal Review	40% - Issued for Internal Review
B	In Progress	50% - Address Internal Review Comments
B	Issued for Client Review	60% - Issued for Client Review
C	In Progress	70% - Address Client Comments
C	Issued for Client Approval	80% - Issued for Client Approval
D to Z	In Progress	90% - In for Final Check
0	Issued for Construction	100% - Issued for Construction (IFC)

Note: The percentage completes listed are those from one of the international engineering firms and shown here for illustration purposes. Actual progress reporting milestones for any particular project will depend on the engineering company selected. Several engineering firms use milestones within their CAD drafting process to report progress. Such step methodologies for progress reporting are frequently utilized by engineering firms but such techniques are not a best practice. Earned value methodology is always the better way to report progress, difficult as it is to accurately measure for engineering tasks.

FIGURE 27.2 Drawing progress milestones

Drawing Revisions

Accompanying any drawing sequence protocol is a drawing revision identification protocol. Revisions are always denoted by letters, not numbers.

Drawings always start as Revision A (Rev A) while being initially worked on and, as such, will show "in progress" in the revision block. Design engineering drawings then go through the alphabetical revision milestones as shown in Figure 27.2, until they are eventually ready to be transmitted for client approval as Revision C (Rev C).

Drawing Issuance Milestones

The progression of the drawing issuance milestones and their accompanying alphabetic appendages is as follows:

Rev A. For internal review. Rev A drawings are produced full size and placed in an assigned review area in the engineering office. Members of the internal review team include personnel such as the engineering manager, discipline leads, and the project manager. Typically a period of 7 days is allowed for review, and each reviewer has to sign and date the review and the comment cover sheet.

Rev B. For client (Owner) review. Rev B drawings are a full-size set of drawings transmitted to the Owner, who is typically given 7 days to review and comment. The Owner's comments on the returned drawings are either addressed by the Engineer or a reason is given for nonaction.

Rev C. For client (Owner) approval. Rev C drawings are a full size set of drawings reviewed by the chief designer or engineering manager and then issued to the Owner with a transmittal cover sheet for final sign-off. Note: The chief designer's review does not constitute the final check—the final check can only be performed after client approval.

Rev D. After Rev C drawings are approved by the client and the final engineering check has been made and signed, then the design drawings can be assigned a WBS code and proceed to detail engineering as Rev D.

Rev D–Z. Client-approved drawings requiring modification and/or additional work begin from Rev D and proceed alphabetically with each change. Each is shown as "in progress."

Rev 0. When detail engineering drawings are final, they become Revision 0 (Rev 0) and are stamped as issued for construction (IFC).

Each piece of equipment has to be identified and named on the IFC drawings and then relabeled if necessary after the actual installment but before construction demobilization.

Note: IFC (Rev 0) drawings revised after initial issuance to the construction contractor (i.e., during the project execution life) are each uniquely identified with a revision number incremented by one number for each new issuance. Thus, a Rev 0 drawing will become Rev 1 for its first revision, then Rev 2 for the second revision, and so forth, for each subsequent modification. A brief description of the change is noted in each new drawing's revision block.

ENGINEERING PHASES

Just as each project is divided into explicit development phases, the engineering work is similarly accomplished in a series of identifiable phases (Brokenshire, Easterberg, and Saccany 2007). Appropriate review follows each phase to ensure that the Owner's goals and the functional, technical, and regulatory requirements are all being met.

The work phases involving (or potentially involving) the Engineer include the following:

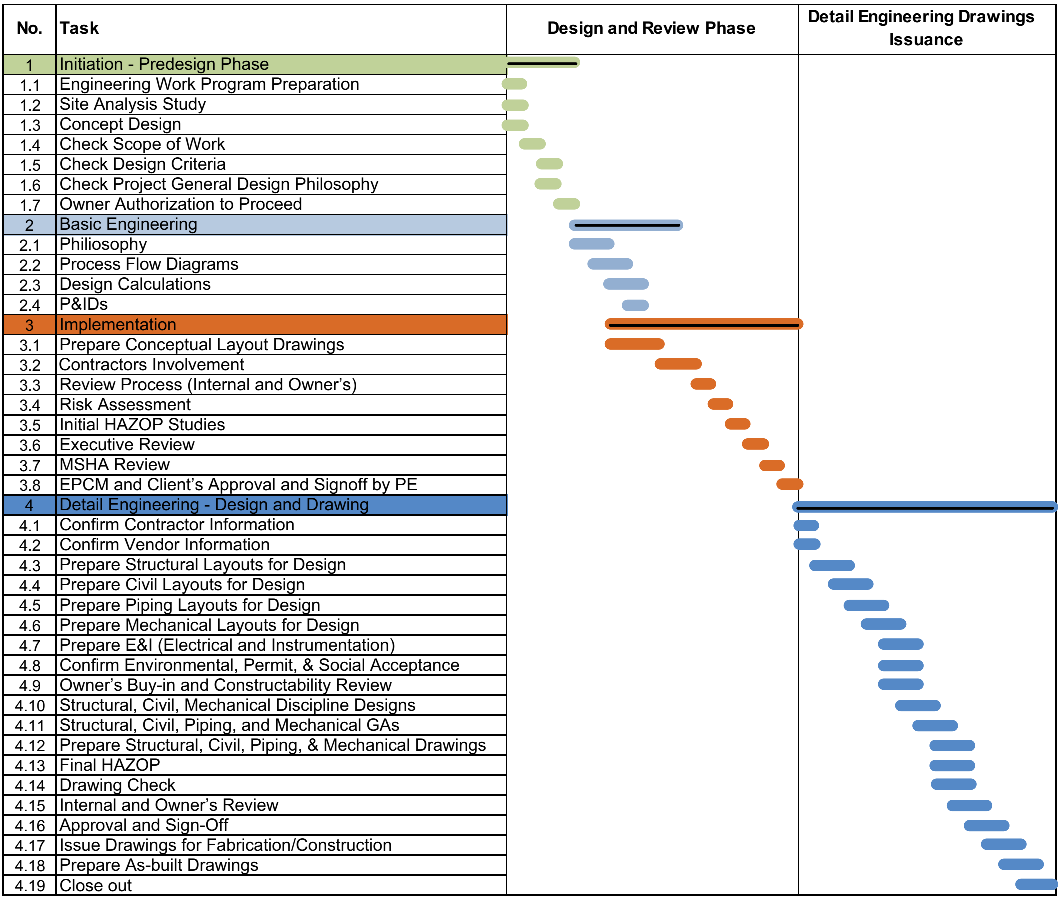
1. Predesign phase
2. Site analysis study
3. Conceptual (schematic) design initiation
4. Basic (design) engineering
5. Detail engineering (final design)
6. Drawing reviews (overlapping the design and detail engineering phases)
7. Specifications
8. Engineering scope control (applies to all engineering work phases)
9. Deliverables of detail (final design) engineering
10. Cost-estimating input
11. Construction bidding support (and contract agreement award support)
12. Field engineering
13. Project completion and closeout

Not all phases listed will be required of the Engineer in all projects. Each project and associated contract must be reviewed for its own requirements to determine the appropriate engineering work effort. In some instances, others (e.g., the Owner, specialty subcontractors) may be better positioned to tackle certain phases, such as activities after completion of the detail engineering and specifications.

A typical progression of the design and engineering process is illustrated in Figure 27.3. This is a takeoff from an actual progress chart used by a U.S. engineering firm for a North American client's project in 2007.

Regardless of the exact number of phases undertaken on a project by the engineering contractor, all project engineering activities have to be executed consistent with a

- Project procedures manual (see Chapter 17),
- Work breakdown structure (WBS; see Chapter 11), and
- Project master schedule (Level 3 Project Coordination Schedule; see Chapter 10).



No.	Task	Design and Review Phase	Detail Engineering Drawings Issuance
1	Initiation - Predesign Phase		
1.1	Engineering Work Program Preparation		
1.2	Site Analysis Study		
1.3	Concept Design		
1.4	Check Scope of Work		
1.5	Check Design Criteria		
1.6	Check Project General Design Philosophy		
1.7	Owner Authorization to Proceed		
2	Basic Engineering		
2.1	Philiosophy		
2.2	Process Flow Diagrams		
2.3	Design Calculations		
2.4	P&IDs		
3	Implementation		
3.1	Prepare Conceptual Layout Drawings		
3.2	Contractors Involvement		
3.3	Review Process (Internal and Owner's)		
3.4	Risk Assessment		
3.5	Initial HAZOP Studies		
3.6	Executive Review		
3.7	MSHA Review		
3.8	EPCM and Client's Approval and Signoff by PE		
4	Detail Engineering - Design and Drawing		
4.1	Confirm Contractor Information		
4.2	Confirm Vendor Information		
4.3	Prepare Structural Layouts for Design		
4.4	Prepare Civil Layouts for Design		
4.5	Prepare Piping Layouts for Design		
4.6	Prepare Mechanical Layouts for Design		
4.7	Prepare E&I (Electrical and Instrumentation)		
4.8	Confirm Environmental, Permit, & Social Acceptance		
4.9	Owner's Buy-in and Constructability Review		
4.10	Structural, Civil, Mechanical Discipline Designs		
4.11	Structural, Civil, Piping, and Mechanical GAs		
4.12	Prepare Structural, Civil, Piping, & Mechanical Drawings		
4.13	Final HAZOP		
4.14	Drawing Check		
4.15	Internal and Owner's Review		
4.16	Approval and Sign-Off		
4.17	Issue Drawings for Fabrication/Construction		
4.18	Prepare As-built Drawings		
4.19	Close out		

Note: P&ID should not be initiated before conceptual layout.

FIGURE 27.3 Design and engineering process chart

The need for any equipment installation or service providers, vendor support staff, technical consultants, and/or engineering subcontractors is communicated to project management and the sourcing and logistics teams by the engineering contractor during the engineering stage.

Linked directly with the engineering stage are the value engineering trade-off studies, the permit and social considerations, drawing and HAZOP reviews, constructability reviews, fatal-flaw analyses, scope control requirements, procurement protocols, and the project progress measurement system, all of which demand further discussion within this chapter.

It is in the interest of the Owner that throughout the engineering process, the design basis and functionality of the design are continuously reviewed by the project management team and the Owner's operations and maintenance (O&M) staff to ensure compatibility with the company's internal standards.

Manuals, training, and start-up plans are formally addressed for the first time during the engineering stage, that is, documentation for these elements are initiated. The project team has to inform the Engineer as to the appropriate final format(s) for the drawings to be delivered to the Owner (hard copy, Mylar, electronic, etc.) and how the drawings are to be transmitted (courier, e-mail, etc.). Ownership of the drawings always stays with the mining company, regardless of form.

Because of the scope development work within most engineering phases, engineering is generally conducted on a cost-plus (time and materials) basis. Lump-sum contracts are not well suited to the evolving nature of engineering work.

PREDESIGN PHASE

The predesign phase establishes the basis for undertaking and accomplishing the engineering. The engineering work program is prepared; regulatory and other external requirements are identified; and initial data to support the engineering activities are gathered.

Engineering Work Program

The engineering work program forms the basis for the work effort to be performed by the Engineer and establishes the design criteria and constraints which instruct the project. Typically, the scope of work developed for the engineering proposal, as revised in subsequent negotiations, is used as the program guide. The program is set with and approved by the Owner, resulting in documentation that captures the following:

1. Owner goals
    - The function of the constructed project
    - The desired characteristics of the facility and the incorporated equipment
    - Any anticipated future expansions
    - Identification of Owner issues that could affect project delivery
2. Cost limitations (if any)
    - Setting the total project cost limitation (if appropriate)
    - Establishing cost limitations for each project element (civil, structural, etc.)
3. Requirements of the facility to be designed
    - List of the elements that compose the facility
    - Description of each element: giving capacity, design load, and any other constraint
    - The specific design criteria, codes, manuals, and computer programs to be used, including compter-aided design (CAD) system requirements
4. Functional description and requirements
    - List of the general construction elements: buildings, utility systems, and so forth
    - Depiction of any special construction materials and finishes
    - Explanation of all required site improvements
    - Description of the various discipline requirements
5. Site data
    - Description of existing conditions, requirements, and restrictions
    - The methodology for obtaining data for topics such as surveys, soils, groundwater, drainage, zoning, existing utilities, traffic, and so forth
    - The process for obtaining information for applicable environmental aspects, for example, wetlands, endangered species, historic sites, archeological sites, and so forth
6. Master plan: a drawing or sketch showing the location of the proposed facilities that
    - Shows planned and possible future improvements and expansions,
    - Depicts adjacent facilities (current or future) which may affect the project, and
    - Identifies contact agencies or businesses regarding adjacent developments.

7. Code restrictions
   - List of all applicable codes
   - Identification of the limiting code requirements that will affect the project
8. Project agreements
   - Copy of the engineering agreement with the Owner
   - Copies of any subconsultant agreements (Note: Subconsultant terms must mesh and comply with the Engineer's agreement terms.)
9. Report forms: All relevant project management and engineering reporting forms
10. Time restrictions
    - Establish the project schedule, giving dates for
      - Conceptual (schematic) design,
      - Basic design engineering,
      - Final detail engineering,
      - Construction contract documents development support,
      - Construction contract(s) bid period,
      - Award of construction contract(s), and
      - Construction (start date and planned completion date);
    - Need to show lead times required for major items requiring long deliveries;
    - Must consider potential time delays due to review agencies; and
    - Need to allow adequate time for postreview corrections.
11. Engineering quality assurance and quality control (QA/QC) plan: Description of the specific QA/QC plan for the project
12. The engineering budget, the schedule, and the staff organization chart that identify
    - Project phases, task breakdowns, budgets, and charge codes; and
    - The staffing plan with estimated work-hours, budgets and responsibilities.
13. Distribution list for the engineering work program, including the Owner representative and key engineering team members

Administration of the Engineering Work Program

The engineering work program is administered under certain protocols:

1. Any proprietary information that has to be segregated is respected.
2. Changes or revisions:
   - Changes that deviate from the written program are issued and distributed as numbered and dated addendum.
   - The impact of each change to schedule, budget, and/or work scope is communicated to the Owner and to each person on the distribution list.
   - If changes become excessive, this is a signal to review the entire program.
3. Program coordination:
   - Prior to work program start, responsibility for adherence to the program is acknowledged in writing by each engineering team member.
   - A check of the engineering work program is conducted with the Owner at completion of each phase to ensure that the engineering is on the desired track.

SITE ANALYSIS STUDY

During the site analysis study phase, information about the proposed project site and any alternative sites is gathered and evaluated. Types of data that may be obtained include zoning regulations, utility locations, geotechnical data, environmental features, and survey records. Photographs and/or videotapes of the site, existing conditions, and so forth, are collected when available.

CONCEPTUAL (SCHEMATIC) DESIGN INITIATION

The conceptual design initiation phase (sometimes termed the *schematic design*) encompasses the preliminary design effort to establish the Owner's requirements for the project and to define these requirements on paper (or computer), so that both the Owner and the project team clearly understand the scope and limitation of the services. The conceptual design is typically initiated in the project's opportunity stage as part of a scoping level evaluation.

The main requirements of this phase include the following:

1. Schematic design concept evolution studies
2. Conceptual design
3. Probable cost estimate (when applicable)
4. In-house review
5. Owner review and approval of the conceptual design
6. Owner authorization to proceed with design engineering development

To initiate the conceptual design work, the project manager creates the scope of work, budget, schedule, and drawing list, and the Owner provides a signed work order to the Engineer.

Schematic Design Concept Evolution Studies

The project manager supplies the Engineer with the Owner-approved scope of work, broad design criteria, functional philosophy, and any other information that the Engineer's designers need to proceed. The project manager, engineering manager, and EPCM engineers and designers then jointly develop the overall concepts for the facility or the systems, mostly through the use of schematics. Once the design concepts have been established, the EPCM engineers and designers proceed with the actual conceptual design.

Conceptual Design

The drawings and/or sketches that define the proposed concepts are created. Sketches are the preferred medium at this phase, as they are easier to create and revise; they can be used to convey different options, and they are convenient transmittals for vendors or contractors if external input is needed. Typical design sketch documents created at this stage are general arrangement drawings (GAs) and process flow diagrams (PFDs). Occasionally, a few piping and instrumentation diagrams (P&IDs) and an electrical diagram are included in this conceptual design mix.

GAs show the locations and main dimensions of the key equipment in the plant, including the major piping, valves, fittings, and the like. PFDs illustrate the overall conceptual process by showing all the process streams and identifying each key piece of equipment using relevant symbols, flow rates, and equipment numbers. P&IDs are developed from PFDs and show more detail: the main piping, valves, and control instrumentation associated with the project. PFDs and P&IDs are predominantly created by the piping designers.

All drawings in this initial phase (as in all engineering phases) are issued with unique numbers (whether or not they are sketches), and they each need to use the standard alphabetical revision sequence of A through Z as required. (Refer to drawing document numbering sequence convention in the "Drawing Identification Protocol" section in this chapter.) Generic written descriptions of the various systems to be used are developed, including mechanical, electrical, plumbing, environmental, and fire protection design criteria, as well as applicable code restrictions, and exceptions are typically included.

Probable Cost Estimate

Sometimes the engineering work scope includes preparation of cost estimates at the conceptual design phase. These are rough estimates, usually prepared to a scoping evaluation level (i.e., an ASPE [American Society of Professional Estimators] Level 1) using unit costs and extrapolations from recent projects of similar nature.

In-House Review

When the conceptual design has been sufficiently developed but before submittal to the Owner, the project manager has to arrange a conceptual design review. The reviewers should include experienced and qualified individuals who have not previously been involved in the project.

The purpose of the review is to

1. Evaluate the design against the Owner's goals as outlined in the program,
2. Make sure that the design concepts of the various systems are coordinated, and
3. Approve the conceptual design or return it to the design team with recommendations for additional work.

After an acceptable review, or after the resolution of the recommended modifications, the project manager verifies that the conceptual (schematic) design checklist is fulfilled and then presents the design to the Owner.

Owner Review of Conceptual (Schematic) Design

The project manager is usually the person who presents the conceptual design to the Owner. The review should include a discussion of design concepts and (if appropriate) the accompanying cost estimates with respect to the Owner's original objectives. The Owner then has to approve the design concept or return it to the design team with a recommendation for additional work.

Owner Authorization to Proceed

The project manager must obtain in writing the Owner's final acceptance of the conceptual design and an authorization to proceed into the basic engineering stage.

BASIC (DESIGN) ENGINEERING

During the basic engineering phase (often referred to as design engineering), all design issues are resolved, and the typical and critical parts of the design are developed in detail, then coordinated and finalized in preparation for detail engineering, procurement, and construction contract documents preparation. It is not necessary or even desirable that every detail be worked out during this phase. But it is necessary that typical and critical conditions which impact the work of the individual engineering disciplines be resolved.

As this phase involves considerable interaction and coordination between each discipline's designer, a carefully scheduled work plan is required to ensure that each participant's work is completed in a timely way and can accommodate integration of the other disciplines' efforts. The requirements and impact of each discipline's design on the work of others must thus be understood and foreseen.

Basic engineering generally commences as a component of the prefeasibility study, but the majority of basic engineering is typically completed in the feasibility study stage. Almost 30% of the drawings required for a project are produced in some format (not necessarily final) in the basic engineering stage.

Work Start

Work in this phase commences only after conceptual design is completed and approved and generally only after a capital budget estimate is approved. Otherwise, considerable time can be lost developing the wrong designs.

The basic engineering phase consists of the following distinct steps:

1. Setting of the functional philosophy
2. Establishment of the basic design development requirements
3. Owner and Engineer agreement on standardization of parts and systems
4. Design engineering drawings and calculations
5. Specifications outline
6. Verifying design assumptions with approval agencies
7. Construction cost estimate (when applicable)
8. In-house review
9. Owner review and approval

Functional Philosophy

The functional philosophy is a narrative description of what the designed project will provide and how the systems within the project will operate. The functional philosophy also covers the following:

- Battery limits of the project
- Associated facilities
- Design duty of the project and any standby equipment
- Control and instrumentation architecture

Design Development

Design development is a continuation of the Owner-approved conceptual design. Using a mineral processing plant as an example, one finds that the design of each plant essentially follows the same logical steps, regardless of process complexity or the commodity. The methodology and documentation produced are the same; only the processing detail is different (SRK Consulting 2013). Design development consists of these sequential steps:

1. Assemble metallurgical test data and any operating data from the Owner that exists.
   - Test samples must represent the complete deposit and plant feed over the life of the mine; that is, they must show the mineral deposit variability.
   - Testwork identifies processes, the metallurgical recoveries, and product quality.
   - A pilot plant establishes process parameters for economic recovery of the output minerals.
   - Slurry rheology line flow tests are required for most process plant designs.
2. Develop the process design, which normally involves some level of modeling work.
3. Produce the design criteria document. This document summarizes the main parameters for sizing the plant and equipment.
4. Define the process flow sheet.
5. Capture the overall process progression on PFDs.
   - Show all the process streams (water, reagents, utilities, etc.)
   - Identify each piece of equipment by number.
   - Physical separation processes require relatively simple PFDs, for example, coal.
   - Complex processes involving chemical reactions (heat, phase changes, etc.) entail very complicated PFDs, for example, soda ash plants.
6. Link the PFD process streams to the mass and metallurgical balance calculations.
   - Mass and metallurgical balances are the main calculations to size the plant.
   - Simple PFD balances can be prepared with spreadsheets.
   - Complex PFD balances will likely require propriety software, for example, Metsim.
7. Initially attempt to finalize the mass and energy balances (which may get tweaked later).
8. Produce a plot plan for design.
9. Produce the process description document.
   - This document details the main requirements and process steps.
   - Complex processes will require detailed chemistry descriptions.
   - Special requirements such as environmental mitigations are addressed.
10. Produce the project specifications.
11. Prepare the process equipment list.
    - Identify each piece of equipment with a unique tag number.
    - Provide key details such as equipment type, size, and power requirement.
    - Specify the materials of construction.
12. Produce a mechanical equipment list—for cost-estimating purposes.
13. Develop a process data sheet for each piece of equipment; data sheets identify the performance duty and any process-specific features.
14. Prepare the equipment specifications for procurement request for quotation (RFQ) and construction usage.
15. Develop the PFDs into P&IDs.
    - P&IDs detail every pipe, valve, piece of in-line equipment, instrument, and control loop.
    - P&IDs specify materials of construction.
    - Utility P&IDs can generally be left for later development.
16. Conduct first HAZOP review (either here at the end of design development or before commencing final design).
17. Develop process data sheets for the additional equipment items shown on the P&IDs.

18. Produce a process control philosophy document to outline overall control requirements.

The project manager's role is to ensure that all design work conforms with the following:

- Project scope of work
- Functional philosophy
- Design criteria
- Project control budget (for the engineering component)
- Any Owner capital expenditure restrictions for the project (if applicable)
- Any general construction or operating philosophy that may have been established at this early stage (not typical, but does sometimes exist within some Owners' projects)

The project manager is also tasked with making sure that operability, ease of maintenance, potential hazards, and environmental protection measures are all addressed within the steps of the design development process. All applicable Owner standards and specifications have to be obtained and then followed with regard to the selection of materials and equipment.

The Engineer uses the documents produced in the design development process to create the basic engineering drawings. From this work, the Engineer establishes the extent that further design development may be required within the basic engineering phase by identifying critical design components and the critical areas for systems coordination.

Standardization

Within both the engineering and the procurement stages, constant attention must be paid to the standardization of parts and systems, for example, conveyor idlers, pulley bearings, crusher motors. And it is just as important to standardize between stand-alone facilities as it is within each facility. Thus, the instrumentation and control logic system for the crusher needs to be compatible with and have a similar logic to that of the agglomeration drums, solvent extraction and electrowinning processes, mill circuits, and so forth.

Engineers should research their own resources for standard details and other projects with similar designs, construction, and details, and then obtain Owner concurrence on the appropriate level of standardization within the engineered facility. While the implementation of standardization may slightly increase the capital cost, it is usually worthwhile because it can materially reduce operating cost and maintenance frustration.

Note: Compatibility of instrumentation or control logics is best affected by having the procurement entity bring a single instrumentation or control subcontractor into this design engineering stage (even better is to bring this sub in at the initiation of the prefeasibility study). A single control system and logic protocol will best ensure that all the control loops in each facet of the project can truly communicate with one another. This will go a long way to aiding a trouble-free start-up. Different computer or electronic control systems in different parts of a project are an invitation for disaster.

Basic Engineering Drawings and Calculations

Each individual engineering discipline (civil, piping, mechanical, etc.) determines and describes the systems to be used, provides the design calculations and details necessary to establish the workability of the overall facility, and then sets the time and budget allocations appropriate for its particular design components.

Produced drawings at this basic engineering stage can include any or all of the following:

1. Site plan
    - General topography and facility elevations
    - Roadways, parking and paving, and roadway accesses
    - Utilities
    - Landscaping, fencing, and exterior lighting
2. GAs and alignment and dimensions of project facilities
3. Floor plans
    - Control dimensions, column spacing, and wall thicknesses
    - Equipment layouts, space identification, and door and window locations
    - Power, lighting, plumbing, and special systems layouts
4. Elevations
5. Sections
    - Typical sections and details, in large scale, to satisfy the major design conditions of each discipline
    - Transverse and longitudinal sections showing grades, floor locations, ceiling heights, and structural thicknesses
6. Schedules
    - Equipment schedules with estimated power requirements, motor sizes, and so forth
    - Finish schedules
7. System schematics
    - Schematic flow diagrams
        - PFDs
        - Mass balance diagrams
    - Single-line mechanical layouts with equipment sizes and location
    - P&IDs
    - Electrical diagrams

At completion of the basic engineering effort, a drawing checklist for detail engineering is produced, documenting the suite of drawings expected to be needed from this next phase.

Specifications Outline

As part of the basic engineering work scope, a descriptive outline of the specifications for the major systems and equipment within each engineering discipline is derived, including any or all of the following:

- Process
- Architectural
- Civil
- Concrete
- Structural (steel, etc.)
- Piping
- Tanks
- Mechanical
- HVAC and plumbing
- Insulation, painting, and fireproofing

- Electrical
- Instrumentation and controls
- General

Decisions supporting the selection of the equipment sizes are documented, along with preliminary calculations, backup analysis, and a description of the components. Specifications are broken out for each discipline, and a list of the materials, methods, and qualities expected is recorded.

Computer-Aided Design and Computer-Aided Drafting

Computer-aided design (CAD) needs to be mentioned here, as no mining project will be built today without it. CAD refers to the use of computer systems for the creation, analysis, or optimization of a design. CAD is a tool used by every EPCM. CAD software increases the productivity of the designer, improves the quality of design, enhances communications through documentation, and helps create an easily retrievable database.

The acronym CAD also stands for computer-aided drafting, which is the process of creating a technical drawing with the use of computer software. Thus, in the EPCM world, the acronym CADD is sometimes used for computer-aided design *and* drafting.

CAD software uses either vector-based graphics to depict the objects of traditional drafting or raster graphics to show the overall appearance of designed objects. CAD involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD is used to convey information, such as materials, processes, dimensions, and tolerances. Generally, CAD deliverables are electronic files for print, but they can be in other media. CAD is widely used to produce animation for plant construction sequencing, process flow interactions, and technical manuals. CAD can be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.

Virtually every major EPCM uses Intergraph PDS (Plant Design System) as its CAD tool, while most major mining companies use AutoCAD, developed by Autodesk. Ten years ago, converting PDS files into AutoCAD for mining clients at the close of a project was a very lucrative business for the EPCMs, but today it is an inexpensive, simple task.

Verification with Approval Agencies

The project manager is responsible for coordination of legal and code compliance activities among the engineering disciplines. Each discipline, however, typically confirms its own separate compliance with the applicable jurisdiction codes, including building, fire, and utility codes, and with the pertinent statutory regulations such as environmental directives. The project manager presents the overall project facility design to the regulatory and funding agencies to determine if the produced design is acceptable.

Construction Cost Estimate

If required in the engineering scope of work, each discipline submits an estimate of cost for the construction of its portion of the project. The project manager then assembles the estimates and checks against the design documents for accuracy and completeness.

In-House Review

An engineering review by an experienced reviewer or committee (preferably by the same group that reviewed the conceptual design) is conducted. Each discipline team attends the review for its particular discipline.

The purpose of the design review is to

- Critique the technical adequacy and costs,
- Check for conformance with Owner goals as stated in the program, and
- Ensure that the designed systems from the different disciplines are all coordinated.

The review team either approves the preliminary design documents or returns them to the project manager with recommendations for rework. After any recommended modifications have been resolved, the project is ready for presentation to the Owner.

Owner Review and Approval

The project manager, engineering manager, EPCM project sponsor, and other engineering design team members, as appropriate, present the basic engineering material to the Owner. The Owner reviews the various systems selected, the probable cost of the individual components, and the overall estimated construction cost. The Owner then either approves the documents or returns them to the design team with recommendations for rework. After any recommended modifications have been resolved, the Owner should be able to approve the project for continuation. Owner approval needs to be by written authorization form.

Changes to the Work

It is very easy during this phase of the work for team members to inadvertently change the scope or quality of the project from that defined by the approved conceptual design schematics and budget. The project manager and each discipline leader must continually monitor the work to ensure that it conforms to the approved conceptual design.

If, however, the basic engineering work effort shows that changes should sensibly be made, then these modifications, along with related fee, budget, and schedule changes, need to be approved by the Owner for implementation. Similarly, if the Owner requests or inadvertently makes changes, the resultant engineering fee, budget, and schedule changes must be approved in writing by the Owner before such modifications are actually implemented.

DETAIL ENGINEERING (FINAL DESIGN)

The principal deliverables of engineering are the drawings needed by the construction contractor. Additional documentation includes data sheets, specifications, purchase requisitions, equipment lists, material control registers needed by the procurement entity, and the manuals needed by operations. These deliverables are produced by the engineering contractor in the detail engineering (also known as final design) phase.

Before beginning the detail engineering phase, the drawing checklist created at the completion of design engineering needs to be reviewed and updated as appropriate. At the "notice to proceed" milestone, the project manager should bring together the engineering staff and the design and drafting personnel in a project overview meeting. The overall purpose of the project should be reconfirmed (or explained if necessary) and any unique requirements made clear.

The project overview could include a site visit, photographs, examples of similar projects, or anything else that helps the engineering personnel visualize the project and see it as more than just lines on a computer. Whenever possible, the project manager should include key design and drafting staff in site visits during and after construction, to identify successes and problems related to the design and the drafting quality control process. Drafters are essential for the work and should be included in all team meetings.

Personnel and Roles

The project manager and the engineering manager are responsible for being familiar with the established drafting and CAD standards when marking up plans and/or directing the design team leaders of the drafters and CAD operators. The design team leader (i.e., the drafting manager), through the efforts of the checker, is responsible for verifying that the work produced adheres to established drafting and CAD standards. That said, the drafters are still responsible for checking their own work. The design team leader, using markups and revisions, directs the drafters to make any changes necessary before delivering the drawings to the engineering manager and the project manager.

The functionality of the design needs to be continuously reviewed by the project management team and the Owner's O&M staff representatives throughout detail engineering to ensure that suitability for purpose is being maintained.

Scheduling the Detail Engineering Effort

Before making schedule promises to the Owner, the project manager needs to consult with engineering team members to see if the schedule can be reasonably met. Drafters and CAD operators should be included in this schedule planning. The established schedule needs to provide adequate time for any unique design elements, build in appropriate contingency for unforeseen circumstances, and allow reasonable time for checking and revisions.

The project manager and the design team leader together establish the milestones for meeting the various phases and deadlines of the engineering work. Typically, they start at the completion deadline and then do *backward planning* to determine the latest possible start point for each phase of the project as shown in the following sequence:

1. Completion deadline
2. Final quality check (no more drafting expected)
3. Quality check (minimal drafting expected)
4. Final drafting (no more design changes or new data without moving the deadline back)
5. Completion of final design
6. Freeze engineering design (typically by the 30% work-effort milestone)
7. Beginning of drafting
8. Start of final design
9. Notice to proceed with detail engineering

Design Freeze

One of the initial efforts of the detail engineering stage is the finalization (freezing) of the process PFDs and design criteria.

The necessity to fully freeze a design in a timely manner is so fundamental to project success that it needs special mention. Schedule and budget will never be met if design changes are allowed to happen after the official freeze date. This step is essential for detail engineering to begin and for project scope to be maintained.

The key elements to freeze are the PFDs, P&IDs, and the plot plan for the major facilities. All parties (especially the Owner) must commit to no more changes before the Engineer is allowed to embark on detail engineering. It typically takes a month after the Owner agrees to the design freeze before drawings are actually issued for design (IFD).

Final Design Criteria

The objective of the final design stage of the detail engineering is to take the plant concepts from the feasibility study or design engineering scope documents and put them into formats that can be understood and used by others to procure and construct the plant.

Detail engineering begins with the project-specific criteria. EPCM companies use different forms and vocabulary, but nothing can be engineered until everyone agrees what is to be built and where and how it is to be built. The design criteria component of the engineering specifications answers these what, where, and how questions.

If the HAZOP review was not conducted at the end of basic engineering, it must take place now, with the PFDs and the vast majority of the P&IDs in hand, with the major equipment layouts frozen, and before detail engineering gets fully underway. The initial HAZOP review has to be conducted before P&IDs can be IFD.

Final design requires conduct of all the review and approval steps laid out in the project procedures manual, including the completion of all calculations and any remaining value engineering trade-off studies.

Value Engineering Trade-Off Studies

All value engineering should have taken place, to the greatest extent possible, in the prefeasibility study phase (the period specifically set for looking at project alternatives). The remaining alternatives that were not looked at in the prefeasibility (or feasibility) phases are looked at now, prior to embarking on final design (see Chapter 6).

Value engineering is the formal review of plans, drawings, specifications, and schedules to achieve advantageous innovative design changes or substitutions. As General George Patton once remarked, “If everyone is thinking alike, then somebody isn’t thinking.” The goal is to reduce projected capital or operating costs and/or to shorten the schedule. Invariably, the greatest cost-saving opportunities will come from procedures that shorten the project schedule, for example, by devising means to complete critical activities concurrently rather than in sequence. Value engineering is a tool that can find a more cost-effective means of achieving the desired result.

Thus, during the finalization of design, process and design concepts are reexamined and optimized wherever possible. Functional analysis is used to eliminate or modify scope items that do not add value, to eliminate the nice-to-have and the technical overkill items that may have slipped into the project. That said, the project team must still manage the engineering contractor to ensure that only feasible engineering solutions are found, and that the work performed remains in accord with the standards required. It is preferable that these remaining value engineering efforts be complete before the first HAZOP review, but not mandatory.

Environmental Impact and Permitting

Environmental impact and permitting considerations can impose restrictions on engineering. Thus it is the responsibility of the project manager to coordinate these requirements in such a way that project progress is not impeded, and that the engineering is performed in accord with permit constraints. The amount of reciprocal input from the Engineer to the permitting process will depend heavily on the relevant experience of the engineering team and its familiarity with the process and location. All preconstruction permits must obviously be secured during the engineering stage.

Social Acceptance and Sustainability

The Owner's social responsibilities within the project area are more likely to affect procurement and construction rather than engineering, but even so, social issues along with sustainability considerations can often result in project restrictions. It is the responsibility of the project manager and his or her team to ensure that the engineering is performed in conformance with all such requirements.

Detail Engineering Drawings

The project manager develops a checklist for the project, summarizing the general drafting needs such as standards, scale, sheet numbers, and drawings content:

- PFDs
- Mass balance schematics
- P&IDs
- GAs
  - Civil GAs
  - Area layouts
  - Final plot plans
- Facilities
- Architectural
- Civil
- Concrete
- Structural steel
- Piping
- Pipeline list
- Tanks
- Mechanical
- Mechanical and electrical equipment lists
- Electric motor list
- HVAC and plumbing
- Valve list
- Cable and conduit layout
- Electrical schematics
- Electrical physicals
- Instrumentation schematics
- Instrument list or instrumentation log

Each time plans are drawn, marked up, checked, or approved, the designer, drafter, and reviewer need to personally initial and date the drawing rather than using an initials stamper.

The detail engineering drawings that need to be sent to contractors, vendors, and others for quotations or information are tracked by revision letter (i.e., beyond Rev D). For control purposes, any drawing issued for markup, comment, and so forth, must be taken to the next revision letter before any further work takes place on that drawing. On reviewed drawings that require subsequent revision, the revision date and the type or purpose of the review should always be indicated. Additional changes should not be made until the drafter has had the opportunity to incorporate all prior revisions.

Drawing Checks

When a drawing is 90% complete, the drawings can be submitted to the Engineer's checkers for review, along with all backup materials used to create the drawing. Backup materials include the scope of work, design criteria, and functional philosophy.

Checkers have to be thorough and consistent in the manner in which they mark up prints. In particular, checkers need to look for

- Conformance to project scope, specifications, relevant codes, and project procedures;
- Consistency between schematic design, design criteria, and construction documents;
- Uniformity between construction drawings and specifications; and
- Conformance to Owner and Engineer's standards.

Checkers must never use old or superseded prints for markup. Checkers need to make sure that

- Title block information is correct;
- Bills of materials, tables, cross references, and so forth, on the drawings are factually correct;
- Correct system of weights and measures have been used (imperial vs. metric);
- Drawing scale, dimensions, coordinates, and north orientation are all appropriate;
- All sections, centerline usage, and detail call-outs are as per standards;
- Bolt sizes, grades, and quantities are verified, and welding procedures are checked;
- Pipe sizes, grades, and quantities are confirmed;
- Drawings are in compliance with the design criteria and drafting standards;
- CAD files' dimensions and lines have not been corrupted;
- Buildability has been met such that the facilities can actually be built or accessed as shown;
- There is enough information for the constructor to complete the work; and
- Information is clear and leaves no questions unanswered.

After the checker's comments have been addressed, the drawings are ready for final engineering review, that is, a complete review of the drawings by the drafting department head with follow-up review from the engineering manager. The project manager is then responsible for the final drawing review.

To be finalized, the drawing originals need signatures from all the proper parties: the designer, chief designer, discipline engineer (with engineering seal attached), checker, engineering manager, and project manager. After this final engineering review and sign-off, the final detail engineering drawing package can be transmitted to the Owner for approval. Once Owner-approved, the drawings can be deemed ready to be IFC and taken to Rev 0.

DRAWING REVIEWS

Drawing reviews are a requisite element of any engineering effort, as well as a critical component of the project QA/QC program (see Chapter 23). Several additional reviews are needed within the engineering phase, in addition to the aforementioned engineering drawing reviews. Reviews add a finer level of control over projects. The next few sections describe the types of reviews typically used within a major mining project.

Engineering Team Reviews

The engineering drawing reviews requisite for every project are listed here.

- **Conceptual review**—This review takes place early in the design phase to determine if the project will do what it is supposed to do within the budget available.
- **Intradisciplinary review**—Each discipline checks its own work to ensure that assumptions, calculations, and solutions are correct.
- **Interdisciplinary review**—Drawings of each discipline are checked against the other disciplines to detect interference, conflicts, and omissions.
- **Drawing and specification cross-check**—A specifications writer conducts this review to determine if the specification is complete and complementary to the drawings, and that the Owner's standards have been complied with.
- **Multifacility cross-check**—This check is performed on projects with several buildings or installations to ensure that connecting common items are shown correctly matched.
- **Code review**—An experienced designer or building department official conducts this review to ensure code compliance as well as federal and state regulations compliance. Typically, each discipline contacts the applicable utilities and public authorities individually to secure approval for connection to services.
- **Scope and budget review**—The project manager conducts this review after each engineering phase to ensure that the project remains within the approved scope and budget.

Vendor Review

A representative of the supplier conducts this review to confirm that the equipment or material is available, the model chosen is appropriate, and that the specification is current and complete.

Constructability Reviews

Detail engineering drawings are often produced by personnel who have never worked on a construction site. This lack of hands-on field experience needs to be overcome by bringing in people with experience in construction and rigging procedures to review the drawings. Seasoned, knowledgeable individuals (preferably the construction manager responsible for field construction) should conduct the constructability reviews. If field personnel are not available, a retired construction manager is a good resource.

Constructability addresses project layout (rigging, access issues, etc.), construction sequencing, and the timing of construction deliverables. *Constructability* is defined by the authors as "the optimum use of construction knowledge and experience in all project phases, from concept through execution" (DictionaryOfConstruction.com 2014).

Constructability reviews take place prior to construction contract bidding to determine (and hopefully remove) any conflicts or problems in regard to ease of construction. Ideally, the reviewers are brought in as part of the engineering team from the inception of engineering (preferably starting in the conceptual design phase). The ideas and suggestions of these persons will help develop project construction methodology. They should conduct continuous constructability reviews throughout the engineering effort. The merits of any construction staging would logically also be addressed by these same individuals.

Operations Buy-In

A key role for the project manager is to ensure that the Owner's O&M departments are an informed part of all major project decisions. To this end, it is normal (and certainly desirable) for the project manager, along with key members of his or her team and at least one operations process person, to be physically located in the engineering contractor's office throughout the engineering phase.

The project team needs to participate extensively in the engineering activities and to have access to engineering records and documentation. The seconded Owner's representative, typically the future plant manager, becomes part of the project team and uses his or her operations prowess to review the documents, looking for operational issues (e.g., valves located 12 feet above the work floor.)

Operability reviews should include as a minimum PFD reviews, P&ID reviews, and 3D model reviews. The project manager acts as the interface between the operations personnel and the engineering contractor in regard to issues raised during these operability reviews. To achieve a successful project outcome, the project manager must continually ensure Owner operations buy-in of the process, design criteria, plant layout, and all other aspects of engineering that can impact the smooth operation of the Owner's facility.

Hazard and Operability Review

A HAZOP review has to be conducted at least once (preferably twice) during the engineering phase of the project. This review is a structured and systematic examination of the planned project processes and facilities that identifies and evaluates potentially hazardous operations or conditions in the finished facility that could represent risk to personnel and/or equipment, or that may prevent efficient facility operation.

A HAZOP review is a qualitative technique based on guide words and is carried out by a multidisciplinary team (including all the engineering discipline leads and key Owner O&M personnel) within a set of very structured meetings, normally led by an external specialist facilitator. The HAZOP review is typically applied to the project's PFD whenever the full suite of design information is available. The PFD is then examined in small sections, such as individual items of equipment or the pipes between them. For each of these items a design intention is specified. The HAZOP team then determines the possible significant deviations from each intention, along with feasible causes and likely consequences. It can then be decided whether the existing, designed safeguards are sufficient or additional actions are necessary to reduce risk to an acceptable level.

A HAZOP review can be accompanied by other specialist assessments such as a compliance review for the International Cyanide Management Code for the Manufacture, Transport and Use of Cyanide in the Production of Gold whenever a gold processing facility is involved.

These days a HAZOP meeting generally uses one of the several commercial software programs available to record the deviation and the consequence. The leading HAZOP software used within the mining industry are PHA-Pro (expensive but comprehensive) and LEADER (good and less costly than PHA-Pro).

A mining project HAZOP meeting can generally be conducted in 3–10 days, but for very large projects, it may take as many as 6–7 weeks. The HAZOP review is not normally performed until about 25% of the engineering is complete, that is, after all the design information becomes available but early enough to avoid any major rework. The second follow-up HAZOP review is typically undertaken with around 70% of the total engineering complete. The second review usually takes only 60% of the time taken in the initial HAZOP review.

Fatal-Flaw Analysis

One of the final acts of the home-office engineering effort, prior to construction or field engineering activities, is a formal fatal-flaw analysis. This effort is best conducted by one of the niche outsource engineering firms that specializes in this activity.

Drawing Review Checklist

A drawing review checklist should be completed as part of the drawing reviews, to capture for the record the full suite of reviews that have been conducted on the project. The completed checklists are then placed in the project file.

SPECIFICATIONS

Projects need precise engineering specifications for the procurement of equipment on the project equipment list (i.e., the equipment list derived from engineering drawing takeoffs) and the bidding of the construction effort. Construction specifications have to state

- **Where** the facility is to be constructed,
- **What** the materials are,
- **How** they are to function,
- The **quality** of materials and equipment,
- **When** the construction effort is to take place,
- The installation **methods** and **techniques**, and
- The **results** to be achieved.

In addition, construction specifications may also define testing requirements, measurement procedures, and payment procedures. Specifications require clear and concise documentation on which an equipment vendor can quote and/or a construction contractor can bid. The equipment vendor wants the sale, and the contractor wants the construction conducted and then closed out with the least possible misunderstanding. Brevity, consistency, and lack of redundancy are identifying marks of professionally prepared specifications. Accepted industry standards such as SpecText, AIA, and U.S. Department of Defense can be drawn from as a basis for writing specifications, if needed.

Personnel and Roles

Working through the engineering manager, the project manager is responsible for the initial specification determinations and for developing the final specifications products. The project manager is also tasked with establishing the coordination, equipment delivery, and installation schedules that may need to accompany the specifications. The project manager has the final responsibility for checking the specifications. Specification checklists should be used in conjunction with work plan checks.

The engineering manager establishes a specification format to fit the particular project. The engineering manager assembles the documents for technical specifications, general conditions, special provisions, quotation requests, and bid proposals based on the needs of the project and the Owner, and the EPCM's internal standards. The engineering manager verifies the specification format and any Owner special requirements. In the case of construction specifications, the engineering manager also verifies interrelations with the work of other consultants and subconsultants.

Preparing Specifications

The methodology for preparing specifications is generally as follows:

1. The engineering manager submits final design information to the individual assigned to write the specification as soon as data become available from the discipline engineers.
2. The specification writer (usually an assigned engineer from the discipline involved) prepares a first draft of the specification. This first draft is based on the available design information, as well as the known construction program requirements (in the case of construction specifications).
3. The specification format then typically follows the in-house default master document of the EPCM contractor, unless the Owner requires a different arrangement.

The specifications include the following, as applicable:

- Basic technical requirements
  - Specifications, codes, and industry standards, including dates
  - Test, inspection, and special instructions regarding the design, fabrication, construction, cleaning, preservation, identification, erection, shipping, and storage of project equipment
  - Environmental requirements for equipment and material
  - Quality acceptance criteria
- Lists of the documents to be prepared and made available, for example,
  - Drawings
  - Specifications
  - Procedures
  - Procurement documents
  - Inspection plans and records
  - Test procedures and records
  - Personnel and procedure qualifications
  - Material, chemical, and physical test results
  - Instructions on record retention and disposition
- Provisions for the following:
  - Source inspection—Provisions for access to the plant facilities and records for source inspection of procured materials and equipment, when the need for such inspection has been established by the project manager.

- Lower tier (subcontractor, bulk and local supplier) procurements—Provisions for extending applicable requirements of procurement documents to subcontractors and suppliers, including ensuring Owner's access right to facilities and records.

Review and Revision of Specifications

A copy of the draft specification is furnished by the specification writer to the discipline supervisor, who reviews it and then passes it on to the engineering manager, who reviews it and passes it on to the project manager.

The project manager reviews the first-draft specification and recommends revisions to the specification as required. The extent of the review will depend on the uniqueness of the item, the complexity of the design, the degree of standardization, the state of the art of the design, and similarity to proven designs.

The specification writer then revises the draft as necessary, and the revised specification is sent to document control for final preparation. The specification writer checks the completed document produced by document control for correctness and then sends the document to the project manager for final approval.

The bulk of the produced final detail engineering specifications will always be the construction specifications, but on most projects there will also be some equipment specifications for the procurement of certain specialty items on the equipment list.

FILING COMPLETED DRAWINGS AND SPECIFICATIONS WITH AUTHORITIES

Upon completion of the project drawings and specifications, generally before the selected construction contractor mobilizes to the site, a set of the pertinent contract documents normally needs to be filed with the applicable authorities, such as the following:

- County or city building department
- Fire marshal
- Department of Health
- Environmental agencies
- Utility companies and/or governmental services departments

ENGINEERING SCOPE CONTROL

Adherence to tight scope control (see Chapter 21) is paramount during engineering but none more so than in the detail engineering phase. As such, early agreement on the project's PFDs are essential. Project scope changes during the engineering stage of a project have the most potential for significantly impacting the cost of a project (either positive or negative). Hence it is an important project team function to carefully monitor and control scope.

Engineering progress is typically measured via a prescriptive set of rules of credit for certain milestones achieved on each individual drawing and/or specification. The project manager needs to understand these rules of credit, and then once in agreement, makes sure they are adhered to.

In most instances, the EPCM will be assigned the role of managing the engineering costs and, in fact, is generally the best suited entity for the responsibility. Nonetheless, extensive participation and oversight must be maintained by the project manager and his or her team. Certainly, change control approval needs to stay in the hands of the project manager. Close adherence to project procedures for all contemplated changes provides the best likelihood of preventing surprises to costs and/or schedules.

The engineering deliverables require approval by the project team prior to any final execution by the EPCM. Notably, however, such approvals by the team do not absolve the Engineer from his or her contractual obligation to perform. Consequently, care needs to be exercised to ensure that approval does not ambiguously trigger a claim for further work, and that such approval stays in accord with the terms and conditions of the contract. Clouded issues are often seen by contractors, even in the best of partnering relationships, as an opportunity to submit a claim for extra work, particularly with lump-sum contracts. On reimbursable, time and material contracts, care also needs to be taken to ensure that the contractor does not have the opportunity to spend additional time for work efforts that do not advance the project goals.

DELIVERABLES OF DETAIL (FINAL DESIGN) ENGINEERING

The deliverables of engineering through the completion of the detail engineering phase are the following:

- General design criteria
- Applicable standards and codes
- Process design criteria
- PFDs and P&IDs: mass balance schematics
- General engineering specifications:
  - Civil/structural, including concrete, concrete coating, and steel
  - Architectural design (i.e., quality of buildings, facilities, furnishings)
  - Piping design and installation
  - Tank fabrication and erection
  - Mechanical design
  - Major equipment and equipment installation
  - HVAC and plumbing
  - Insulation, painting, and fireproofing
  - Electrical design
  - Instrumentation design
  - Process control design
  - Environmental design
  - Construction
- Specialty specifications criteria and qualifications:
  - Quality
  - Environmental compliance
- Control philosophy (Expert Systems, programmable logic controllers [PLCs], and/or distributed control systems [DCSs])
- Data sheets
- Equipment lists (see breakout details in the following section):
  - Mechanical equipment list
  - Electric equipment list
  - Electric motor list
  - Valve list
  - Instrument list (often referred to as the instrumentation log)

- Plot plans
- GAs
- Engineered drawings (detailed sufficiently to permit construction, i.e., IFC Rev 0 drawings):
  - Civil/structural
  - Architectural
  - Piping
  - Mechanical
  - HVAC and plumbing
  - Electrical and instrumentation
- Pipeline list
- Cable and conduit layouts
- Electrical and Instrumentation schematics
- Calculations for each design package
- Value engineering trade-off studies (typically mostly conducted in prefeasibility):
  - Process design
  - Physical plant
  - Equipment selection
  - Transport mechanisms
- Manuals:
  - Operating
  - Maintenance
- Inspection plans
- Test procedures
- Material, chemical, and physical test results (when applicable)
- Regulatory filing requirements
- Training protocols
- Start-up plans
- Procurement documents: Purchase requisitions (for major equipment)—issued to the procurement group
- Material control procedures
- Instructions for record retention and disposition

It is the responsibility of the document control department to record all deliverables transmitted to any party external to the engineering department.

Equipment Lists

Equipment lists in accord with the WBS codes are prepared by the appropriate engineering discipline leads for all permanent equipment. These would include, as a minimum, the mechanical equipment list, pipeline list, valve list, electric equipment and motor lists, and instrument list (Brokenshire, Easterberg, and Saccany 2007).

Mechanical equipment list:

- P&ID number
- Equipment number as per the WBS code
- Equipment title

- Area where equipment is used
- Number of units
- Specification number
- Installed power (kW or current at stated voltage)
- Supplier of the equipment
- Capacity
- Contract or purchase number of supplier

Pipeline list:

- P&ID number
- Pipe commodity and service code
- Line sequence number (per the WBS code)
- Size
- Pipe material code
- Insulation code
- Activity code
- Design and operating temperature
- Design and operating pressure
- Test pressure
- Commodity state
- Lining

Valve list:

- P&ID number
- Valve tag sequence number (in accord with the WBS code)
- Line specification
- Valve type
- Valve size
- Commodity and service code
- Pipeline number
- Valve flange specification
- Valve body material
- Valve seat type
- Valve operation and actuation
- Valve pressure rating
- Make or model of valve
- Supplier
- The ISA-approved data sheet (for control valves; ISA is the International Society for Automation)

Electric equipment and motor list:

- P&ID number
- Equipment type

- Sequence number (in accord with the WBS code)
- Motor description
- Motor rating (kW)
- Operating voltage (V)
- Full load current (A)
- Motor speed (rpm)
- Number of poles
- Motor type
- Frame size
- Cooling
- Mounting
- Starting method
- Coupling type

Instrument list:

- P&ID number
- Type of instrument
- Sequence number (in accord with the WBS code)
- Suffix
- Tag number
- Loop number
- Instrument make
- Instrument description
- Process equipment description
- Process equipment number
- Associated ISA-approved data sheet

COST-ESTIMATING INPUT

Cost estimating is frequently a requisite part of the engineering process. If estimating is a component of the Engineer's scope, then before beginning the estimate itself or providing input to the party creating the estimate, the Engineer must understand what level of estimate is required. Recall from Chapter 11 that the quality and accuracy of any produced cost estimate will directly depend on the progress stage of the design development and/or the level of completion of the drawings and specifications. The required level of estimate defines the precision for the quantities.

The Engineer will also need to know how the Owner intends to use the estimate. Will it be to budget for actual construction or just a scoping evaluation of probable cost? If the Owner is using the estimate to obtain financing, the contingency level will have to cover design issues that may not have emerged yet. As design develops, contingency factors will shrink, but even final estimates still have to include some allowance for changes encountered during construction. Once the type of estimate required is understood, the determination of quantities, costs, and markups can be undertaken by the Engineer and then submitted to the party responsible for project budget assembly.

CONSTRUCTION BIDDING SUPPORT—ENGINEER'S ROLE

The EPCM is the entity that undertakes most of the support work for the project manager in the bid process which selects the site construction contractor(s). See Chapter 29 for more details.

Invitation to Bid

The Engineer's role in supporting the Owner with the invitations to bid on the construction work effort is generally quite extensive. The following duties are typically required of the Engineer.

1. Verify for the project manager that the assembled contract documents are complete enough to allow accurate and competitive bidding. For multiple contracts, verify that the limit of each contract's work scope is clearly delineated.
2. Verify that the construction contractor and/or the Owner agreement is consistent with the Engineer–Owner agreement language.
3. If bids are by invitation, assist the project manager in the request for qualifications (RFQ) process to create the list of qualified contractors. Help establish a basis for evaluating the bids.
4. Help the project manager prepare the list of bid documents and drawings. Determine a cost for the plans and specifications supplied to bidders.
5. Assist the project manager in the distribution of bid forms and documents.
6. Assist the Owner with preparation of agreement forms, bonds, certificates, and so forth.
7. Set a cutoff time for written questions and substitution requests from bidders.
8. Keep a set of the bid documents on file for review in the EPCM office.
9. Treat bidders equally in all respects throughout the bidding period.
10. Distribute responses to inquiries to *all* bidders. Do not accept verbal inquiries.
11. Record all contacts and transactions with the bidders in the project file.
12. Prepare and issue addenda covering clarifications and revisions to the bid documents throughout the bid period. Keep a log of the documents distributed.
13. Restrict the tender of bids to only one office, typically the EPCM office.
14. Set a deadline for bid submissions. Do not accept bids after the stated deadline.

Bid Opening and Evaluation

The Owner is in charge of bid opening, but the project manager, aided by the entity that prepared the bid documents (the EPCM), typically manages the bid-opening process.

1. The EPCM prepares a bid tabulation sheet for the project manager. Bids are evaluated for the following:
   - Compliance with the request for proposal (RFP) document
   - Technical considerations
   - QA requirements
   - Contractor's capability, including personnel capabilities
   - Physical conditions of contractor's fabrication facility and equipment
   - Management attitude toward quality, safety, and environmental and social issues
   - Construction contractor's past performance
   - Alternates available

  - Exceptions
  - Arithmetic within the submitted bid, that is, a search for math errors
2. After the evaluation, the project manager (aided by the EPCM) makes a recommendation to the Owner for the award of one bid or the rejection of all bids. If all bids are rejected, the EPCM has to develop a detailed rationale for the action. The Owner's decision is final.
3. The EPCM assists the project manager in notifying the unsuccessful bidders.

Bid Award

Selection of the winning bidder initiates the bid award process:

1. Upon receipt of the Owner's contract award authorization and successful bidder notification, the EPCM prepares the paperwork for the Owner to award the winning bid and the contract documents for execution by contractor and Owner.
2. The EPCM helps the project manager obtain all the required documents from the successful contractor, such as bonds, insurance certificates, subcontractor lists, and schedules.
3. If the chosen bid is over budget, a review of the original estimate is made to determine if the estimate was appropriate. If changes to the bid are feasible, these are negotiated with the successful bidder to bring the amount into budget.

Quality should never be lowered to bring a bid into line; rather, delete scope. If no changes can be made, the Owner will need to revise the budget. If scope is changed, the pertinent drawings and specifications will need to be updated and reissued.

Substitutions

Construction contractors frequently propose substitutions to the original bid request package specifications, mostly for the contractor's benefit, not the Owner's:

1. To control substitutions after award, construction contractors must be required to accompany substitution requests with complete data on the proposed substitution.
2. Substitutions must provide the same guarantees as the specified product, and the contractor has to assume all substitution costs.
3. A proposed substitution has to be evaluated for the consequences of change. The project manager normally uses the EPCM to perform these evaluations. The cost of the EPCM's evaluation time should be billed to the contractor by the Owner.

FIELD ENGINEERING

The basic relationship between the parties in a construction project is that the Engineer designs the project, the construction contractor builds the project, and the Owner pays for the project that the engineering company has designed and the contractor has built.

Field Engineer's Role

The design engineer should always endeavor to be the entity that provides full field engineering services for the construction phase, because such services provide the last and best opportunity to identify and correct issues arising as a result of misunderstanding or misinterpretation of the engineering drawings and specifications and/or the contract documents.

The field engineer will typically be assigned the authority to reject work that is defective or does not meet contractual requirements and recommend to the project manager that work be stopped due to nonconformance or negligence on the part of the contractor. The field engineer normally does not have the actual authority to stop work under industry-standard agreements. Only the project manager (on behalf of the Owner) can stop the work. The field engineer's efforts are directed toward securing compliance of the finished product with design specifications.

The field engineer's standard of performance is as follows:

- The field engineer is not accountable for observing every act of the contractor.
- The field engineer should not supervise or direct the work or instruct the contractor on how to perform.
- The field engineer must meet a reasonable standard of skill and competence in observing the work and in endeavoring to determine if the work is done in accordance with the design specifications and contract documents. The field engineer can be held responsible by the Owner for negligence if these "reasonable" standards of performance are not met.

Field engineering services within an Engineer–Owner contract need to be carefully defined, as they go beyond traditional engineering duties. It is often beneficial to negotiate a separate contract and fee for these services. Certainly, the Engineer will expect additional compensation for this extra work because of the additional risks and accountabilities.

Field Engineer's Tasks

The field engineer's duties are, in large part, administrative support tasks on behalf of the Owner to ensure that the construction contractor delivers the specified design. Tasks include the following:

1. Attend the preconstruction kickoff meeting. Attendance is typically mandatory for the Engineer, as well as for the construction contractor, all major subcontractors, and major subconsultants. Agenda items that would affect the field engineer's role include the following:
   - Introductions (identification of who makes the decisions for each party)
   - Project review
   - Communications procedures
   - Submittal procedures
   - Change order procedures
   - Technical specifications
   - Insurance compliance documentation
   - Required testing, including any special conditions
   - Project meetings protocol (when, who attends, and who runs the meetings)
   - Any pertinent field observations made to date by the EPCM or subconsultants
   - Utility concerns
   - Contractor concerns
   - Issuance of Notice to Proceed
   - Project permits (particularly the construction permits) and who secures them
   - Review of the contractor's schedule of required shop drawings

  - Review of the construction contractor's estimated progress schedule
  - Review of the Owner schedule for submitting applications for permanent gas, electric, water, and telephone services, and for securing those services on-site
2. Attend construction meetings and prepare memos as required by the project manager.
3. Ensure survey marks are established as needed.
4. Obtain and review all required test reports.
5. Maintain a complete set of project drawings, specifications, and standards on-site. Electronic transmittal of documents from a home office to the field is a necessity.
6. Maintain the drawing control list to ensure that work is carried out to the latest issue.
7. Review shop drawings, then comment and return them to the project manager for delivery to the contractor.
8. Receive samples, then review, comment, and return them to the project manager for delivery to contractor.
9. Make sure submittal reviews are timely so as not to delay the project.
10. Maintain shop drawings and sample logs.
11. Review delivery schedules for EPCM-procured materials.
12. Assist with the coordination of Owner-supplied items.
13. Review all supplier test certificates, data, drawings, and manuals for completeness and compliance with design intent.
14. Keep a complete set of vendor prints and O&M manuals on-site.
15. Maintain an up-to-date equipment list and data sheet file on-site.
16. Have engineering subconsultants visit the site to observe specific events.
17. Monitor actual work progress versus the project master schedule.
18. Keep the project manager informed of the progress of the work and any problems.
19. Review the contractor's proposals for design changes. Ensure that change order procedures are followed.
20. Prepare field orders (i.e., those no-cost items not affecting schedule or design intent).
21. Coordinate with subconsultants for change orders, reports, site visits, and so forth.
22. Maintain a file of all construction QC reports.
23. Maintain site reports, construction meeting memos, telephone logs, and so forth, in the project file.

Shop Drawings Review

The project manager needs to make sure that the construction contractor is aware of the Engineer's duties with regard to shop drawing submittals. These duties need to be spelled out in the general conditions of the construction contractor agreement.

1. The constructor must provide a submittal schedule for shop drawings:
   - Shop drawing submittals should consist of one transparency and six prints.
   - Each shop drawing should include date received, project name and number.
2. Before the Engineer reviews shop drawings, he or she must verify that the contractor has already reviewed them.
3. The Engineer has to maintain a complete set of shop drawings with the construction drawings, identifying their location and submittal date in the shop drawing log.
4. The Engineer must not add shop drawing requests that go beyond the contract terms.

5. The Engineer must avoid requests to resubmit shop drawings that could delay the project.
6. Within the reviews and/or markups, the Engineer should not use the phrase "by Others." Use words identifying who is responsible for the work, for example, "by mechanical contractor."
7. If the shop drawings show change from the contract documents, the Engineer must prepare documentation for the project manager to state whether it is approved or not.
8. The Engineer typically has the duty to notify the contractor in writing on behalf of the project manager if a submittal or partial submittal is approved.

Guidelines for Field Engineer Site Observations

The field engineer needs to follow general guidelines when conducting site duties or making site observations:

1. View the work in conformance with the contract documents. Record discrepancies.
2. Be especially observant during early construction; it is easier to correct mistakes earlier than later.
3. Do not suggest means or methods for the contractor to accomplish the work.
4. If the general contractor on-site requests engineering guidance relating to the interpretation of, or coordination with, a subcontractor's work, give the interpretations to the general contractor, never to the sub unless the general contractor is present.
5. Do not be pressed into hasty decisions.
6. All design is supposed to occur before bidding. Once construction begins, put all design growth and/or changes in change orders.
7. Do not give the contractor the impression that you have more authority than you really do.
8. Be aware of your implied duties
   - Not to interfere with the contractor's work,
   - To cooperate with the contractor,
   - To inform the contractor with information relevant to the project, and
   - To assist the project manager in coordinating other contractors not under the general contractor's control.
9. Generally, do not interfere with job-site safety procedures of the contractor.
10. Record all site observations on standard site observation forms. Use either the EPCM inspector's daily report or the EPCM project field observation report.

Site Observation Reports

Project observation reports should always be used to document items discussed in the field and the agreements reached during those discussions. Construction deficiencies should be noted in these reports. The project manager determines who receives the reports.

Copies of testing and inspection reports prepared by outside labs and/or agencies for concrete, steel, soils, and so forth, should be routed to the project manager for review as soon as they are received. Request that test reports be submitted with special markings to identify conditions which do not conform to the contract documents. All important project activities should be recorded on photographs or videos.

Key Site Events to Monitor

At the beginning of the project, the field engineer should create a list of the milestone tasks to be observed, so they are not missed. The minimum time for notifying the Engineer prior to any desired observation milestone needs to be noted in the original contractual specification. The following is an example of such a list:

- Site excavation, grading, and backfill
- Utility layout and installation
- Location of temporary facilities and services
- Foundation layout, formwork, reinforcing, concrete pours, and testing
- Liner layouts and installations
- Slab placement, reinforcing, finishing, and testing
- Crane locations
- Superstructure—steel or timber framing, concrete, masonry walls, and precast
- Roofing—deck placement, insulation, flashing, and roofing systems
- Exterior wall enclosures—windows and doors
- Plumbing—layout, fixtures, and tests
- HVAC—layout, equipment installation, ducting, and testing
- Piping—layout, fixtures, and tests
- Partition layout, erection, and concealed work
- Mechanical installations
- Electrical layout, equipment, and fixtures
- Instrumentation equipment installations
- Finish applications
- Special construction and equipment installation
- All testing requirements

PROJECT COMPLETION AND CLOSEOUT

Project closeout activities of the Engineer, such as archiving files, drawings, and computer data, and conducting project analyses, are accomplished during the construction completion phase.

Record (As-Built) Drawings

Production of the record drawings (the as-built drawings) at the time of construction completion is generally the responsibility of the Engineer—sometimes as a part of basic services and occasionally as an additional service. Record drawings show all deviations from the construction documents that occurred during the period of construction.

The construction contractor is responsible for maintaining the necessary information for creation of this record at the site, noting all changes, deviations, and modifications on a set of red-line documents that have to be transmitted in a timely way to the Engineer. The field engineer is responsible for the collection of this closeout information from the site constructors and delivering it to the Engineer.

Postconstruction Operational Phase

Any engineering assistance for start-up and operation and maintenance of the project facilities, if requested by the Owner, is generally best provided by the Engineer in a separate cost-plus (time and materials) contract to the Owner. Scope definition for this support activity is practically impossible to determine up-front.

ENGINEERING REPORTING AND RECORDS MAINTENANCE

Part of the responsibility of the project team is to establish the reporting systems and control procedures necessary to adequately monitor the progress of engineering.

Schedule Maintenance

All engineering schedules are maintained within the constraints of the project master control schedule. During the engineering stage, the first detailed project execution schedule is developed. This is the initial resource-loaded schedule for use in construction planning.

Engineering Reporting

The control mechanisms for engineering progress need to report the following on a monthly basis:

- Design status
- Drawing production and status
- Specifications package production and status
- Overall engineering schedule status
- Individual engineering discipline progress curves and schedules
- Overall engineering progress curve and schedule—coordinated with project schedule
- Home-office status report
- If work is conducted in multiple offices, status at each office
- Field engineering activity
- Vendor drawings status
- Trend notices
- Labor-hour forecast and schedule
- Actual labor-hour efficiency versus forecast
- Cost and cash flow forecast

The monthly report tracks variances to the project's control schedule and communicates makeup methodologies for any significant project deviations. Full distribution of the monthly report keeps all stakeholders informed of engineering progress. Separate, targeted distribution of weekly activity reports aids in this communication effort. See Chapter 22 for details of the overall project reporting requirements.

Record Keeping

Document control typically keeps the following records to track the engineering effort:

- Drawing status schedule
- Specification status schedule
- Drawing transmittal record
- Specification transmittal record
- Equipment list—coordinated with procurement and project management
- Scope definition and control, including tracking change orders—coordinated with project management

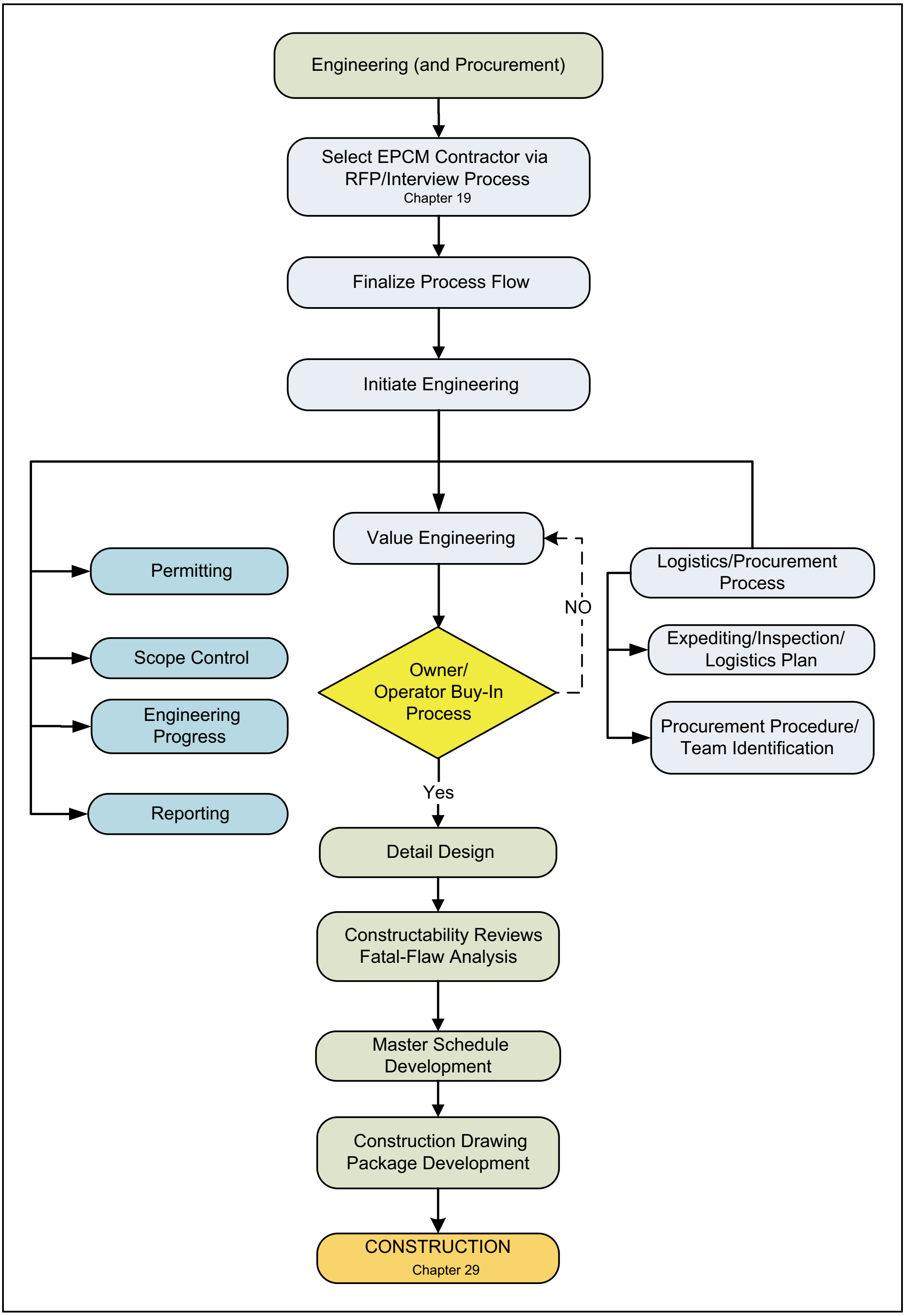
CHECKLIST 27.1 ENGINEERING

No.	Item	Status	Date	Initials
1	Engineering (EPCM?) contractor—appointed			
2	Project scope of work—set			
3	Project coordination master schedule—established			
4	Drawing identification protocol—adopted			
5	Predesign phase—undertaken			
	A. Engineering basis—prepared			
	B. Engineering work program—set in conjunction with Owner			
	1. Progress measurement procedures—defined			
	2. Engineering master schedule—established			
	3. Labor-hour forecast—issued			
	4. Scope change approval process—established			
	5. Forecasting and trending—instituted			
	C. Engineering procedures—set up			
	D. Program administration and coordination protocols—established			
	E. Progress and status reporting requirements—defined			
6	Site analysis study—complete			
	A. Site information—gathered			
7	Conceptual design—developed			
	A. Schematic conceptual designs—issued			
	B. Probable cost estimate—derived			
	C. Owner authorization to proceed to basic engineering—approved			
8	Basic engineering—conducted			
	A. Functional philosophy—established			
	B. Design development steps—undertaken			
	1. Applicable standards and codes—adopted			
	2. Design criteria—issued			
	3. Process flow diagrams (PFDs)—fixed			
	4. Initial equipment list—produced			
	C. Standardization of systems and components—set with Owner			
	D. Basic engineering drawings, calculations, and specs—issued			
	E. Compliance verification—obtained from regulatory agencies			
	F. Owner authorization to proceed to detail engineering—approved			
9	Detail engineering—completed			
	A. Design freeze—agreed with Owner			
	B. Final value engineering trade-off studies—completed			
	C. Environmental impact, permits, social considerations—imposed			
	D. Vendor review comments—incorporated			
	E. Control philosophy (expert system, PLC and/or DCS)—set			
	F. Operations buy-in—accomplished			
	G. Constructability review—undertaken			
	H. HAZOP and fatal flaw analysis—completed			
	I. In-house drawing reviews and checks—complete and signed off			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
10	Engineering deliverables—issued			
	A. Design criteria, standards, and codes			
	B. PFDs, mass balances, and P&IDs			
	C. Engineering specifications			
	D. Calculations			
	E. Control philosophy (expert system, PLC and/or DCS)			
	F. Data sheets			
	G. Equipment and pipeline lists			
	H. Cable and conduit layouts			
	I. Electrical and instrumentation schematics			
	J. Manuals and training protocols			
	K. Plot plan and general arrangement drawings (GAs)			
	L. Detail engineering drawings (Rev 0)—issued for construction (IFC)			
	M. Test procedures and inspection plans			
	N. Regulatory filing requirements			
	O. Start-up plans			
	P. Purchase requisitions—issued to procurement group			
	Q. Material control procedures			
	R. Records retention instructions—issued to documents group			
11	Specification deliverables—issued			
12	Filing of completed drawings and specifications with authorities—delivered			
13	Cost-estimating input—provided			
14	Construction bidding support—provided			
	A. Construction packages (drawings, specs., etc.)—prepared			
	B. Bid evaluations—reviewed for compliance			
	C. Substitutions—evaluated			
15	Field engineering role and duties—defined			
	A. Design conformance—monitoring and reporting			
	B. External testing and inspection reports—oversight and approval			
	C. Shop drawings—review and approval			
	D. Latest issue control drawing list—complete set maintained			
	E. Vendor drawings and manuals—obtained in a timely way			
	F. Field orders—prepared for the project manager			
	G. Construction quality and site reports—maintained on file			
16	Project closeout duties—undertaken			
	A. Record (as-built drawings)—completed and delivered to Owner			



FLOWCHART 27.1 Engineering

CHAPTER 28

Procurement

> *Too many people spend money they haven't earned, to buy things they don't want, to impress people they don't like. — Will Rogers, 1879–1935*

OBJECTIVE

The objective of this chapter is to provide an effective approach to capital project procurement, along with a step-by-step road map through the principal activities that require attention during the procurement component of the project.

HOW TO APPROACH PROJECT PROCUREMENT

Effective procurement for a major capital project requires the following.

1. **Create a clear procurement road map:**
   - Involve the project's procurement personnel in the project capital estimate.
   - Separate the items to be procured into their logical major categories:
     - Raw materials
     - Prefabricated equipment
     - Stationary equipment
     - Mobile equipment
     - Consumables
     - Services
   - Produce a "spend" baseline for each major category to be procured.
   - Identify the high-impact value creation levers within the major categories. This facilitates prioritization of procurement resource allocations.
2. **Dissect the major categories to build an understanding of market economics:**
   - Use analytical tools to develop perspective on supplier dynamics and pricing.
   - Assemble an inventory of current demand for each category.
   - Break down the categories based on criticality and risk (project impact).
   - Examine the categories for complexity (level of customization, know-how).
   - Break out the long lead-time items and items with likelihood of delay (*lead time* is defined as the time from order placement to material delivery).
3. **Segment the goods to be procured in each category into work packages:**
   - Build a procurement strategy for each package.
   - Understand the delivery timing needed across each package.

- Segment the packages for procurement responsibilities.
- Take into account risk to the overall project when segmenting the package.
- Bear in mind the desired level of supplier interaction over the operating life of the mine.
- Define the best sourcing approach for each package.
- Set the negotiation strategy for the major equipment and services packages.
- The main drivers to package segmentation are site geography, contract strategy, construction sequencing, and drawing and materials availability.

4. **Follow a cost minimization approach:**
   - Use “clean sheet” models to develop cost targets for each major package.
   - Understand the total value versus total cost drivers within the major packages.
   - Involve procurement personnel in the development of specifications that fit the market, keeping in mind that small specification changes can have large price implications.
   - Work with engineering to reduce construction complexity.
   - Structure the spend categories around key supply markets.
   - Create effective bundling within the packages.
   - Maximize standardization and modularization.
   - Maintain a global perspective on supply markets and players.
   - Explore the viability of sourcing from low-cost countries.
   - Actively involve local community suppliers and vendors.
5. **Select an efficient contracting and subcontracting strategy:**
   - Identify the key sources of supply risk—the probability and impact of events.
   - Set rationale for apportioning risk among Owner, contractors, and suppliers.
   - Optimize the delivery model for project and Owner requirements.
   - Resolve any make-versus-buy considerations.
   - Tailor the bid process to the service attributes being sought.
   - Agree on the appropriate sourcing approaches (multiple bid, sole source, etc.).
   - Design contracts that align incentives and pricing mechanisms.
   - Design contracts that manage pricing volatility and encourage collaboration.
6. **Beneficially align the EPCM and Owner procurement organizations:**
   - Develop the organizations to shore up the procurement process.
   - Establish clear internal and external role descriptions.
   - Hire the procurement manager and team sufficiently early in the project life.
   - Use both Owner and engineering, procurement, and construction management (EPCM) knowledge to build the right capabilities.
   - Communicate expectations to the procurement team.
   - Draw on the Owner procurement team for oversight and monitoring.
   - Establish mitigation strategies for high-impact events.
7. **Track the progress of procurement activities and the savings captured:**
   - A procurement dashboard can be useful to track activities.

PROCUREMENT MANAGEMENT ORGANIZATION

Decisions made during project kickoff will impact how procurement is managed and administered within the project, including items such as

- Appointment of a procurement entity (typically the same contractor as the Engineer),
- Type of contract (this affects the project control protocols), and
- Time schedule.

If the procurement provider is also the engineering contractor, then much of what is expected from procurement is already included in the documentation prepared for appointment of the Engineer (see Chapter 19). Note: This book's text assumes, as stated earlier, that a single (EPCM) contractor provides the suite of core project services (engineering, procurement and construction management).

The scope undertaken by the procurement provider needs to be examined to identify any interfaces with other affected areas of the mining company, such as the site and/or Owner's corporate purchasing departments. Then, to ensure full support from all parties, suitable interface procedures need to be implemented to make certain that each stakeholder is kept abreast of decisions made. Figure 27.1 illustrates the linking mechanisms between the engineering and procurement functions. Work scope changes during the procurement phase can impact project cost. Hence it is important that the project team carefully monitor and control procurement activities.

ENGINEERING SUPPORT TO PROCUREMENT

The principal deliverables of the engineering contractor to the procurement provider are those items that are needed by the various vendor suppliers and contractor entities:

- Drawings
- Data sheets
- Specifications
- Equipment lists
- Purchase requisitions
- Material control procedures
- Manuals
- Training protocols
- Start-up plans

Any need for equipment installation service providers, vendor support staff, technical consultants, and/or engineering subcontractors is also communicated to the sourcing and logistics teams (and to project management) by the engineering contractor during the engineering stage. The procurement protocols are thus linked directly with the detail engineering stage and, as a result, become an integral part of the project progress measurement system.

Standardization

As in the engineering stage, but even more so in the procurement stage of the project, attention must be focused on maximizing the standardization of parts and systems, along with standardization and compatibility between facilities. Compatibility of instrumentation and control logics is best realized by the procurement entity engaging one provider to handle the full spectrum of project instrumentation and control needs.

PROCUREMENT RESPONSIBILITY

The procurement function on most capital projects is an activity that will strongly influence both the overall cost and the time schedule of the project. Specific, linked methodologies need to be developed for the sourcing, expediting, and logistics functions of procurement.

EPCM Procurement Responsibility

The procurement service is typically provided by the same EPCM contractor that provides the engineering. Although unusual, the procurement function may sometimes be provided (but more likely just supplemented) by the mining company's local operations unit, if this is determined to be in the best interests of the project.

Regardless of who conducts the procurement function, it is always beneficial to involve the mining company's materials management group (corporate and/or site) at the early stages of the engineering. Typically, one of the Owner's sourcing people is placed in the engineering office for 2–8 weeks, early in the engineering process. This procurement and logistics involvement ensures that full benefits are obtained from any long-term supplier alliance programs in place at the mining company, and that the Owner's procurement group properly understands the project's needs.

Assuming that an EPCM contractor handles the project procurement, then a best practice project procurement process is as follows:

1. The engineering department of the EPCM contractor designs and specifies all the project equipment to the satisfaction of the Owner, and from this creates the technical specifications. Such specifications will lay out any early supplier involvement requirements of the project team and Owner.
2. Each engineering discipline delivers its own material requisition for quote (MRQ) requests with both specifications and data sheets to the EPCM procurement group. The MRQ identifies the vendor data needed by the discipline and allows procurement to specify to the vendor exactly what the project is seeking.
3. A market analysis is performed by the EPCM procurement group to develop an understanding of the supply-and-demand dynamics and potential value levers for this project, in this locale, at this time.
4. The procurement department of the EPCM contractor then develops a list of bidders (in conjunction with the Owner's materials management personnel).
5. The EPCM contractor prepares an RFQ (request for quotation) using Owner corporate sourcing input in conjunction with local site purchasing (if available).
6. The EPCM contractor evaluates the bids and quotes and leads any negotiations, but the project manager (with Owner concurrence) determines the final bidder and vendor selection.
7. Existing supplier relationships of both the Owner and the EPCM are used to advantage.
8. The role for any in-place Owner sourcing alliance agreements has to be defined for the project in relationship to the Owner, the EPCM, and the construction contractors.
9. The actual purchase order (PO) is placed using either Owner paper or that of the EPCM contractor acting as agent for the Owner, depending on Owner preference and the circumstances of the particular project.

To accomplish the preceding tasks, the necessary Owner resources required to execute the purchasing function (e.g., signing POs and change orders) are assigned to the project manager's team from the Owner's sourcing or purchasing departments. These parties then work closely together in support of the EPCM procurement group. Within the EPCM procurement group there will be procurement managers, sourcing specialists, logistics advisors and expeditors—a suite of skill sets most Owners cannot match.

While a team approach is advocated for reaching an order placement decision, only one entity—generally the EPCM contractor—has responsibility for placement of the order, even though the Owner representative in the EPCM office typically is the one who signs the PO when it is executed on Owner paper. This single accountability for order placement, along with the execution and management of all other procurement duties, eliminates problems arising from split responsibility and/or lack of continuity. To this end, it is best if the same group of people stays together for all stages of project procurement, from the feasibility study onward.

Procurement risk manifests itself in financial form (cost overruns from not purchasing the least costly items), schedule (project delay from goods arriving on-site at the wrong time), and quality (failure to ramp up to output targets due to equipment malfunctions).

Owner Procurement Staff Involvement

The Owner's procurement personnel need to participate in company projects as team members at as early a stage as possible in the project life. Certainly this should be by the beginning of detail engineering, but even better would be at the prefeasibility or feasibility study stage. It is not just a buy-in of the EPCM contractor's procurement procedures. The project team needs to become cognizant of the EPCM's procurement and expediting skill sets, that is, their strengths and weaknesses. The project team can use the Owner's materials management expertise to help assess the EPCM's procurement proficiency and then to help define life-of-project sourcing strategies and requirements for suppliers and future operations staff.

The Owner's materials management people are highly encouraged to learn about the EPCM's reviews, oversight, procedures, and the needs of future operations. The Owner's materials management team's involvement over the project life will ensure that during the final transition of the sourcing and logistics procurement functions from contractor to Owner (at the end of the project), the Owner will know how to handle these functions and have a better understanding of what has been procured and from where.

The Owner's materials management personnel assigned to the project will be able to assist the project manager to do the following:

- Define the critical procurement success factors relating to logistics, sourcing, and supply-base capabilities.
- Identify opportunities for early supplier involvement in the project or system designs that could positively impact project schedule and cost.
- Target key supplier relationships.
- Establish the appropriate inventories of spares, materials, and other consumables required by future operations.
- Define and structure the best use of existing alliances and sourcing relationships of either the Owner or the engineer. (The project manager has to determine whether the Owner's alliances provide a better value to the project than the engineering firm's alliance relationships.)

- Provide information on local resource centers, which can be leveraged for project advantage (materials inventory storage locations, labor supply, technical and diagnostic services, specialist repair, classroom workshop training, etc.).

The Owner's operating or purchasing staff should be called on to review each selected bidder's recommended spare parts list and, in conjunction with the EPCM contractor, make recommendations for the project team to act upon. In some instances it will be expedient to link the project procurement function electronically with the Owner's purchasing department.

PROCUREMENT PROCESS

Procurement encompasses sourcing, purchasing, expediting, and then shipping and receiving. These last two items have been separated into the "Logistics" and "Site Materials Management and Warehousing" sections in this chapter to highlight their importance.

Sourcing

The first procurement sourcing step for a major minerals project requires the project team to:

- Agree on a clear procurement plan, and
- Identify all critical, long lead-time equipment.

Second, the Engineer has to generate data sheets and equipment and material specifications:

- Mine technical specifications are based on production capacity and mine layout.
- Plant technical specifications reflect production capacity and process requirements.
- The Owner has a review role to ensure optimization of the total cost of ownership.
- Project management should lend support to any technical analysis.

Third, the Engineer has to specify all vendor drawings, test certifications, manuals, and/or training documentation requirements. Typically, these are laid out on an MRQ form. Once a procurement plan and the Engineer's specifications and material requisition data sheets are in hand, then suppliers can be contacted:

- The EPCM procurement group prepares a bidders list of potential suppliers for early project management and Owner approval. Most major EPCM contractors maintain a database for prequalifying vendors and suppliers. This database should be referenced before the project team (project manager, process engineer, procurement) nominates its vendor list. This ensures optimal vendor selection.
- Quotations for goods and services are solicited via a document inquiry, such as a formal RFQ.

If the right EPCM has been selected, it is in the sourcing phase that the real value of the P for *procurement* in the EPCM should come to the fore. In today's global economy, best value can come from anywhere in the world. It is the job of the procurement arm of the EPCM to unearth those best-value sources. In the authors' backgrounds, these sources have come from all over the world:

- Structural steel from Singapore (multiple boatloads) for four projects in Indonesia
- Seven crushers from Brazil (one, the largest in the world at the time) for a Chilean project

- More than 300 km of large-diameter pipe from South Africa for a Chilean project
- Thirty miles of steel cord conveyor belt from Germany for a U.S. project
- Electrowinning equipment from Canada for two projects in Peru
- State-of-the-art overhead cranes from Austria for two projects in Chile
- Structural steel from China and Korea for multiple projects
- Large electric motor packages from Japan for multiple projects
- Subcontract detail engineering from China, India, Chile, Canada, and the Philippines, among other countries on various projects

The point is that best-value sources likely lie outside the countries that the project, the Owner, and the EPCM are located within. The project manager must ensure that the procurement entity is fully tapping these resources, be it for high value or detail engineering, structural steel, pipe, original equipment manufacturers, or whatever.

Initial quotes from the identified sources are then evaluated to understand supplier and contractor offerings:

- Bids are analyzed to fully understand their technical, financial, and other terms. Are there escalation clauses? Are there progress payment requirements?
- The inclusion of, or necessity for, spare parts is noted.
- The team should use this time to obtain benchmark data on supplier performance. Note: Most suppliers and vendors do not offer their best terms when responding to an RFQ, because they know this is merely "window shopping" by the mining company to get approximate figures into a feasibility study or a value engineering trade-off.

The project management role is to identify opportunities to reduce the total cost of ownership:

- Component selection should be refined, if it cuts total cost of ownership.
- Parts standardization needs maximizing. This needs to involve engineering.
- Smart spares need to be defined.
- Transport costs need optimizing, for example, on-site labor minimization by modularization.
- Design modifications reflecting vendor capability, on-site reassembly, and/or erection costs may be worthwhile.

Requirements of the financing institutions (e.g., Ex-Im Bank, EDC) that relate to tax credits, assistance, and so forth, must be identified before order placement, and then actively tracked.

Purchasing

With the procurement plan now set—the engineering data captured on a material requisition for purchase (MRP) and the initial quotes in hand—the EPCM procurement group can prepare a bidder list of qualified suppliers that have met their own and the Owner's approval:

1. The approved suppliers are recontacted.
2. Formal bids are solicited via a document such as a request for proposal (RFP). The suppliers now know this is a serious bid request, because this is an RFP form, not an RFQ.
3. Responses are evaluated and conditioned for commercial and technical acceptance.

From the bid responses, a recommendation to purchase is made, and then, with Owner concurrence, POs and contracts are drawn up and negotiated for price, delivery, spares, service, payment terms, and the like, with the chosen supplier.

Note: If the Owner has approved or requested a single-source supply (presumably because it adds a value benefit to the project), then the RFP can be dispensed and purchasing can proceed with a PO. As a best practice, however, competitive bidding is the better path.

The EPCM prepares detailed negotiation scripts and conducts negotiations. The EPCM's procurement role is to understand the market environment and the supplier dynamics. The PO and contract review and approval sequence (who approves what, in what order) needs to be set at project kickoff. Normally, the Owner approves and signs the actual PO, but the EPCM makes the award and enters all the relevant data into the project control systems. For schedule efficiency, the Owner needs to place a person with authority to sign POs in the EPCM office. The award of the PO triggers two important facets from the project perspective:

1. The requirement for delivery of vendor engineering drawings. Vendor drawings allow EPCM detail engineering to get fully underway. Vendor drawings should be mandated for delivery to the EPCM as soon as possible, which typically means no more than 6 to 10 weeks.
2. Initiation of fabrication at the vendor facility. This initiates major cost by the project and hence the need for inspection and expediting effort from the EPCM.

The terms of purchase must be determined as a strategy during the early stages of the project to set the parameters for overall insurance coverage. For domestic projects it is generally more efficient to purchase goods "FOB jobsite," as ownership of purchased goods then stays with the vendor until goods are received on-site. The vendor is thus responsible for packing, preparation, and accuracy of packing lists, inland freight, and delivery.

Construction schedule enhancement can sometimes be gained by prepayment of funds to certain key vendors, particularly for the long lead-time items. Prepayments can get one's project ahead of others in the equipment delivery queue.

Vendors, particularly smaller, local suppliers, will likely demand progress payments to fund their cost of obtaining materials for fabrication and so forth. The initial progress payment can vary from as low as 10% to as high as 50%, but generally it runs around 25% to 30%. The project manager should always try to demand something tangible for any up-front payments, for example, vendor drawings or invoices of materials purchased.

With the "roller-coaster" world of today's commodity prices, many Owners want the ability to get out of expensive equipment awards if the market turns severely down prior to construction start. This can generally be done, for a price. A PO award with a cancellation clause will generally have to agree to fund the supplier for all out-of-pocket expenses and manufacturing disruption costs up through the cancellation point in time. Any progress payments made to the vendor prior to cancellation are mostly lost.

Long Lead-Time Equipment

It is advantageous to keep track of all the long lead-time equipment schedules, as illustrated in Figure 28.1, which is an example borrowed from a 2012 remote Asian gold mine. These items generally occupy at least one leg of the project critical path, so a weekly update and post of this schedule to the key project staff is helpful to their planning activities.

Equipment	Lead Time, weeks
Semiautogenous Grinding Mill	70–80
Ball Mills	70–80
Primary Crusher	36–38
Oxygen Plant	94–104
Autoclave Reactors	68–90
Slurry Pumps Package	30
Thickener with Mechanisms	25–27
Boilers	32
Cooling Tower	24–26
Heat Exchanger	32
Belt Conveyor	40–42
Conveyor Feeders	40
Compressors	31
Pressure Vessels	32
Cyclones	37

FIGURE 28.1 Long lead-time equipment schedules

Expediting

For all critical goods, the project manager must appoint project expeditors and prepare a shop-expediting or surveillance plan with early-warning reporting of potential slippage. The prime function of the expediter is to monitor the progress of each order from the date of award to delivery on-site (or any other location dictated by the PO). A detailed expediting plan has to be drawn up and then constantly monitored to ensure that the equipment and material supply is maintained in line with construction requirements (Hickson 1996). Weekly updating is typically required.

Inspection of the fabrication and assembly quality is generally carried out by the purchasing provider, that is, the EPCM contractor; but in certain instances, a representative of the project team will be in attendance. Identification of which equipment requires this special attention during manufacture needs to be recognized in the project quality plan.

In all circumstances, regardless of who is given the task of placement of orders and contracts, the responsibilities for expediting and for the actual material delivery function should remain with the EPCM contractor acting as the Owner's agent. This ensures that the EPCM contractor maintains the responsibility for the quality of the equipment and its timely delivery throughout the project. In other words, the equipment and the material supplies are under the responsible control of the EPCM firm at all times from procurement through installation. Contractually, there must be no possibility for the EPCM contractor to claim that Owner personnel held up equipment delivery or caused inferior products to be procured.

The project expeditor is responsible for establishing and maintaining post-award contact with the suppliers to ensure that schedules are maintained, and materials and equipment get delivered to site in accordance with PO and construction requirements. Most EPCM procurement groups assign criticality ratings and inspection level requirements to each piece of equipment on the equipment list. The expeditor initially sets the frequency of visits to the supplier facilities based on the criticality rating of the goods and the construction schedule requirements, but the number of visits set will likely need to change as the project progresses, in response to supplier progress and construction needs.

Before critical goods are released for shipment from vendors, the material must be inspected (pre- and postpacking) and the packing lists verified. Preshipment inspection at a supplier's facility usually does not include verifying packing lists, because the goods are open for inspection and not yet packed. A second visit would thus be required for designated "critical" goods after packing is complete. If export packing is to be performed by others, then a new packing list will be needed. Terminology such as "1 lot as per attached list" should be avoided as a line item on POs. The use of "1 lot" may be unavoidable with complex equipment, however, given that the buyer and seller may not know component breakdown until after the goods are produced.

Field Issues

The EPCM contractor will generally furnish the large-quantity imported bulk items (pipe, rebar, cable, etc.) to the construction contractors, because the EPCM can generally handle this at considerable savings in cost and time. Construction contractors should purchase the smaller-quantity bulk items, along with tools and expendables, especially on overseas projects. Contractors typically have better local knowledge; therefore, shorts, damaged, and small bulk items should remain their responsibility.

Procurement continuity must be maintained from home-office engineering into the field. While it is generally beneficial for the responsible procurement person to move with the project to the site, it may not always be appropriate; for example,

- If engineering continues in the home office and purchasing needs to remain close;
- Where local agents have the knowledge to better perform the small-value, rapid-response field transactions; and
- With overseas work, where a field agent with language fluency is essential.

Field purchasing generally makes sense for the low-dollar-value and low-risk materials and supplies, for example, safety supplies, office equipment and supplies, pickup and delivery services, small construction equipment rentals, and some temporary facilities.

LOGISTICS

Project management is responsible for arranging equipment transport to the site and for ensuring that the transport methods used are optimized for cost and delivery. Material handling and security are particularly important when the project is located in remote, difficult-to-reach areas or in a foreign country where local transport may be unreliable. In such locations specialist logistics subcontractors may be hired to fulfill the project's logistical requirements, for example, for materials inspection, freight forwarding, export packing, freight consolidation, chartering, contract carriage, customs clearance, brokering, and/or port services.

Offshore projects, as well as large, logistically complex projects, require a logistics study. Such a study usually results in confirming the requirement for the services of a freight forwarder and a customs broker. To properly handle logistics, one must first understand the transit cycle. This likely depends on the season and the state of the roads; 3 days from port site may stretch to 3 weeks, or more, in the wet season.

Freight Forwarder

If a freight forwarder is used, one should award that contract early. A freight forwarder is chosen on the basis of real (not claimed) experience and competency. Principal issues for selection are strength of representation in the country where the project is located, strength of representation in the country where goods are shipped from, and past successful performance.

The freight forwarder's scope of responsibility typically includes collection, inland transportation to port of export, seaworthy packing, export crating, booking of vessels, customs clearance, and inland transportation to the site, as well as producing its own packing list based on actual packed contents. (Such a list needs to be as accurate as the vendor's list.) If the freight forwarder is tasked with subcontracting trucking services from vessel to jobsite, then the freight forwarder assumes responsibility for proper equipment use and rigging.

Receiving Port

It is essential to appoint a good, local transit agent at project outset. More important, make sure this agent knows how to work with government officials to move goods in and out of port. Procedures for seamless customs clearance have to be put in place. This sounds easy, but it only happens if local savvy is brought into the project.

If building one's own port, then the necessary, experienced port facility personnel need to be hired early (harbor master, warehouse personnel, etc.). If an existing port infrastructure is to be used, then it must be reviewed and improved as necessary to fit the project's needs. The project will probably need to establish a heavy-equipment offloading facility and a bonded yard for "in bond" shipments at the entry port. To save on transportation costs, dedicated ships with consolidated cargoes should be used. This will require establishment of consolidation marshalling yards, at both the port of entry and staging area.

Materials Tracking

The EPCM procurement group typically provides the bulk material management procedure (usually a proven computer software module today) to track materials from material takeoff (MTO) estimation, through procurement, shipping, and warehousing to issuance of materials to contractors. The EPCM logistics plan should provide specific transport routing instructions for each PO package, for each geographic area of supply.

Consolidated packing lists are required on-site for each container. The freight forwarder (and/or vendor) must provide a consolidated packing list per container. Site staff use these packing lists to receive all pieces, for customs clearance and for tax clarification.

The project team must be vigilant in ensuring that the vendor interprets PO specifications accurately. The logistics lifeline to a remote site can be 4 months or more; receiving just one wrong part can ruin the entire project schedule.

On-Site Equipment Assembly

The final part of the logistics work component entails the EPCM contractor ensuring that the requisite expertise is on hand to work with the equipment manufacturers and construction contractors to safely and properly assemble the delivered equipment.

SITE MATERIALS MANAGEMENT AND WAREHOUSING

Site management of the equipment and material deliveries, including warehousing and laydown yards, is the last activity of the procurement provider. The received equipment is inspected for damage, and variance of quantity prior to acceptance and/or issue to the construction contractors.

Equipment or materials received damaged on-site need to be back-charged immediately to the supplier or fabricator, as the case may be. The Owner needs to be protected from paying for damaged goods. Consignments received are checked against release certificates, way bills, material certificates (packing slips), and POs. Procurement control relies on each one of these individual receipt acknowledgments being entered into the computerized tracking system at each point on the material's journey and matching it against the original RFQ and PO. To this end, a bar-coding system should be adopted if at all possible. The accounts payable department is then copied with the goods-received voucher to facilitate vendor payment.

Figure 28.2 portrays a typical site materials management activity process flow diagram.

Wherever possible, materials and supplies should be stored inside the warehouse, particularly items that are subject to weather deterioration, such as instruments, gauges, and electronic equipment. Items subject to pilferage need to be in locked facilities. No material can be allowed to be withdrawn from the warehouse or storage area without written authorization, and any material issued must be deducted from the inventory count.

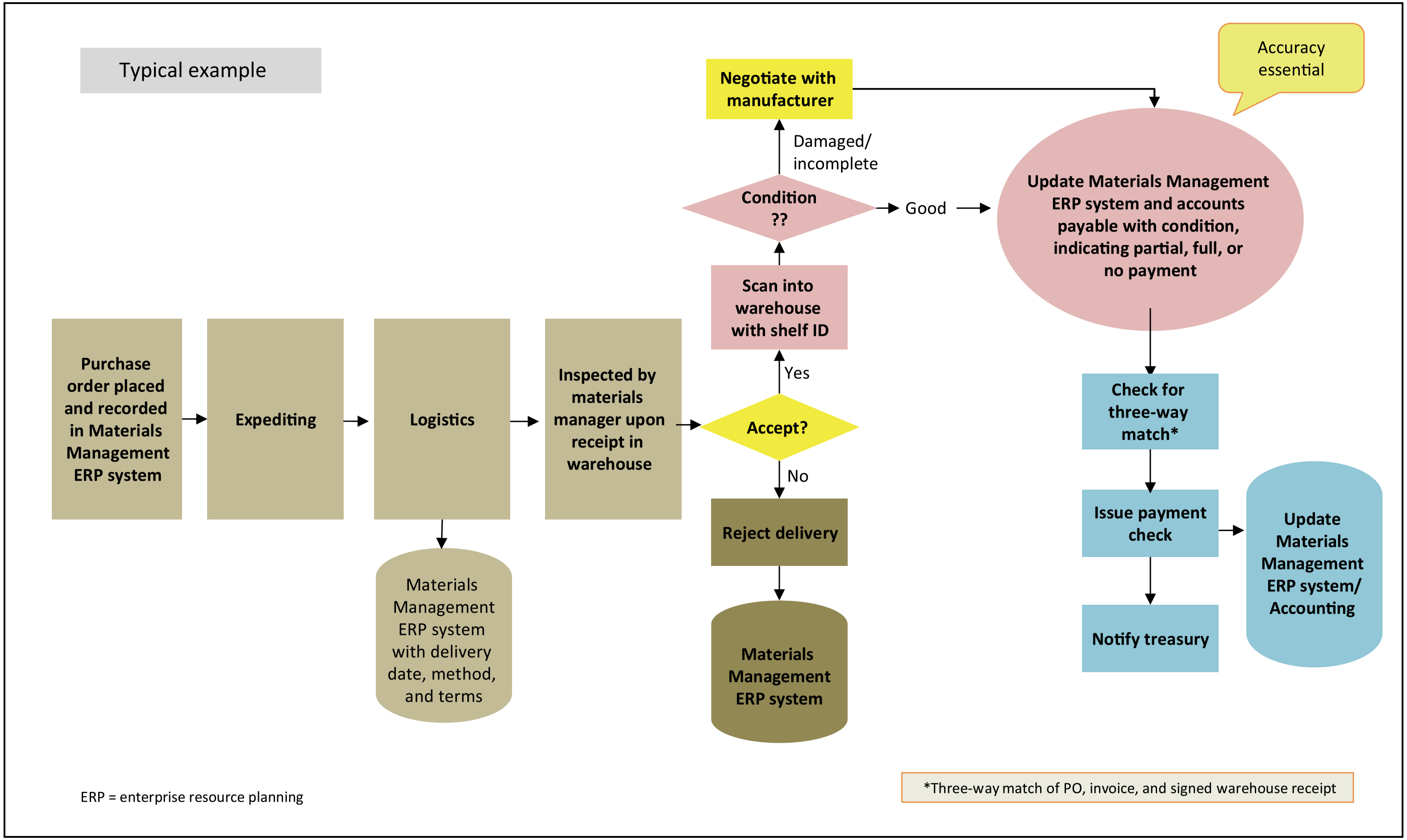
The preceding sentence may seem basic but, unfortunately, is frequently not followed (especially by Owner operations, particularly on brownfield sites). The resultant parts shortfalls inevitably inflict disastrous consequences to the project's schedule and commissioning.

Laydown and Outside Storage Areas

Laydown areas need to be sited to minimize rehandling and for easy retrieval, with adequate internal roadways for equipment movement. Pallets, cribbing, skids, or platforms should be used for all material placements to prevent contact with the ground. Vegetation control needs to be addressed. Fencing is needed for security and theft reasons. Weather protection should be installed for those items subject to weather damage.

If equipment is received and then stored in stackable shipping containers, meticulous storage planning and accurate inventory control are mandatory. When a construction contractor wants to pick up specific goods, the warehouse personnel must know in precisely which container the items are stored, and the goods must then be instantly accessible. Containers need to be laid out and numbered south to north for row, left to right for section, and bottom to top (same system as warehouses use for inside storage).

In remote, mountainous sites with minimal storage space availability, such as the authors experienced in Indonesia, proper placement of the shipping containers is paramount. The authors received more than 6,000 containers over the life of the Grasberg project, at an incoming rate of almost 80 per week (Hickson 1991). The containers had to be stacked seven high. It is vital, in these situations, that all containers and contents be individually bar-coded with the first-needed goods stacked on top and the last-needed items on the bottom. If not, chaos occurs; goods that are not needed will have to be moved, which will inevitably result in lost or damaged equipment and schedule delay.



ERP = enterprise resource planning

*Three-way match of PO, invoice, and signed warehouse receipt

FIGURE 28.2 Materials management activity flow diagram

PROCUREMENT POLICIES

When the procurement function is included as part of the EPCM's scope of work, the EPCM procurement personnel must become fully familiar with the Owner's company policy and procedure requirements regarding the following:

- Sourcing agreements that may be in place
- Preferred vendor lists
- International sourcing policies
- Standardization requirements
- Spare parts policy
- Vendor assistance during ramp-up and/or start-up
- General terms and conditions of purchase
- Applicable duties and taxes
- Warranty and guarantee requirements
- Insurance requirements
- Issues resolution and adjudication procedures

The procurement function must be able to provide systems capable of determining whether any materials, supplies, or equipment incorporated into the project are subject to a general security agreement, financing contract, or other type of agreement whereby an interest is retained by the vendor and/or others, and then to notify Owner of same.

SUPPLIER ALLIANCES

On occasion, a supplier may be reluctant to share a client's preferential alliance pricing with certain EPCM firms, particularly with the smaller engineering companies. In these instances (which are the minority of cases), the supplier should be allowed to quote normal pricing to the EPCM and then direct a rebate to the project's Owner account, thus preserving the confidentiality of the supplier's pricing arrangements.

PROCUREMENT DELIVERABLES

The following are the deliverables of procurement:

- Purchase orders, including MRQ and MRP support material from engineering such as:
  - General design criteria
  - Applicable standards and codes
  - General engineering specifications
  - Control philosophy
  - Data sheets
  - Equipment lists
  - Owner manuals
- Material control procedures
- Construction and project services agreements

The following are record-keeping and document management conventions:

- PO register
- Vendor document log

- Equipment lists—coordinated with engineering and project management
- Scope change orders—coordinated with engineering and project management

PROGRESS MEASUREMENT

Part of the responsibility of the project team is to establish the reporting systems and control procedures that enable the team to properly monitor procurement progress.

Procurement Reporting

The control mechanisms for procurement progress include the monthly reporting of the following:

- Procurement progress utilizing progress curves and schedule
- Overall project progress curve and schedule coordinated with project management
- Trend notices
- PO status
- Expediting status and schedule
- Labor-hour status, forecast, and schedule
- Actual labor-hour efficiency versus forecast
- Cost and cash flow status and forecast

Full distribution of the monthly progress report keeps all stakeholders informed of procurement status. Targeted distribution of the weekly activity report aids this communication effort.

Schedule Development and Adherence

All procurement schedules are maintained within the constraints of the project master schedule. A dedicated procurement dashboard can monitor whether the activities are on track.

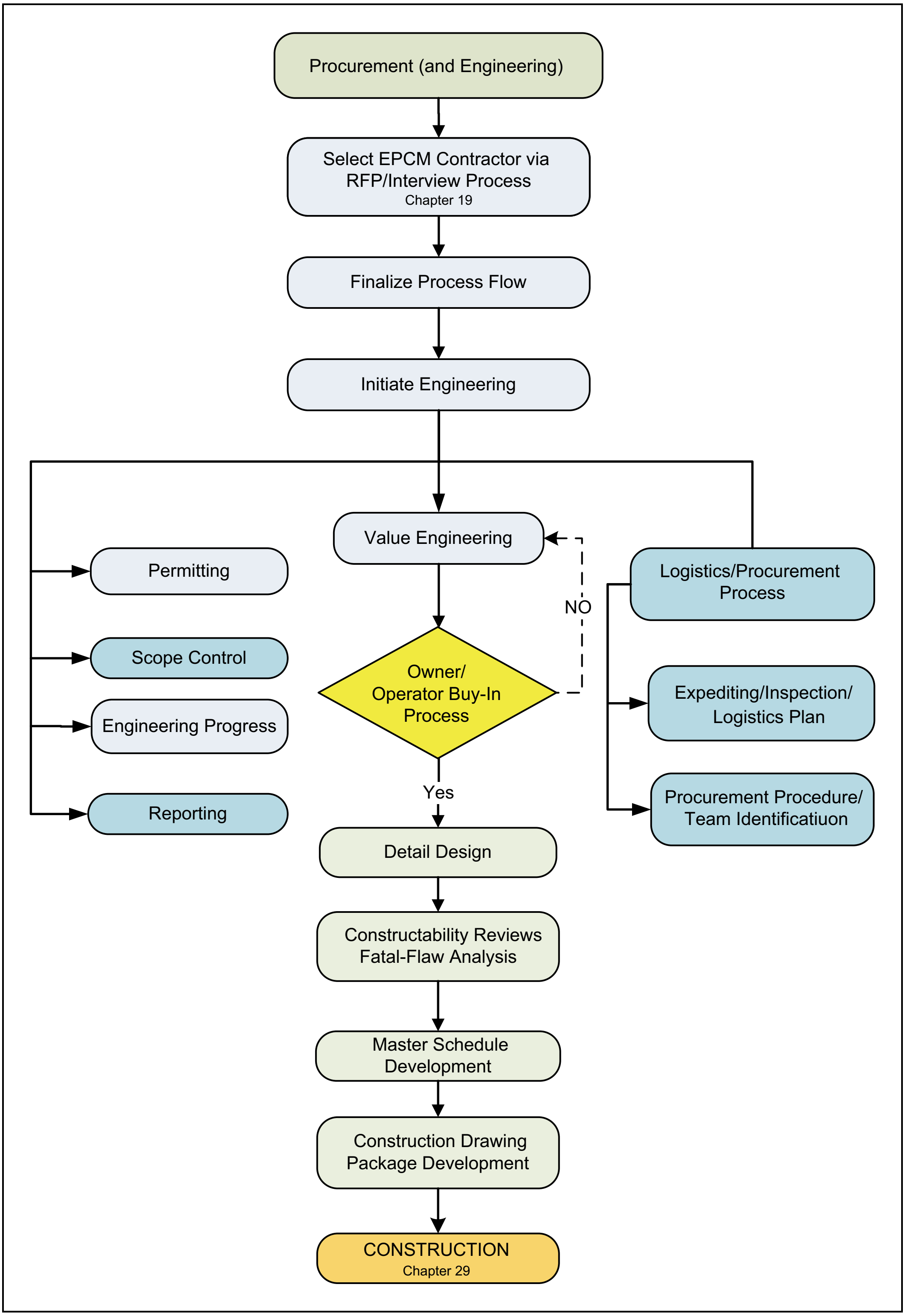
CHECKLIST 28.1 PROCUREMENT

No.	Item	Status	Date	Initials
1	Purchasing provider (EPCM contractor?)—appointed			
2	Procurement manager and procurement team—in place			
3	Procurement strategy—developed			
	A. Procurement road map—created			
	B. Categorization of goods to be procured—undertaken			
	1. Critical (high-impact and high-value) items—identified			
	2. Long lead-time items—identified			
	C. Supplier dynamics and market analysis—conducted			
	D. Standardization of parts and systems—agreed with Owner			
	E. Work package segmentation—accomplished			
	F. Total value versus total cost package drivers—understood			
	G. Global perspective and local supplier support—adopted			
	H. Negotiations script—prepared			
	I. Alignment of EPCM and Owner procurement—established			
4	Procurement responsibilities (Owner vs. EPCM)—defined			
5	Engineering support process and status—reviewed and understood			
6	Procurement plan—set in conjunction with Owner			
	A. Procurement procedures—established			
	1. Progress measurement (and S-curves)—defined			
	2. Expediting program and schedule—established			
	3. Labor-hour forecast—issued			
	B. Progress and status reporting requirements—defined			
	1. Forecasting and trending—instituted			
	2. Scope change approval process—controlled by project manager			
	3. Cost and cash flow reports—delivered to project controls			
7	Procurement documents—prepared			
	A. General terms of purchase—complete			
	B. Engineer specs and material data sheets (MRQs and MRPs)—complete			
	C. Equipment lists—final			
	D. International sourcing policies—in hand			
	E. Purchase orders (POs)			
	1. Warranty and guarantee requirements—determined			
	2. Vendor assistance at start-up—defined			
	3. Manuals publication support—outlined			
	4. Spare parts policy—issued			
	F. Construction contracts			
	1. Insurance and bonding requirements—determined			
	G. Issues resolution and adjudication—addressed			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
8	Sourcing options—determined			
	A. Owner's and EPCM's preferred vendor lists—consulted			
	B. Owner's and EPCM's supplier alliances—utilized			
	C. Bidders list—developed			
	D. Requests for quotation (RFQs)—solicited			
9	Approved supplier list—prepared			
10	Requests for proposals (RFPs)—issued specifying bidder deliverables			
11	Bid evaluations—completed			
12	Bidder selection—identified and agreed to by Owner			
	A. PO business terms (warranties, terms)—negotiated			
	B. Supply risks—assigned to natural owner of each risk			
	C. Vendor drawings delivery date—set			
13	PO—awarded, if negotiations successful			
14	Expediting and inspection:			
	A. Expediting program and schedule—established			
	B. Expeditors—appointed			
	C. Shop surveillance and quality assurance plan—conducted			
15	Logistics:			
	A. Logistics survey—undertaken			
	B. Logistics plan—developed			
	C. Bar-coding system for materials tracking—adopted			
	D. Freight forwarder and receiving port transit agent—hired			
	E. Materials tracking program—installed			
16	Site materials management:			
	A. Warehouses and laydown yards—established			
	B. Quality conformance—inspections conducted			
	C. Goods receipt in sync with procurement paperwork—OK			
	1. Purchase order register—maintained			
	D. Vendor data log—maintained			



FLOWCHART 28.1 Procurement

CHAPTER 29

Construction

What is not started today is never finished tomorrow.
—Johann Wolfgang von Goethe, 1749–1832

OBJECTIVE

The objective of this chapter is to single out the main elements of project construction, as well as to identify the principal roles needed on-site to effectively manage the construction execution steps. Specific input is required from the project management team to ensure that construction is executed not only in accordance with industry standards but also in compliance with the standards and safety regulations used by the mining company for that locality.

This chapter discusses what constitutes construction completion, and the ramifications of the different completion definitions used in the projects world. To the maximum extent possible, this book's authors discourage a fast-track project mentality. The control procedures for a successful project cannot help but be violated in such a forcibly rushed schedule.

WHEN SHOULD CONSTRUCTION START?

Construction should be initiated only after detail engineering has progressed to the point that an efficient field construction effort can take place. For most projects, this point is after 50% of the project's drawings are at issued-for-construction (IFC) status; however, it is best to have more than 70% at IFC status. For major projects, this means not until at least 5 to 7 months after the initiation of the detail engineering effort.

Procurement of all critical long-lead items also needs to be complete prior to field mobilization. Generally, this is accomplished in the first 2 months of detail engineering. The scope of work (SOW) is generally so firmly established after this level of engineering and procurement effort is accomplished that the focus of the project can now smoothly transfer to the field, and the project management team can sensibly shift its concentration to the timely and safe field construction of the engineered facility.

CONSTRUCTION STRATEGY

It is generally beneficial to break the large SOW for a major project into logical, manageable pieces for execution in the field. This is typically accomplished by separating the work effort into smaller-sized construction work packages for the project.

A construction work package (CWP) is a well-defined scope of construction work that terminates in a deliverable product or completion of a service. Each package is a breakout element of the work breakdown structure (WBS). The battery limits of each CWP are set so they can each be sensibly managed as a unit. It is crucial that the breakout of the work into the packages logically reflects the way that the construction effort will be controlled.

Engineering drawings and associated materials form the basis of a CWP, but it is the construction execution plan that determines the project work packaging philosophy for each CWP. The CWP system forms a framework for communication, coordination, and interaction among design, project controls, materials management, and construction. See Chapter 28 for a description of the drivers for the creation of these work packages.

Most often, the division of construction scope into manageable packages is based on geographical boundaries. The work packages are then used to control the focus of construction efforts by geographic area until construction progress has advanced sufficiently to shift that focus to systems completion. Work package planning does not replace systems turnover planning. Both must occur simultaneously, so that a transition from geographic-based control to systems-based control can be made when construction of a system is sufficiently advanced.

PROJECT MANAGEMENT CONSTRUCTION RESPONSIBILITY

The responsibilities of the project manager and his or her team during the construction stage are similar to the team's responsibilities during the engineering stage, regardless of whether there is an engineering, procurement, and construction management (EPCM) contractor involved or not. The only differences between an Owner-directed construction effort and an EPCM contractor–directed effort is that the EPCM entity will usually already have existing procedures in-house for the control and monitoring of the contractors.

This book assumes, as stated earlier, that a single (EPCM) contractor provides the suite of core project services (engineering, procurement, *and* construction management); thus a significant portion of the project manager's responsibility for ensuring field conformance to the engineering design specifications will be undertaken by the EPCM contractor.

CONSTRUCTION CONTRACTOR SELECTION

A key role of the project manager is to direct the selection of competent construction contractor(s), hereinafter called "the constructor(s)." The project manager has to ensure that the chosen constructor has the capacity, resources, and experience to undertake the work in a timely and cost-effective way and to meet the project's quality standards.

The selection of the constructor requires a somewhat similar procedure to that used for the selection of the EPCM contractor (see Chapter 19), but there are sufficient differences to warrant a separate discussion herein. Unless the Owner elects to use the same EPCM entity that performed the engineering to also undertake the construction (in an EPC arrangement), the constructor is selected through a competitive bidding procedure.

Very occasionally, by the Owner's preference, the constructor is appointed directly by the Owner without bidding. This is not wrong, but it is not recommended. Even if the Owner favors one particular constructor because of previous good performance, competitive bidding to test the current marketplace always makes the best sense. If the Owner cannot be dissuaded from direct selection of the constructor, then the project manager and the EPCM roles default to negotiating the best terms possible for the Owner. In some instances, there will be more than one field contractor appointed. In these cases, there is an added coordination role required from the project management team.

Invitation to Bid

The project manager first has to verify that the assembled contract documents are complete enough to allow accurate and competitive bidding. If multiple contracts are contemplated, the project manager also needs to verify that the limits of each contract's SOW are clearly delineated.

The EPCM's standard invitation-to-bid format is generally used unless the Owner or funding agency desires some other format. The Owner (and the Owner's attorney) should be encouraged by the project manager to use standard industry documents. The following list shows the bid invitation steps for the project manager and the project team:

1. Verify that the construction contractor–Owner agreement is consistent with the language of the Engineer–Owner agreement.
2. If the bids are by invitation, determine qualifications via the request for qualifications (RFQ) process, establish a basis for evaluating the bids, and then prepare the list of qualified contractors.
3. Review the bid advertising procedure with the Owner so that the Owner is aware of what procedure will be followed. If the Owner has any special requirements for bid advertising, such as where it should be advertised, the number of advertisements, and so forth, these Owner requirements need to be incorporated.
4. Prepare the bid forms, instruction to bidders, invitation to bid, schedule of drawings, and any other bid documents.
5. Provide the same schedule to all bidders, preferably a Level 2 Management Summary Schedule.
6. State the project-reporting requirements in the bid package. These are cost elements that affect the bid price. Do not try to introduce them after bidder selection. The prospective bidders need to know items such as the following *before* they bid:
    - One common WBS will be mandatory throughout the project.
    - Activity coding will be consistent among all entities (labor coding, etc.).
    - Progress will be reported on an earned value management (EVM) basis.
    - Specific safety statistics reporting will be required (state the frequency).
7. State if there will be project precommissioning or commissioning requirements for key contractor personnel to continue working after mechanical completion, to assist the Owner in the start-up phase. These are cost elements that affect the bid price.
8. If possible, include in the bid documents the Owner's definition of completion.
9. Determine a cost for the sets of plans and specifications supplied to the bidders. (Sometimes projects charge for these plans; but generally they charge only for extra sets).
10. When appropriate, particularly for large projects, hold a prebid conference and distribute the bid forms and contract documents to bidders at this meeting.
11. Contract documents are usually kept on file for review at the EPCM's office, though some Owners prefer that they be kept on file at the Owner's office.
12. Assist the Owner with the preparation of agreement forms, bonds, certificates, and so forth.
13. Allow enough time for contractors to research and prepare high-quality bids, but set a cutoff time for written questions and substitution requests from the bidders.

14. Treat bidders equally in all respects throughout the bidding period and distribute written responses to inquiries to *all* bidders. Do not accept verbal inquiries. All contacts with bidders should be recorded in a memo and placed in the project file.
15. Keep a log of the bid documents distribution. It is the project manager's responsibility to maintain a record of transactions during the bid period.
16. Issue addenda addressing any necessary clarifications to the bid documents during the bid period.
17. Contractor bids should be tendered to only one office, typically the EPCM office, but if the Owner prefers, it is okay to tender to the Owner's office.
18. Set a deadline for bid submissions, including the hour and minute. Do not accept bids after the official deadline.

One factor that can limit bidder interest in tendering a bid relates to the Owner's desire to transfer risk to the successful constructor though aggressive general conditions clauses, performance bonds, liquidated damages, and the absence of dispute resolution methodologies (Green 2010). The Owner may thus want to consider the tone of the language in the request for proposal (RFP) to increase bidder interest in the competitive bidding process.

Bid Opening

Do not schedule bid openings for Sunday, Monday, Friday, Saturday, or legal holidays. At the stated deadline, announce that bidding is closed and no more bids will be received. Enforce the time limits on return of plans after bidding with regard to bid deposits.

Assist the Owner with the bid opening. The Owner is in charge of the bid opening, but the entity that prepared the bid documents (generally the project manager, but it could be the Engineer or the EPCM) usually manages the opening process. The bid opening is generally a closed, private event, with no bidders present. Public bid openings are not dealt with within this book, as such openings are extremely rare in the mining industry. After the bid closing, all bidders are thanked in writing for their submittals. They cannot be notified who the successful bidder is, though, until after the bids have been evaluated.

Bid Evaluation

The project manager prepares a formal bid tabulation sheet on all bidders for the Owner, including unit prices where appropriate. Each bid's arithmetic is checked for accuracy. Math errors are common and must be brought to the Owner's attention immediately. When evaluating bids and recommending contractors to the Owner, the following guidelines apply:

1. Evaluate the bid with regard to the following:
   - Compliance with the RFP document
   - Technical considerations
   - Quality assurance requirements
   - Contractor's capability
   - Contractor's past performance
   - Alternates available
   - Exceptions
   - Bid price arithmetic (i.e., search for math errors)
2. Evaluate the contractor's past performance by
   - Looking at contractor's history of constructing similar installations,

  - Evaluating the performance of the contractor's constructed facilities in actual use,
  - Evaluating the experience of other owners of similar installations constructed by the contractor, and
  - Evaluating the Owner's own records in connection with previous experiences.
3. Make sure historical data are representative of the contractor's current capability.
4. Evaluate the contractor's current capabilities by looking at
   - Personnel capabilities;
   - Physical conditions of fabricating facilities and equipment; and
   - Management attitude toward quality, safety, environment, and social issues.
5. If there has not been previous experience with the contractor, the bidder should be requested to provide information on similar projects for evidence of capabilities.

The evaluation is best conducted by using a matrix grid that assembles a detailed assessment scorecard weighting the selected criteria similar to that described in Chapter 19 for EPCM selection and as shown in Figure 19.3. However, the weightings are likely to be different for the construction contractor. One large global mining firm evaluates constructors on the following weight distribution:

- Personnel—25%
- Plan of execution—45%
- Contract strategy—10%
- Safety—10%
- Other (location familiarity, regulatory and governmental contacts, training, etc.)—10%

After the evaluation, the project manager makes a recommendation to the Owner for the award of one bid or the rejection of all bids. If all bids are rejected, the project manager has to develop detailed documentation of the rationale for the action. Avoid statements that may be interpreted as libelous. Final selection always rests with the Owner. The Owner's decision is final, whether or not the project team recommendation is followed.

Bid Award

Upon receipt of the Owner's contract award authorization and successful bidder notification, the project manager prepares at least three complete sets of the contract documents, properly filled in and ready to be signed, initialed, and kept by the contractor, the Owner, and the project manager. The project manager is responsible for obtaining all the required documents from successful bidders such as bonds, certificates of insurance, subcontractor lists, and project schedules.

Dealing with Desirable but Over-Budget Bids

If the bid is over budget, the original estimate and the SOW need to be reviewed to determine whether the original estimate was appropriate. If changes in the received bid are feasible, these need to be discussed with the Owner, and then the package should be rebid or negotiated with the successful bidder to bring the amount within budget limitations.

Note: Never lower quality to bring the quote in line. Reduce scope rather than substitute for quality (as long as the scope change in itself does not reduce quality). If no changes can be made, a decision from the Owner is required to revise the budget. If scope is changed, the pertinent drawings and specifications will need to be updated and reissued.

One needs to be careful when amending a bid—the contractor may consider it a counteroffer, making the original quote null and void. The project should always accept the original bid price first and then list acceptable alternatives modifying the price as noted.

If potential field problems exist with the particular contractor selected by the Owner, the project manager needs to point out the need for any additional project funds for managing the problematic contractor, for example, additional inspections and/or staff.

Handling Contractor-Requested Substitutions

Contractor-requested substitutions tend to make the award process more difficult. One can reduce the likelihood of substitutions by making the original engineered selections very carefully:

- Involve the Owner in material and product selection.
- Do not propose products the Owner cannot afford.
- Ensure that the products specified will be available and can be delivered timely.
- Use specification options wisely.
- A closed specification restricts the contractor to working only with the products and manufacturers listed.
- An open specification allows the contractor to make that choice themselves.

To control substitutions after the contract award, consider providing the following guidelines to the contractor:

1. A substitution request must be accompanied by complete data on the proposal.
2. Permission to submit substitutions is not to be construed as preapproval.
3. Requests for substitutions, when received by the project manager from the contractor, are understood to mean that the contractor
    - Has thoroughly investigated the proposed substitute,
    - Will provide the same guarantee as for the specified product,
    - Has included all cost data and waives all and any future costs, and
    - Will coordinate the installation.
4. The Engineer will record all time spent in evaluating proposed substitutions. Whether the project manager approves the substitution or not, the contractor will pay for the Engineer's evaluation services.

Evaluating Contractor-Requested Substitutions

When evaluating a proposed substitution, the project manager has to determine why the substitution has been proposed and then, if the change has significant consequences, review the consequences with the Owner before making a decision. The project manager needs to consult with all those affected when evaluating a product or material substitution.

If rejecting a proposal, concrete reasons should always be provided, such as

- Cannot match specified capacities, size, purpose, etc.;
- Not available in desired color or finish; and
- Requires more power to operate.

A project manager should never be intimidated into accepting a substitute just because the successful bidder favors it; common sense has to prevail.

CONTRACT TYPE

The type of contract chosen (i.e., turnkey, lump sum, time and materials, fee plus, schedule of rates, guaranteed maximum price, unit rates, or design-build) influences the degree of control and interaction necessary by the project manager and his or her team. Construction contracts lend themselves particularly well to incentive–penalty arrangements. (See Chapter 20.)

CONSTRUCTION CONTRACT MANAGEMENT

Construction contract administration may be the most difficult service to fulfill in all of professional practice. An attitude has evolved within Western society that now readily accepts (or even seems to prefer) litigation over discussion and negotiation to resolve differences. This is a shame; the only real winners in most litigation are the lawyers.

If a litigation environment exists, this places the project manager in a position of always having to practice defensively. This is counterproductive to successful project management. Successful project outcomes require proactive outreach by the project manager to all project players.

Contract Administration Philosophy

The basic relationships between the parties in a construction project are the following:

- The engineer designs the project.
- The constructor builds the project.
- The Owner pays for the project that the engineer designs and the constructor builds.

The construction contract is between the Owner and the constructor. The engineer is not typically a party to the construction contract (not in an EPCM contract, though this may not be the case with an EPC contract).

Contracts Administrator or Manager

A project is best served by the appointment of a professional, well-seasoned contracts administrator reporting directly to the project manager. This administrator's job is to ensure that all work assignments, payments, and deliverables are as specified in the formal contracts among the parties, that is, Owner, EPCM, constructors, and subcontractors.

This role involves more than just review and approval of all contract issues and disputes on the Owner's behalf. Throughout project execution, a myriad of gray areas will arise, no matter how well-written the contract document is. Skillful, timely negotiation and resolution of these gray areas by the contracts administrator will keep the project on schedule, save the Owner major dollars, and keep the contractors relatively happy. Regular monthly contractor progress meetings will aid in achieving contract conformance as well.

Project Manager's Role

The project manager, either singly or through his or her direct reports,

- Interprets the contract documents and all changes to the documents,
- Establishes standards of acceptability for materials and workmanship,
- Ensures that constructor work quantity and quality meets contract requirements,
- Approves progress payments to be made to the contractor for completed work,

- Recommends acceptance of the project at the time of substantial completion, and
- Keeps the Owner informed of the project status.

While the project manager cannot guarantee the performance of the constructor, the project manager is accountable for any failure by the constructor to carry out the work in accordance with the contract documents.

Construction Contractor's Role

The construction contractor (the constructor) has the duty to

- Carry out the work in accordance with the contract documents;
- Supervise the assembly of all materials;
- Supervise all the labor to complete the project work;
- Determine methods, means, techniques, and procedures for constructing the project;
- Adhere to all laws and regulations affecting construction;
- Maintain safety precautions and programs; and
- Complete the project within the specified time limitations.

Field Engineer's Role

The field engineer typically has the authority to reject work that is defective or does not meet contractual requirements. The field engineer is also expected to advise the project manager to stop work whenever any contractor nonconformance or negligence is observed. However, the field engineer usually does not have the authority to stop work; only the project manager (on behalf of the Owner) can stop the work. The engineer's efforts are directed at securing compliance of the finished product within the design specifications. (See Chapter 27 for more details on the role of the field engineer.)

PRECONSTRUCTION TASKS OF THE PROJECT MANAGER

After awarding the successful bidder the construction contract, but before the contractor moves to the site, there are a number of duties that the project manager has to take care of.

1. Prior to contract award, the constructor's list of subcontractors is reviewed by the project manager, and the constructor is notified of any rejections. It is the constructor's responsibility to secure acceptable substitutes.
2. After the Owner has chosen the winning bidder, the project manager prepares the Notice of Award. The Owner signs the Notice of Award, and copies are sent to each of the Owner, EPCM, and construction contractor. The Notice of Award is needed by the constructor to secure performance, payment bonds, insurance certificates, and possibly financing for working capital.
3. The project manager prepares the contractor–Owner agreement for signing. The constructor's bid form is an attachment to the agreement. The constructor should be given 15 days to return the signed agreement, required bonds, and insurance certificates.
4. After reviewing the returned documents, approving them, and inserting them into the project procedures manual, the project manager sends a signed copy to the Owner.
5. The project manager schedules and conducts a preconstruction kickoff meeting. Attendance is mandatory for the engineer, constructor, all major subcontractors, and the major subconsultants. Local utility companies and pertinent government regulators

should be invited to attend when appropriate. The Owner's representative should also attend. A typical agenda should include the following:

- Introductions and sign-in
  - Name of contact person (decision maker in each organization)
- Contractor submittals (for project manager approval)
  - Bonds and insurances
  - List of subcontractors
  - Schedule of values (for lump-sum projects)
  - Proposed performance schedule
- Brief review of project (by project manager)
  - General provisions
    - Communications procedures
    - Submittal procedures
    - Pay request procedures
    - Change order procedures
    - Project closeout procedures
  - Technical specifications
    - Required testing
    - Special conditions
  - Project meetings (when, who attends, and who runs them)
  - Current field observations by EPCM and subconsultants
  - Contract changes to this point in time
- Utility concerns
- Contractor concerns
- Issue notice to proceed (by project manager)

6. Actions taken at the preconstruction kickoff meeting, including assignment of firm dates and those actions to be completed later:
   - The project manager identifies the permits that the Owner secures and pays for.
   - The project manager identifies the permits that the contractor secures and pays for.
   - The project manager confirms the constructor's schedule of required shop drawings.
   - The project manager reviews with the Owner the constructor's proposed progress schedule, and approves if appropriate.
   - The Owner's schedule for applying for permanent gas, electric, water, and telephone services on-site, and for securing those services, is furnished to the constructor.
   - The Owner's property insurance policies are provided to the constructor. If the constructor requests that insurance for special hazards be included in the property insurance policy, the project manager has to have the Owner purchase such insurance and follow up with a change order.

CONSTRUCTION PLAN

The practices and methodologies used by the construction industry to execute a mining project are not the focus of this book; they would require a complete book of their own. The concern here is the management of the constructors. As such, it is helpful to know the makeup of a typical construction plan.

Construction Work Packages

For execution on-site, the project SOW is broken down into manageable CWPs. Each CWP is a logical unit of work for a construction contractor to undertake and a logical unit of work for project management to control.

Construction contractors bid on and then are awarded some or all of the packages. Typical work packages could comprise the provision, erection, building, installation, and/or tie-in of any of the following:

- Civil works
  - Access roads
  - Internal roads
  - Mine prestrip and waste disposal
  - Bulk earthworks
  - Building foundations
  - Tailings storage facility
- Shafts, shaft facilities, and shaft stations
- Hoist houses, winders, and headframes
- Ventilation, heating, and refrigeration
- Concrete
- Structural steel
- Tank fabrication and erection
- Preengineered buildings
- Overland pipelines (water, gas, fuel, concentrates)
- Piping fabrication and installation
- General mechanical
- Equipment installation
- Cranes
- Conveyor systems
- Pad stackers and reclaimers
- Electrical
- Instrumentation
- HVAC and plumbing
- Painting and coating
- Insulation
- Fireproofing
- Fencing
- Security systems
- Power lines
- Electrical substation and grid tie-ins
- Power plants
- Utilities (water, compressed air, gas, telephone, radio, Internet, cellular towers)
- Oxygen plant
- Water wells
- Pond and leach pad liners

Construction Schedule

Once the work packages are awarded and the construction contractors identified, the construction plan and schedule are set in place by the project manager and the major construction contractors together.

This is an interactive process, in large part defined prior to mobilization. Once the project objectives and drivers are understood, a sequence of construction can be established and a detailed activity schedule developed.

Up to this point, the project manager has been working with a Level 3 Project Coordination Schedule, but now the project manager needs to see a Level 4 Execution Schedule; and the individual contractors with the most complex tasks should be working with a Level 5 Detailed Short-Term Schedule (see Chapter 10).

Construction Mobilization

The actual mobilization of the prime construction contractor on a major mining project is not an inconsequential undertaking. Full mobilization involve hundreds of pieces of equipment, require several thousand individuals, and cost the Owner a few million dollars. Thus, it should not be activated until there are sufficient IFC drawings in hand to allow multiple, efficient work fronts.

It makes sense to mobilize the bulk earthworks contractor ahead of the main mobilization effort, to get the rough grading work done and help create the multiple work fronts needed for efficient site-wide construction. Generally, one does not have to wait for all the drawings to be IFC before such early mobilization. If more than 40% of the total engineering drawings are IFC and the civil drawings are at over 75% IFC with all major foundations designed, then there may be sufficient work ready for an earthworks contractor to start.

However, most owners make the mistake of pushing to see results on-site too quickly, by moving dirt much too soon, which merely puts wasted money into the contractor's pocket as the contractor's workers and equipment go into standby mode waiting for drawings (Hickson 1996). The project manager should resist efforts to mobilize too early. (There is rarely any push to mobilize late.)

Full mobilization of the complete construction workforce can take from 10 to 16 weeks (typically around 3 months) after contract award, but early mobilization of elements of the earthworks contractor can generally be effected in a month or so after award. Mobilization should never be authorized until

- A fully executed contract is in hand (with any required bonds, as applicable),
- An acceptable insurance certificate is provided,
- A site-specific safety plan has been approved, and
- A quality management (QA/QC) plan is in hand.

Some Owners require a construction mobilization readiness review 60 days before construction mobilization. The authors endorse this concept, though it can be hard to implement, because often the constructor has not been chosen 60 days prior to mobilization.

The objective of the readiness review is to perform an independent assessment of the state of preparedness of the project team and the project processes, to determine if enough engineering deliverables are in hand for the constructors to maintain a smooth work flow if field forces are mobilized. The 60-day lead time is sufficient to correct deficiencies, change strategy, or make a decision to delay mobilization.

Keys to Construction Success

It is absolutely critical to be prepared for the ultimate size of the construction workforce and its rate of buildup. Determining these numbers requires knowledge of labor productivities, workweek norms, overtime expectations, craft crew mixes, union jurisdictional rules, turnarounds, and local customs. It is vital that the project manager get a proper handle on this construction staffing, because it affects camp size, canteen capacity, transportation requirements, and supervisory needs.

To put all this in context, the rapid buildup of the 4,000-person crew for a South Pacific nickel project is shown in Figure 29.1. Assembling a crew of this size anywhere in the world is a major undertaking, and in a remote location, it is doubly difficult.

The crew size the authors used for the remote El Abra project on the high Altiplano of northern Chile was more than twice this size at 9,700 people, and the crew that built the Grasberg project on the Indonesia jungle island of West Papua topped out at 7,600 workers. Dealing with huge workforces like these is a project in itself: getting them in place in a 3- to 6-month period; housing, feeding, and transporting them; and providing laundry, toilet, and recreation facilities. If this aspect of the job is not done right, the project will not succeed.

Additional keys to a successful construction execution plan include the following:

- Ensure that an adequate staff and workforce are truly available to the project location.
- Integrate engineering and procurement with construction from project outset.
- Focus on maximization of work fronts and minimization of site restraints.
- Facilitate materials and equipment deliveries and continuously track delivery dates.
- Enforce a hands-on approach to safe practices and quality delivery.
- Establish sequences and methods for the civil, underground, and structural steel work that minimize interference with the mechanical, electrical, and instrumentation crews.
- Eliminate all contractor interfaces that add no value—the fewer, the better.
- Encourage site productivity enhancements and efficient use of resources and tools.
- Maximize the use of common services (cranes, scaffolding, concrete supply, etc.).
- Implement policies that discourage contractor employee poaching.
- Set clear, unambiguous camp rules prior to worker arrival.
- Develop a systems turnover database for coordinating and tracking status of the project systems and subsystems that will facilitate the Owner taking care, custody, and control of the project.
- Perform all construction activities with the end in mind.

Construction Plan Elements

The following items need to be addressed within the construction plan:

- Sequence and prioritize the major construction activities. Identify the critical path.
- Set the master schedule milestones.
- Establish the sequencing of IFC drawings.
- Establish the procurement delivery schedule for site (materials and equipment).
- Understand the effect of leveling or not leveling construction resources.

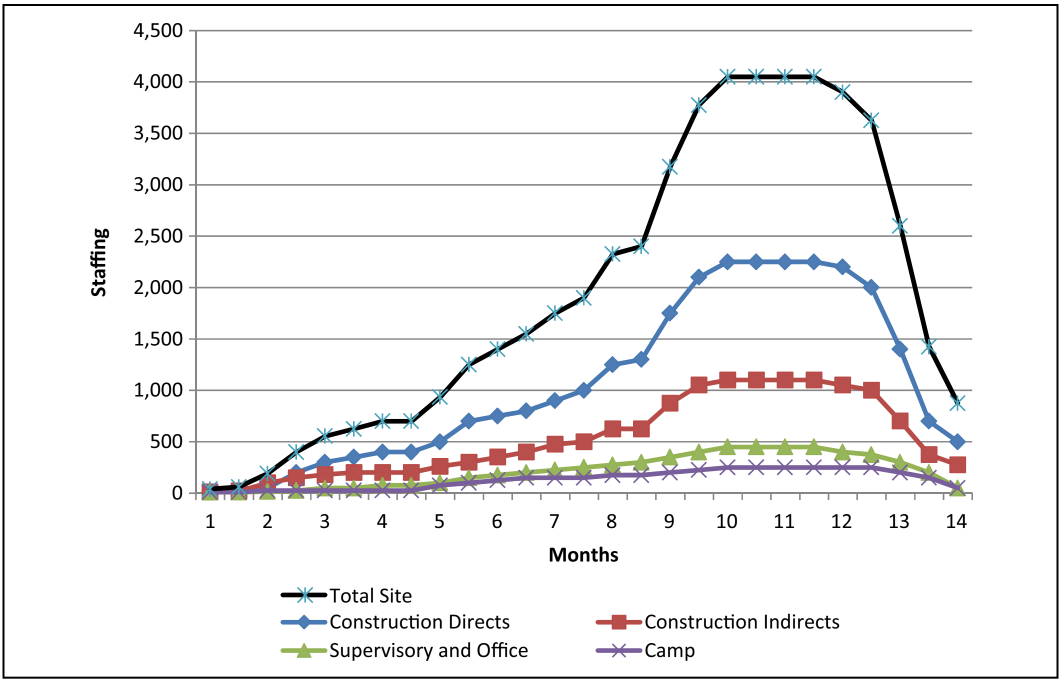


FIGURE 29.1 Construction staffing

- Ascertain the density requirements for craft personnel, as well as their availability and cost.
- Produce a site-hazards analysis (and proactively address same).
- Provide easy, well-designed construction access to the site, and enhance the accesses on-site.
- Set up as many temporary facilities as regulatory authorities will allow prior to permit approvals.
- Maximize off-site fabrication. This reduces dependency on the weather and on-site labor.
- Maximize preassembly off-site and/or in laydown areas.
- Establish site logistics early, that is, the transport to and from site, laydown areas, and warehouses.
- Prepare heavy-lift plans. Plot space and access points, as well as the availability of large cranes.
- Coordinate major lifts to minimize crane rentals and site congestion.
- Level (optimize) site support equipment requirements.
- Provide laser scan equipment to accurately and efficiently identify tie-ins.
- Determine and then establish the project's information technology (IT) needs.
- Involve the Owner operations and maintenance (O&M) staff from the outset.
- Establish a health, safety, and environmental management program.
- Become aware of any likely adverse weather conditions.
- Set the calendar for regular construction meetings.
- Set up programs to measure constructor progress, performance, and effectiveness.
- Institute an easily reviewable quality management program.

ADVANCE SITE PREPARATION

Certain advance works can (and should) be undertaken by the project manager before implementation of the main construction effort (Green 2010). These advance works can help clear the way for an early construction start and thus improve the odds of successful completion.

1. Acquire as many of the key project permit approvals as possible in advance of bid tendering (e.g., local approvals of site plans and aboveground structures).
2. Complete all property acquisition needs, including purchases, property access rights, and temporary and permanent easements. This will help ensure the uninterrupted progress of construction activity, particularly where private lands are involved.
3. Improve site access roads. This will yield uninterrupted access of heavy loads and provide a positive legacy for the impacted local communities.
4. Secure spoil sites in advance of project construction activity.
5. Install survey monuments, fencing, gatehouses, and powder magazines.
6. Complete site grading, soil improvement, and site drainage modifications.
7. Install water wells and reservoirs.
8. Relocate local utilities, to both serve the project and to place them out of harm's way.
9. Set up preliminary infrastructure, including power and communications.
10. Locate sources of both construction and potable water.
11. Install rail spurs, natural gas pipeline extensions, telephone lines, and cellular towers.
12. If feasible, upgrade port facilities, airports, and power transmission lines.
13. If budgets allow, construct warehouses, laydown yards, and camp facilities.
14. Set up the concrete batch plant(s).
15. Arrange for snow removal.
16. Obtain native tribe clearances for all construction areas.

CONSTRUCTION ENHANCEMENT TECHNIQUES

Within the construction universe there are a number of proven practices that can potentially enhance the construction process.

Lean Management Principles

When reviewing site construction efforts, project managers are encouraged to embrace *lean management* principles. Lean management examines how teams can eliminate waste and hence work more efficiently (Taylor 2013). By reviewing how work activities pass between construction teams, lean management seeks to expose the weak links in the project execution chain, identify nonessential project elements, and eliminate bottlenecks.

Lean management relies on rigorous EVM tools to accurately record the hours expended on work tasks, along with a strong WBS. The connections between construction teams are scrutinized for quality and performance impacts on project deliverables and milestones. In many ways, lean management is an extension of Six Sigma, the business management strategy developed in 1986 by Motorola that focuses on resolving quality-related problems to minimize defects in goods and services.

Prefabrication and Modular Construction

The design drawings, specifications, purchase orders (POs), and contract documents should be scrutinized for opportunities to prefabricate off-site and/or to assemble on surface before transport underground. The scrutinizers need to look beyond the obvious structures and mechanical components; they also need to examine the project's piping and electrical components (Hickson 1996).

Mass Construction

The construction contractor will always prefer to undertake mass construction tasks, that is, installing large bulk quantities of materials (concrete pours, pipe runs, electric wires, cable trays, etc.) over the more intricate, time-consuming efforts of finish work (concrete facing, wiring terminations, etc.). The constructor can create, on paper, a greater percentage of progress by focusing on the mass construction efforts and thus potentially generate higher, earlier payments. For the most part, this focus benefits both project and constructor.

The project manager must, however, guard against a constructor undertaking mass construction work out of sequence with what the project schedule needs. Finish work must be undertaken when scheduled for the project good, not at the constructor's convenience. The constructors must be required to follow the work sequencing of the master schedule. This can be accomplished in part by stipulating that the Owner owns the float in the schedule, and that any use of float requires prior approval of the project manager.

Having all the mass construction work done early, but the finish work done later than scheduled, may show on an earned value basis that the project construction effort is on schedule. But in reality commissioning will suffer delays because nothing is finished sufficiently enough to allow precommissioning to start.

Photos and Video Recordings

The project manager should identify up-front all those project elements that need to be recorded by photographs or videotape/DVD. Certainly, every aspect of construction should be recorded. One caution to keep in mind, however, is that digital photographs may not always be accepted as evidence in litigation because of the ease of subsequent alteration.

Photos and videos should have an imprinted date if possible. Otherwise, the date and pertinent information should be written on the back of photos. Audio narration describing what is being recorded should be done when video-recording.

Project elements that likely need photographing for the record include

- Preconstruction conditions;
- Structural system details, for example, concrete rebar positioning and structural connection;
- Layout of piping or wiring prior to being buried or concealed;
- Mechanical system installation; and
- Postconstruction conditions.

PROJECT MANAGER DUTIES DURING CONSTRUCTION

The heart of any project is construction. The duties of the project manager and the project management team during this stage are myriad. The more important elements are captured within this section.

Project management guidelines:

1. Focus on creating a project environment for the constructor to successfully execute the assigned project SOW.
   - Keep the constructor informed of all facts relevant to the project.
   - Manage the coordination of contractors not under the general contractor's control.
2. Avoid directing or advising on the means or methods by which the contractor should accomplish the work. Concentrate always on work outcomes.
3. Only give design or contract interpretations to the general contractor, never to the subcontractor unless the general contractor is present.
4. Do not succumb under pressure to make hasty decisions.

General oversight duties:

1. Implement a project management organization for the site.
2. Provide and manage the staff necessary to supervise the constructors' activities.
3. Direct the work in conformance with the contract documents and the Project Execution Plan (PEP).
4. Consistently communicate the project goals.
5. Implement and enforce the safety, health, environmental, and social policies based on Owner requirements, PEP, and the local, regional, and national regulations.
6. Manage the construction schedule; monitor progress against the master schedule.
7. Mandate that all contractors use the same baseline schedule.
8. Monitor compliance with work rules and codes of conduct.
9. Coordinate engineering support for the construction contractor(s).
10. Have the Engineer and Engineer's subconsultants visit the site to observe specific events as conditions warrant. Require objective, written field reports of each visit.
11. Manage the on-site temporary facilities.
12. Inspect the work completed.
13. Ensure that service providers and constructors comply with the relevant authorities.
14. Attend the daily construction meeting and have memos prepared of the meetings.
15. Monitor and report on costs and time against budget and schedule.
16. Be responsible for on-site document control and distribution.
17. Prepare the monthly progress report.
18. Keep the Owner informed of the progress of the work and any problems.
19. Notify the Owner of SOW variations by the site contractors.
20. Advise the Owner of potential revisions to the anticipated occupancy date.
21. Prepare deficiency reports and the agreements reached to correct the issues.
22. Arrange for suitable replacement of any contractor whose contract is terminated prior to work completion.
23. Designate one (qualified) person on the project manager's staff as the authorized contracts administrator to give directions on contract interpretations.
24. Manage the timely delivery of subconsultant reports, site visits, and the like.

25. Coordinate site presence of vendor representatives for installation and start-up.
26. Interface with the regulatory agencies.
27. Maintain complete site observation reports, construction meeting memos, telephone conversation reports, and so forth, in the project file.
28. Maintain daily records of weather and project site conditions (for possible claims).
29. Manage the project's insurance coverage.
30. Monitor title to the work site and equipment for liens and encumbrances, and then, for the Owner's protection, take timely steps to deal with any affected payment.
31. Manage the interfaces between the construction and precommissioning activities.
32. Have the constructors prepare subsystem tie-in packages for the commissioning.
33. Set the necessary construction shutdown periods to complete commissioning.
34. Prepare the handover procedures and documentation for commissioning and start-up.
35. Secure prompt rectification of all defects found prior to or at project completion.
36. Manage the issuance of all relevant certificates.
37. Certify the acceptance of work, subject to any holds as defined in the quality plan.
38. Perform the closeout activities.

In addition to these general duties, there are numerous specific responsibilities that the project manager is accountable for during the construction phase, which are described in the next sections.

Work-Site Services

The project manager has to ensure that all site services needed by the construction contractors are timely provided. The project manager has to perform the following duties:

1. Ensure that project mobilization of all contractors, subcontractors, and consultants takes place in a timely way, in accordance with the approved PEP.
2. Arrange for external transportation to and from the site, as necessary.
3. Manage the movement of people and supplies on-site for productivity efficiency.
4. Establish camp rules, for example, dry camp or wet camp? Who, if anyone, can go off-site?
5. Provide construction equipment (including certification, insurance, rigging plans, etc.), site office, site office equipment and related facilities (computers, printers, copiers, furniture, lighting, etc.), construction small tools, scaffolding, consumables, site bulletin boards, and other temporary materials and facilities as contractually required and as necessary to safely carry out the project SOW in a timely way.
6. Provide site services as contractually required and as necessary, including electrical outlets, telephones, Internet, potable water, toilet facilities, waste dumpsters, and so forth.
7. Maintain access roads and parking areas; arrange for debris and snow removal.
8. Be responsible for and arrange for demobilization, demolition, and/or salvage of all temporary facilities that are not part of the permanent facilities.

Industrial Relations

An important facet of the project manager's responsibilities is ensuring that industrial relations issues do not impede site construction progress. The project manager has to perform the following duties:

1. Manage all matters relating to industrial relations that arise during project execution, including labor conflicts, disputes between construction contractors, and so on.
2. Implement policies that foster teamwork among EPCM, constructors, consultants, Owner-seconded staff, and key vendors.
3. Help develop and install construction labor training plans, if work effort requires.
4. Implement initiatives for the employment of local indigenous people.
5. Review the suitability of key contractor personnel prior to their moving to the site.
6. If necessary, remove constructor personnel from site. The project manager has the right to do this, but this power should only be used for the project good.
7. Monitor the suitability of Owner-provided amenities. Ameliorate any shortfalls.
8. Implement and then monitor accommodation and transport procedures.

Safety and Health

The project manager has to ensure a safe working environment on-site. The project manager must require that all relevant safety rules and regulations that apply to the particular site are strictly adhered to, as prescribed by the mining company and the relevant regulating authorities, for example, conformance to Mine Safety and Health Administration (MSHA) regulations.

A specific formal safety and health program needs to be implemented for the project. This program should include incident and accident reporting procedures, hazard awareness and avoidance programs, in-house inspections, and safety status reporting. A joint safety manual, developed together by the EPCM, Owner, and construction contractors, is a desirable element of the program.

Persons working on or visiting the site will have to undergo a safety orientation prior to site entry. The safety and health program can generally be accomplished efficiently with videorecordings, classroom presentations, and follow-up tests. The purpose of the safety program is to recognize and mitigate workplace hazards, and to protect project workers from any hazardous situation escalating into an actual incident. This is accomplished through attention to the "Six Cs":

1. **Control** of workplace procedures and environment
2. **Competent** employees, properly trained
3. **Communication**—unambiguous and clear
4. **Culture**—a robust, positive attitude toward safety
5. **Commitment** from management and from each individual in the workforce
6. Never allowing **Complacency** to set in

Invariably, the project management team will include a stand-alone safety and health supervisor or manager. But this person is not the only one responsible for project safety—the whole project management team is responsible. Thus it is important to cross-train other team members so that they can cover during the hours when the safety supervisor is not on-site.

While overall project safety is the responsibility of the project management team, the project manager needs to ensure that the Owner client does not become accountable (legal or otherwise) for the contractor's safety program and performance. The constructor should be required to submit a site-specific safety plan. The project manager then approves the contractor's safety program and has the project team monitor the contractor for compliance. The ultimate responsibility for health and safety of the contractor's personnel is the contractor. From a legal viewpoint, the project manager needs to preserve this arm's-length arrangement for the Owner.

Physical Progress Measurement and Productivity Monitoring

Progress is measured in the field by the construction contractors, verified by the EPCM, then calculated and reported by the project controls staff on an earned value basis. The project controls staff handles the details of tracking progress and schedule against the plan:

- Actual physical progress versus plan
- Actual direct labor expended versus planned personnel
- Productivities by activity and trade

Even if construction is being managed by an EPCM entity, the project manager is still responsible for ensuring that progress is being properly reported and that the schedule is being maintained. This is achieved through frequent site visits, inspections, attending the daily and weekly coordination meetings on-site, reviewing control documents (such as the 3-week rolling horizon schedules and the forecast productivity curves), and then measuring and comparing these verbal and documented yardsticks against actual physical progress on-site.

Subcontractors

The project manager must require that each contractor apply sufficient effective control over their respective subcontractor operations throughout project life to ensure that subcontractors' schedule, budget, and quality all maintain conformance with project requirements.

Quality

The project manager is responsible for maintaining the quality performance contractually required from the constructors and suppliers. The project manager's role includes ensuring that each site constructor has a quality control plan in place, and that all are in accord with the overall project quality plan.

The timing and scope of the workplace audits are set by the project manager. Audits are performed on the construction contractors and the Owner's self-perform teams. Where possible, formal test procedures are used to objectively measure quality compliance. The work in the field needs to be constantly inspected to ensure compliance with the quality plan, industry codes, and engineering and Owner specifications:

- Nonconformities are highlighted and then followed up for correction.
- Constructor inspections and tests are witnessed.
- Test documentation is audited.
- Constructor's test equipment is verified.
- The quality of the constructor's direct labor is verified, for example, welder certifications.
- Tool-, equipment-, and electronic-measuring device calibrations are regularly checked.
- Each contractor's record keeping is verified.

The field engineer normally maintains all the QA/QC files, calibration records, test data, nonconformance logs, punch lists, and quality rectification reports for the project manager.

Budget Control and Cost Monitoring

The project manager has to assert sufficient control over construction to ensure that project facilities are completed within the approved budget, and to garner enough relevant to-date and predictive trend information to allow corrective action when necessary.

To maintain the cost of construction within budget, the project manager must deal promptly with any changes of scope or claims relating to site condition. This means that an up-to-date record of all cost-to-date and value-to-date work done, contract value change requests, commitments-to-date, extra or less work, back charges, and other construction costs have to be maintained, along with trend forecasts of possible future changes.

Particular attention should be paid to the indirect cost areas, given that field costs relating to temporary facilities, utilities, equipment standby charges, field POs, vendor representatives, and construction management can often rapidly spiral out of budget. For any meaningful information to be drawn regarding budget status, the construction contractors' cost control systems *must* correspond to the project's approved WBS. Any and all contractor objections to this principle must be emphatically denied.

Schedule Adherence

The master Level 4 Execution Schedule defines the interaction between engineering, procurement, and the various on-site constructors. By having the constructors each focus on the designated key milestones within the master schedule, the project manager can avoid the constructor's personal interest taking over the overall project interest.

There is debate within the construction community about whether the construction look-ahead schedules should be 21 or 30 days. While there is no wrong answer, the shorter 21-day look-ahead makes most sense to the authors. It is quicker and easier to produce (thus more likely to get done), and days 22 through 30 are not that important for most short-term work assignments.

Schedule Enhancements

In addition to the master project schedule, an early-completion, aggressive schedule is encouraged with earlier milestone dates than in the master schedule. To be meaningful, an aggressive schedule requires buy-in from all affected parties, namely, all field contractors and subcontractors. Project tracking is performed against this early-completion schedule *and* the master schedule.

Change Control

Complete and detailed predictions of the cost and time needed to finish the project have to be maintained by the project manager. Any allowed change will affect these predictions.

1. All contractor proposals for change must follow the change order procedure. Extra work change orders are prepared by the field engineer, negotiated with the construction manager, and approved by the project manager.
2. Since the design is supposed to be complete before bidding, once construction begins, design change can only be reflected by change order.
3. Owner authorization is required for scope change that affects overall budget or time.

4. Once approved, all approved change orders are forwarded to the contractor, with copies maintained in the change order log.
5. The project management team additionally prepares and issues written field orders (i.e., those no-cost items not affecting the schedule or design intent) as appropriate.

Procurement and Expediting

A comprehensive logistics plan must be in place and functioning before field construction activities start. The project manager has to ensure that all procured equipment and materials, including Owner-procured items, are on schedule, and that delivery matches the construction schedule. (See Chapter 28.) Where bulk materials are ordered from the site, the project manager must ensure that adequate systems are in place on-site to execute the order functions and then receive the materials efficiently and cost-effectively. When field purchasing from local vendors is used to provide supplies and consumables and/or cover field shorts, the acquisitions need to stay within the approved procedures.

Wherever possible, the procurement arm of the EPCM firm should be used to handle as many of the sourcing functions as possible, particularly for bulk items. This keeps the responsibility for expediting and material delivery with the EPCM contractor.

Site Materials Management Control

The project manager is responsible for implementing a materials-handling plan and integrating the estimated time-of-arrival dates of the equipment and materials into the master Execution Schedule. The plan has to control the timing of material movements in order to ensure the availability and traceability of equipment and materials for installation, as per the schedule and priority sequences, and to minimize delays and quality claims.

Materials management control involves the management and storage of all equipment and material deliveries, and the issuance of such equipment and materials to the construction contractors. Site materials management, including effective warehousing and materials preservation, is typically handled by the procurement provider, reporting to the project manager. Wherever possible, a bar-coding system is encouraged. Consignments received on-site are checked against way bills, release certificates, packing slips, and the POs provided by the procurement entity. The received equipment is checked for damage and/or variance of quantity. Both procurement and accounting are copied with the goods-received voucher.

While the project manager typically controls the materials management warehouses and laydown yards for most site contractors, this will not be the case for any lump-sum contractor. Lump-sum contractors generally control their own materials in their own separate facilities. Consequently, on a site with both lump-sum and non-lump-sum contractors, procurement progress tracking becomes difficult. Thus, whenever a lump-sum contact is awarded, the contract should specify that the contractor must track and report its materials movement monthly to the project management team. The project team needs to know when the lump-sum contractor's materials are on-site, as invariably this contractor will be interfacing with other contractors.

Vendor Representatives

POs must specify if there are any requirements for the services of a vendor's technical representative during construction. The field engineer initiates and coordinates vendor support activities for the constructors.

Spare Parts

A verification procedure has to be established that all recommended spare parts (specified by both the Owner and the EPCM firm) and first-fill consumables are procured and physically on-site prior to commissioning. The project's 80% construction completion milestone date is typically used for the target date for on-site spare parts and consumables readiness. This 80% construction completion milestone generally coincides with the completion of most of the mass construction effort. The reason for this early target is because if checks reveal that any parts are missing, there is still time to bring them in before commissioning (when they are really needed).

Environmental Impact and Permitting

The mining company's environmental department will typically assign environmental personnel to work on the project and thus ensure that it is built in accordance with the environmental permitting constraints as well as the design standards. In addition, an environmental compliance program should be implemented that focuses on the conduct of the project site activities, including on-site inspections and overview audits. The project manager is responsible for making certain that the Owner has all necessary permits in place, and that the constructors (working with the Engineer) get all the building, utility, and work permits in place in a timely way.

Social Acceptance and Sustainability

The Owner's social responsibilities within the project area frequently affect the conduct of construction. It is the responsibility of the project manager and his or her team to direct the field construction contractors to respect all social and sustainability limitations, and to ensure that construction work is performed in accord with any and all constraints.

Site Security

The project manager is accountable for seeing that the construction manager enforces site security, including preventing unauthorized persons from entering the site; registering all personnel entering the site; preventing property theft; and eliminating unauthorized weapons, alcohol, drugs, and vehicles from the site.

Risk Management

The management of project risk is a central responsibility of the project manager and an inherent component of all the project manager's duties. The role of the project manager is to come up with strategies that remove or at least mitigate these and all other risks. Risks encountered in the construction phase include the following, in the construction industry's order of reported significance:

1. Delay in issuance of permit to construct
2. Delays in receiving IFC drawings and work packages from the Engineer
3. Delays in the delivery of equipment and materials

4. Scope changes (predominantly by the Owner)
5. Social issues concerning the local community
6. Labor skills shortages
7. Delays due to nonperformance by site constructors
8. Interface problems among site constructors, Owner operations, and IFC drawings
9. Weather
10. Construction accidents (not necessarily involving human injury)
11. Sufficiency of water and utilities (electric power, ventilation air, etc.) to perform
12. Constructability difficulties
13. Site access restrictions

Constructor Payments

A process for approving construction contractor payments must be set for the Owner's representative assigned to the project team. The project manager is the person who authorizes the contractor invoices for payment. The project manager has to certify to the Owner that the work listed in a constructor's application for payment has been done and complies with the contract documents and rates. The project manager's staff checks the contractor's work progress claim against the actual physical progress, as well as against the retained percentage, and the staff provides an assessment of any defective work.

The project manager has the responsibility of recommending that a portion of the payment for the work be withheld if it is not in compliance with the contract, or in the case of a lump-sum contract, if there is reason to believe that the balance of the work will not be completed within the contract period or with the remaining funds. If no grounds exist for withholding payment, certificates of payment will be issued to the Owner, with copies going to the contractor. In the case of a lump-sum contract, before the constructor's first application for payment, the project manager must review and approve the constructor's schedule of values (see Chapter 20).

Communications

The project manager implements a site communications plan that covers communications among all site constructors as well as communications to Owner personnel. This plan (which is essentially the same plan that is in the PEP; see Figure 17.4) should include all the necessary templates for formal communication, for example, submittals, requests for information (RFIs), change requests, invoices, and release of liens.

Document Management and Control

The project manager manages the document flow. Before construction begins on-site, the field engineer prepares the document distribution matrix for the project manager. Informational documents need to move to and from the site in a timely way; control documents need to be suitably prepared. All the following documents are used in the construction phase; they each need formal management and control:

- Technical documents
  - Drawings
  - Vendor drawings and documentation (test reports, material certificates, etc.)
  - Specifications

  - Manuals
  - Reports
- Contract documents
  - Variation orders
  - Payment schedules
  - Meeting minutes
- Correspondence
  - Letters
  - Facsimiles
  - Meeting minutes
- Material control
  - POs and PO amendments
  - Goods-received acknowledgment vouchers
  - Variance reports
  - Delivery notes
  - Back charges to vendor

Before it is filed in the appropriate project file, each document must be assigned a unique reference number with a date stamp of issue and/or receipt, as well as a record of its distribution.

Reporting System

Three main sets of reports are needed for control of the construction effort: contractor reports, project monthly reports, and periodic project reviews.

Contractor Reports

Contractor reports are required daily, weekly, triweekly, and monthly. The monthly reports from each site constructor should include the following sections (as applicable):

- Introduction
- Summary progress report
- Highlight statistics (one page)
- Issues, concerns, and remedial actions
- Safety statistics
- Activities during the month
  - Field engineering
  - Procurement
  - Contracts
  - Construction (with progress curve)
  - Quality adherence
- Cost report and forecast
- Project controls
  - Change order summary
  - Deviation and potential deviation logs
  - RFI log
  - Trend analysis

- Latest schedules
    - Level 4 Execution Schedule
    - Critical path methodology (CPM) schedule
    - Area detail schedules
    - Milestone variances
    - Look-ahead forecast completion date
- Environmental, social, and sustainability issues
- Personnel
    - Staffing levels
    - Craft worker productivity
    - Training accomplishments
- Activities missed during the month
- Planned activities for next period

Project Monthly Reports

The project monthly report (the prime information transmission mechanism to the Owner) reports on the completed progress for the initial 80% of the project, and after the 80% point, the work remaining. (For details of the official project monthly report, see Chapter 22.)

Periodic Project Reviews

The periodic project reviews are the periodic senior management information updates produced every 6 to 12 months, as described in Chapter 22.

Handling Visitors

Every project site is inundated with visitors. It cannot be avoided. Individuals such as mine inspectors, government officials, bank financiers, politicians, adjacent landowners, auditors, insurance adjusters, consultants, experts, union business agents, vendors, repair persons, delivery persons, transport drivers, local law enforcement officers, and job applicants all have legitimate reasons to be on-site. So do stakeholders such as the Owner's management team, safety committee, Board of Directors, EPCM representatives, local community leaders, and indigenous people's assemblies. The site will even be asked to accommodate student delegations and mining convention tourists from time to time.

The project manager needs to set up the site to handle these influxes of people safely:

- Adopt a regimented procedure to schedule visits. Do not allow unscheduled visitors.
- Prepare a streamlined safety orientation in a dedicated visitor reception area.
- Designate a visitor parking area.
- Provide inexpensive souvenirs (e.g., site-specific brochures, rock samples, decals).
- Keep sets of personal protective equipment (hard hats, etc.) that are only for visitors.
- Provide an abridged PEP manual on hand (with design data sheets) to aid the visitor escorts in answering questions.

CONSTRUCTION MANAGER DUTIES

The number-one role of the construction manager is to provide work-site leadership. The construction manager is responsible for the management of quality, the execution, and the coordination of all field-related aspects of the construction work that is performed or subcontracted. The goal of the construction manager is to provide a safe work environment at the most economical cost to the project, with proper regard for health, environmental protection, safety, personnel well-being, site security, contract management, planning, scheduling, progress control, cost control, inspection, material and logistics management, and contractor interface management.

Before the site work starts, the construction manager's experience should be drawn upon for establishing the work package breakdown, setting the contacting strategy, setting the execution methodology, and selecting qualified constructors. The following are the specific duties for the construction manager once constructors are chosen:

1. Prepare and manage a detailed construction plan for each phase of construction. Plans need concurrence from the constructors regarding construction methods, optimization of construction equipment use, and site policies.
2. Manage the on-site constructors and their subcontractors.
3. Apportion work between contractors for project benefit.
4. Establish and implement construction monitoring and progress-reporting systems.
5. Maintain the construction schedule and facilitate the attainment of milestones.
6. Arrange and record project site meetings, formal and informal.
7. Manage the RFIs from the constructors.
8. Provide temporary construction facilities, as needed.
9. Monitor the performance of the site contractors against the work plan to enable corrective action to be taken to minimize the effects of possible delays or stoppages.
10. Facilitate the proper and efficient performance of work by the constructors.
11. Minimize traffic congestion on-site.
12. Resolve contractor issues; help diffuse contractual problems and project risks.
13. Maintain a register of all contractor variations.
14. Manage the extension of time requests from the contractors.
15. Manage the receipt and issue of all construction materials.
16. Maintain a clean and safe work environment.
17. Conduct regular inspections to ensure compliance with health, safety, quality, and environmental requirements.
18. Ensure that the adjoining properties are not harmed by project construction activities.
19. Control access to and departure from the site; produce a traffic management plan.
20. Ensure that contractors remedy any damage caused by them to other contractors on-site or to the project itself.
21. Manage and enforce site security.
22. Supervise certification checks and testing carried out by the constructors.
23. Ensure delivery of all requisite closeout documentation and information to the Owner.

CONSTRUCTION SUPERVISOR DUTIES

The construction supervisors reporting to the construction manager are responsible for managing the daily performance of the construction workers on-site (i.e., crafts, equipment operators, laborers, etc.). These supervisors are also responsible for obtaining marked-up drawings from the site constructors and delivering them to the field engineer for production of the final as-built drawings.

FIELD ENGINEER DUTIES

Field engineering ensures that the SOW is conducted in accordance with the design drawings, specifications, and agreed-to standards, including such items as field tests, sample logs, red-line drawings, and submittals for review. Typically, the field engineer is custodian and distributor of documents for the project management team on-site, on behalf of the construction manager and the project manager. A full listing of the field engineer's role and duties is included in Chapter 27.

PREPARATION FOR PRECOMMISSIONING AND START-UP

The procedures and interfaces for a smooth precommissioning and start-up have to be developed prior to completion of the construction stage. (See Chapter 30 for more details.) The precommissioning team is put together prior to the end of the construction stage. While the precommissioning team is best led by precommissioning specialists, it needs to draw on the breadth of skill sets abiding within key personnel in the project's EPCM contractor, site construction contractors, and Owner operations.

On fast-track projects where the feasibility study, engineering, and construction may overlap, it is vital to integrate the precommissioning effort into the construction phase and thus ensure that the correct construction sequence is maintained. However, as stated earlier, to the maximum extent possible, fast-track project ideology needs to be discouraged, as control procedures cannot help but be violated in this type of schedule.

OPERATIONS PREPARATION

All the key operations staff and the initial nucleus of hourly paid personnel have to be hired, indoctrinated, trained, and positioned on-site before the end of the construction stage, that is, by the beginning of the precommissioning stage. It is thus important that the training for these initial operations personnel be firmly set and then completed in a timely way. The milestone of completion of 80% of the construction work is typically used for the target completion date of operations preparedness.

PARTIAL UTILIZATION OF PROJECT FACILITY

Portions of a project may be usable before the entire project is completed, and as such, the Owner may wish to occupy them. If partial utilization of the facilities is desired ahead of final inspection of the entire project, the facilities in question will each need to be inspected to ascertain substantial completion (defined later in this chapter) in accord with the contract terms.

To accomplish partial utilization on behalf of the Owner, the project manager will need to complete the following tasks:

- Receive notification of substantial completion of the pertinent facilities from the construction contractor.
- Inspect the work by the project manager to verify substantial completion.
- Prepare a punch list consisting of any incomplete or defective work.

- Notify the appropriate governmental authorities regarding those facilities that require regulatory inspection before occupancy or use.
- Prepare a certificate of substantial completion when the work is eventually deemed substantially complete. Then obtain *both* the Owner's and the construction contractor's written acceptance and approval.
- Obtain a certificate of occupancy or occupancy permit on behalf of the Owner, if either are required by the local building code.

CONSTRUCTION COMPLETION MILESTONE

Construction completion occurs when all systems composing the project have been built in accordance with the contract drawings, specifications, manuals, authorized changes, applicable codes and standards, and permit restrictions; and when all equipment including mechanical, electrical, and instrumentation has been correctly lubricated, aligned, and has been deemed safe and ready for precommissioning.

To assist in ascertaining the completion milestone, the construction contractors should be required to send detailed inspection lists of their own completion verification activities to the project manager throughout the course of the construction phase. These lists will allow the project manager to efficiently plan his or her own completion confirmation work.

Thus when the construction contractor makes the claim that project construction is approaching, or has reached achievement of defined completion, and that the facility is capable of entering the precommissioning and testing stage, then the project manager and his or her team (with the EPCM firm if applicable) will inspect the facility and prepare a punch list of any items not completed in accordance with the contract documents.

CONSTRUCTION COMPLETION DEFINITIONS

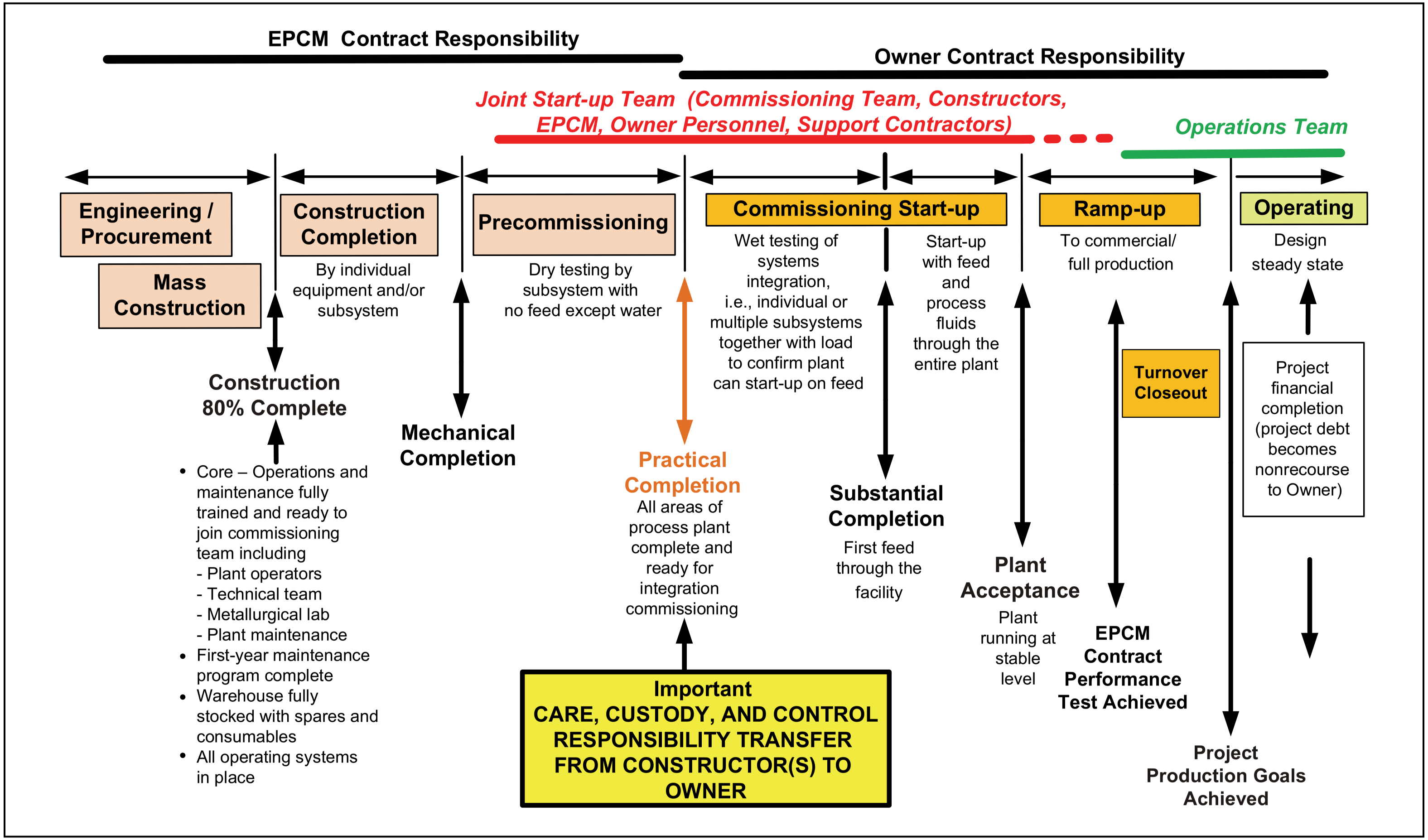
It is critical that precise, unambiguous construction completion criteria be agreed to by all parties *before* construction is started. These criteria are the specific milestone accomplishments that define construction completion for the project.

It can also be helpful to set down on paper the understandings of the parties regarding the differing completion definitions that exist within the project's world, that is, mechanical completion, practical completion, beneficial occupancy, essential completion, provisional acceptance, substantial completion, and so forth. This is not mandatory, but it is often an interesting exercise.

The most common preference (at least for most Owners and EPCMs) is that the contractor's completion milestone be analogous to either substantial completion or practical completion. These milestones are *not* the same as mechanical completion (which construction contractors prefer the most for construction completion). Mechanical completion generally precedes practical completion (see Figure 29.2).

Mechanical completion is normally applied to individual systems, subsystems, or single pieces of equipment (i.e., unit systems) within a project facility rather than to the full project. Thus mechanical completion for a unit system can be achieved when the unit system alone is complete enough to mechanically start and perform a test run.

Practical completion is not reached within a project until sufficient systems have been successfully precommissioned such that the first processing of ore material and/or process fluids can occur; that is, commissioning leading into start-up can now begin to take place. Be careful,



- Core – Operations and maintenance fully trained and ready to join commissioning team including
  - Plant operators
  - Technical team
  - Metallurgical lab
  - Plant maintenance
- First-year maintenance program complete
- Warehouse fully stocked with spares and consumables
- All operating systems in place

FIGURE 29.2 Project completion chart

though, not to rely solely on *practical completion* as the definition of *construction completion*. The reason is that mechanical completion may not have been reached for all systems within the entire project facility when practical completion is claimed and first processing takes place; that is, not all systems may have achieved operations capability. For example, only one mill process line may be operable, or the gold refinery room may not be complete when the leaching process of a gold project first starts up.

A full project that is *substantially complete* is likely to be more advantageous for the Owner than for a facility that has achieved practical completion without all project systems being operable. Substantial completion is when all systems and facilities are ready to accept feedstock for start-up operations and are capable of production.

Mechanical Completion

Mechanical completion means that an individual system, subsystem, or single piece of equipment (i.e., a unit system) within a project facility is complete enough for the unit system alone to mechanically, electrically, pneumatically, and hydraulically start (as the case may be) and perform a test run. Minor work that does not interfere with operation, such as punch list and touch-up work, may still remain. Note that mechanical completion encompasses more than mechanical work. One cannot confirm that a motor is mechanically complete until it has been electrically hooked up so it can be tested.

From the authors' experience (cross-checked with three EPCM firms) a system can be defined as mechanically complete when all the following activities have been performed:

- Equipment and materials have been installed as per detail design documents and procedures.
- Equipment and materials have been tested in accordance with relevant QA/QC procedures.
- Electricity polarity checks and insulation measurements are complete.
- Piping systems pressures have been tested and flushed. All lines and vessels have been dried.
- Process systems have been purged, flushed, and dried.
- All pumps, compressors, motors, seals, and other mechanical equipment have been run in.
- Pump and valve packing have been adjusted properly; all lube oil systems have been run in.
- All instruments have been set, calibrated, and adjusted without load. Factory calibrations have been confirmed in the field. Instruments are accompanied by approved calibration certificates.
- All relief devices and alarms have been calibrated and set.
- Functional testing of electrical controls and instrumentation loops are complete.
- Computer systems have been tested via simulated field signals.
- The system has been flushed and degreased, and the strainers have been removed and/or cleaned.
- All relevant equipment have received first fills of oils, greases, and other lubricants.
- Facilities have undergone final cleanup, including removal of construction items.
- Construction QA/QC results and reports have been submitted and approved.
- A punch list of incomplete items has been agreed to by the project manager and constructor.

- All components of the system are ready to commence precommissioning testing.
- All activities preparatory to precommissioning have been completed.

Practical Completion

Practical completion is achieved when enough necessary construction work has been done on the project such that the project can be certified complete and free from patent (obvious) defects. Practical completion cannot be achieved when patent defects remain in the works. Only very minor defects can be tolerated. To use legal language: "only *de minimis* items of work can be left incomplete, items which can be ignored as trifling."

When the Owner is physically able to beneficially occupy a portion of the project works and use those works for their intended purposes, this standard of completion is called practical completion. This form of completion thus requires sufficient systems within the project to have been successfully precommissioned such that the first processing of ore material and/or process fluids (start-up) can occur.

But while the term *practical completion* is used throughout the construction project world, it comes with drawbacks. For one, there is no accepted legal definition of practical completion. And even if a portion of the works can be beneficially occupied, unless the contract language specifically provides otherwise, if the works are not finished, the Owner has no obligation to take possession.

Thus the concept of practical completion is a frequent source of dispute (Hawkswell Kilvington 2012). Parties disagree not only about what the term means but, more consequentially, whether or not practical completion has been achieved on-site.

The decision as to whether practical completion has been achieved truly matters. Practical completion is a critical milestone in a construction project, particularly for the contractor. Failure to complete the works by the specified completion date means the contractor is in breach of contract, which could result in the deduction of liquidated damages or an Owner claim for delay penalties. In essence, practical completion triggers the passing of the major project risks from the contractor to the Owner.

Once practical completion is achieved,

- The Owner is able to take possession of that portion of the works;
- The Owner's right to instruct variations to the works in that portion ceases;
- Claims for delay on the part of the Owner and for loss and expense, or for extension of time on the part of the contractor, cease to accrue;
- The first part of the payment retention can be released to the contractor;
- The defects liability period begins;
- Responsibility for damage to (and insurance of) the works passes to the Owner; and
- The legal limitation period for claims begins to run.

For these reasons, it is important to be able to identify precisely when practical completion has been achieved. While it is possible to amicably agree up-front on a broad definition of what practical completion means, deciding whether or not practical completion has actually been achieved on a particular project is much more difficult. It ends up being determined on a case-by-case basis. In most contracts it is left to the discretion of the project manager (or Owner) to determine whether practical completion has been achieved by the contractor. Clearly, this can lead to differences of opinion in cases where the contractor considers the works to be complete and the person responsible for certifying does not agree.

This situation should not be allowed to happen; the parties need to come together and specify, up-front, a set of detailed conditions to be met by the contractor before practical completion can be certified. It will not remove all disagreement at work finish, but it will certainly help. To this end, savvy mining companies insert very specific language similar to the following into their construction contracts as *the* determinant of when *practical completion* has been achieved.

Practical completion occurs when all of the following conditions have been achieved:

1. Contractor has completed all civil and structural construction work.
2. Contractor has set all equipment on foundations, connected equipment to other equipment as required by way of piping, wiring, controls, and safety systems.
3. Contractor has completed precommissioning of all systems and subsystems.
4. All permits and approvals required from regulatory agencies have been obtained.
5. All temporary supports, bracing, tie-downs, and materials provided for protection during shipping, storage, and installation have been removed.
6. All construction debris has been removed, disposed of properly, and all areas are clean.
7. Any and all buildings and accessories, including HVAC equipment, have been properly installed and checked to confirm completeness.
8. All safety features are installed and operational, including guards, handrails, etc.
9. All initial fills have been completed.
10. Required insulation, painting, paving, fencing, and like items are complete except to the extent identified on the punch list.
11. Mechanical checklists have been submitted and approved, including QA/QC for alignment, electrical checks, megger test results, first fills, run-in results, etc.
12. All work is ready for wet commissioning and can be operated.
13. The commissioning plan for all operable systems has been approved.
14. Documentation of testing and other QA/QC requirements has been provided for operable systems in accordance with approved commissioning plan.
15. Contractor has provided all required as-built documentation, and has delivered all supplier and vendor drawings, data, certifications, warranties, and manuals.
16. Owner and contractor have agreed on the punch list.
17. Owner has issued a Certificate of Practical Completion.

This approach can be beneficial because it provides some certainty as to exactly what final tasks the contractor must carry out for completion certification. However, it can be detrimental to the contractor, as failure to comply with just one condition, no matter how minor, can allow the project manager to legitimately refuse to certify achievement of practical completion.

A contract containing multiple conditions necessary for practical completion should be reviewed very carefully by the contractor. Practical completion certification can be denied by the project manager simply because the contractor has not completed administrative matters, such as the signing of collateral warranties or the preparation of O&M manuals. The contractor will need to adopt a proactive approach to the administrative duties to avoid becoming subject to “technical” default.

Essentially Complete and Provisional Acceptance

Essentially complete means that *all major* work and all project systems (stand-alone and interdependent) are complete, but minor work such as punch list and minor touch-up work that does not interfere with operational start-up could be outstanding. *Provisional acceptance* refers to acceptance of the project systems and facilities by the Owner, subject only to completion of outstanding punch list items. Thus provisional acceptance occurs when the project is essentially complete.

Essentially complete sounds good and is more encompassing than practical completion, but the term *essentially complete* should be discarded because it has no real legal precedent. It is used less often than practical completion on construction jobs (thus is understood less) and rarely appears in contracts. It is best to stick with what most people use.

Substantial Completion

Substantial completion is the point in the progress of the project work when the project or designated portion thereof is sufficiently complete in accordance with the contract documents, such that the Owner can beneficially occupy the project or a portion thereof for its intended use, and when all systems and facilities are ready to accept feedstock for start-up operations and are capable of production.

Substantial completion in reality is not materially different from essentially complete, but the term *substantial completion* is the legally favored term throughout the construction contracts world. Substantial completion sounds objective enough; but, like practical completion, is not so easy to determine. Many lawyers believe that no milestone in a construction project is more significant than that of substantial completion. From legal precedents already established, this wording in a contract has come to have a tremendous impact on the rights and remedies that the Owner has against the construction contractor.

Because of these legal precedents, Owners find themselves having an inherent interest in treating the project work as less than substantially complete for as long as they can. The reason is that the courts have ruled that the Owner can no longer assess liquidated damages for late completion. The Owner cannot withhold large sums from the contract price; only the costs of repairing or completing punch list items may be retained. In many jurisdictions, once substantial completion has been achieved, the Owner loses the right to terminate the contract for default. (Note that incomplete punch list items are not a material breach.)

These court rulings have led some Owners to manipulate the substantial completion milestone and refuse to acknowledge substantial completion even in the face of certification by the Owner's own designated project manager or construction manager. Substantial completion can be synonymous with practical completion. It all depends on the definitions within the particular contract. The point is that there are multiple definitions of *completion*. The parties need to agree up-front on which definition they want to use.

Typically, the term *practical completion* is more generally used for the situation in which first processing takes place, but not all systems are yet operationally capable; for example, when only one process line of a multiline mill facility is complete.

The term *substantially complete* is more typically reserved for the full project, that is, when all systems have achieved practical completion. But strictly speaking, this does not have to be the case, *substantial completion* could be (and often is) applied to single systems.

This book is not attempting to state which completion definition should be used in any particular construction contract; the choice depends on the situation. What is important is that the project manager be aware of the issues surrounding the various definitions and then to make sure that the Owner is in agreement before signing off on whatever completion definition is adopted.

CONSTRUCTION COMPLETION WORK PROGRAM

Project Manager Duties at Construction Completion

Irrespective of the preceding legal discussion, there are specific tasks that the project manager needs to accomplish to signify the completion of the construction phase:

1. Receive the construction contractor's written notice that all the work is complete.
2. Make a final inspection of the work and prepare a punch list, and then reinspect to verify all punch list items have indeed been corrected.
3. Notify any governmental authorities that require inspection before occupancy.
4. Have the Owner obtain an occupancy permit, when required.
5. Ensure that the construction contractor and subcontractors have carried out their responsibilities for insurance, security, maintenance, damages, and utilities.
6. Obtain all contractually required items from the construction contractor, including the following:
    - Warranties (see the "Warranties" section)
    - Certificates of Inspection and Commissioning
    - Keying schedule for all doors within the facilities
    - Turnover of all requested maintenance stock and supplies
    - As-built (red line) drawings for the Engineer's drawings of record
    - Bonds
7. Ensure that all O&M manuals have been turned over to the Owner.
8. Receive the contractor's final application for payment along with the following:
    - Any release of liens and consent of surety (see the "Lien Waivers" section)
    - Affidavits indicating that all bills have been paid
    - Notification that the Owner has received keys
9. Verify that all contractual conditions have been met.
10. Issue the final certificate for payment when all work is acceptable.
11. Initiate the coordination and holdover of any necessary personnel from the construction contractor and subcontractors for the project commissioning and start-up.

Punch Lists

When it is reasonably believed that construction completion of a facility, system, equipment, or any of their parts has been achieved, then the project manager and the construction contractor will make a complete inspection of the installation and together prepare a list—the *punch list*—of any pending work to be completed, repaired, or replaced prior to precommissioning initiation.

A formal written submittal of the punch list is transmitted to the construction contractor (and Owner) by the project manager as soon as practical, preferably within 48 hours of the inspection's completion. The documentation transmitted to the contractor should show the specification page and paragraph number or drawing detail of each verified deficient item not complied with. This procedure saves time and effort if an item is contested. Re-inspection is required to verify completeness or accomplishment of corrective action. Corrected items should be noted as such, with the completion date on the updated punch list.

Final Inspection

Final inspections and punch lists communicate to the construction contractor the specific items that require repair or completion prior to the initiation of occupancy, the warranty period, and final payment to the contractor. Final inspections are only held when all parties agree that the punch list produced will lead directly to occupancy or use. Inspections made without this agreement are not considered final.

The normal protocol for final inspection is for the construction contractor to request inspection of the entire project or of specific areas or systems based on the beneficial occupancy schedule provided by the Owner. If no such beneficial occupancy schedule has been provided, the contractor can make its own schedule. It is helpful for copies of relevant plans, specifications, and change orders to be assembled for each facility and/or system prior to the inspection.

Warranties

Product warranties provide the Owner with a period of time during which the facility and its equipment are to achieve design operation without malfunction. Any problems not caused by the Owner's misuse will be corrected at no additional cost to the Owner during the warranty period.

Each manufacturer warrants its product to the purchaser. If, for example, the purchaser is a subcontractor, then the subcontractor warrants to the general contractor, who, in turn, warrants the product to the Owner. While warranty periods are typically 1 year, all warranties need to be reviewed at project start by the project manager's team for limits in the manufacturer's guarantee that may attempt to exclude the manufacturer from liability under certain conditions of use. In such cases the contract documents should have language inserted to provide the Owner with protection for the excluded use conditions.

Lien Waivers

Lien waivers need to be provided by all parties under contract in the project, and consent of surety needs to be provided by each of these contracting parties' bonding companies. Lien waivers and consent of surety assure the Owner that no financial encumbrances can be placed against the Owner by any contractor, subcontractor, supplier, or laborer. Lien wavers may be used in conjunction with each periodic payment to the contractor(s) and are almost always used in conjunction with final payments to the contractor(s).

Record (As-Built) Drawings

Record drawings should be mandatory in all mining construction projects. These drawings of record—or as-built drawings as they are more commonly termed—capture all the deviations from the construction documents that occur during the period of construction.

The construction contract needs to state that the constructor is responsible to maintain all necessary information for this record at the construction site, noting all changes, deviations, and modifications on a set of the construction documents (known as the "red lines") with cross-references to relevant specifications, standards, and codes. The construction contractor's contract should allow Owner access to the as-built drawings during the construction period and should specifically define the requirements and timeliness of transcription and the transmittal protocol to the Owner.

The actual production of the as-built record drawings from the red lines for the Owner is generally the responsibility of the Engineer—sometimes as a part of basic services and occasionally as an additional service. The documents should be provided in electronic form (hard copies are rarely needed today).

Completion Certification

Once the facility (or a system within the project facility) completes its precommissioning systems check (see Chapter 30), and it is acceptable to the project manager, the Owner, and the operational staff, an interim completion certificate can be issued in accordance with the terms and conditions of the contract. This certificate will activate the warranty period and allow a phased demobilization of the construction resources. Completion certification for the full project does not take place until commissioning and start-up are satisfactorily complete (see Chapter 31).

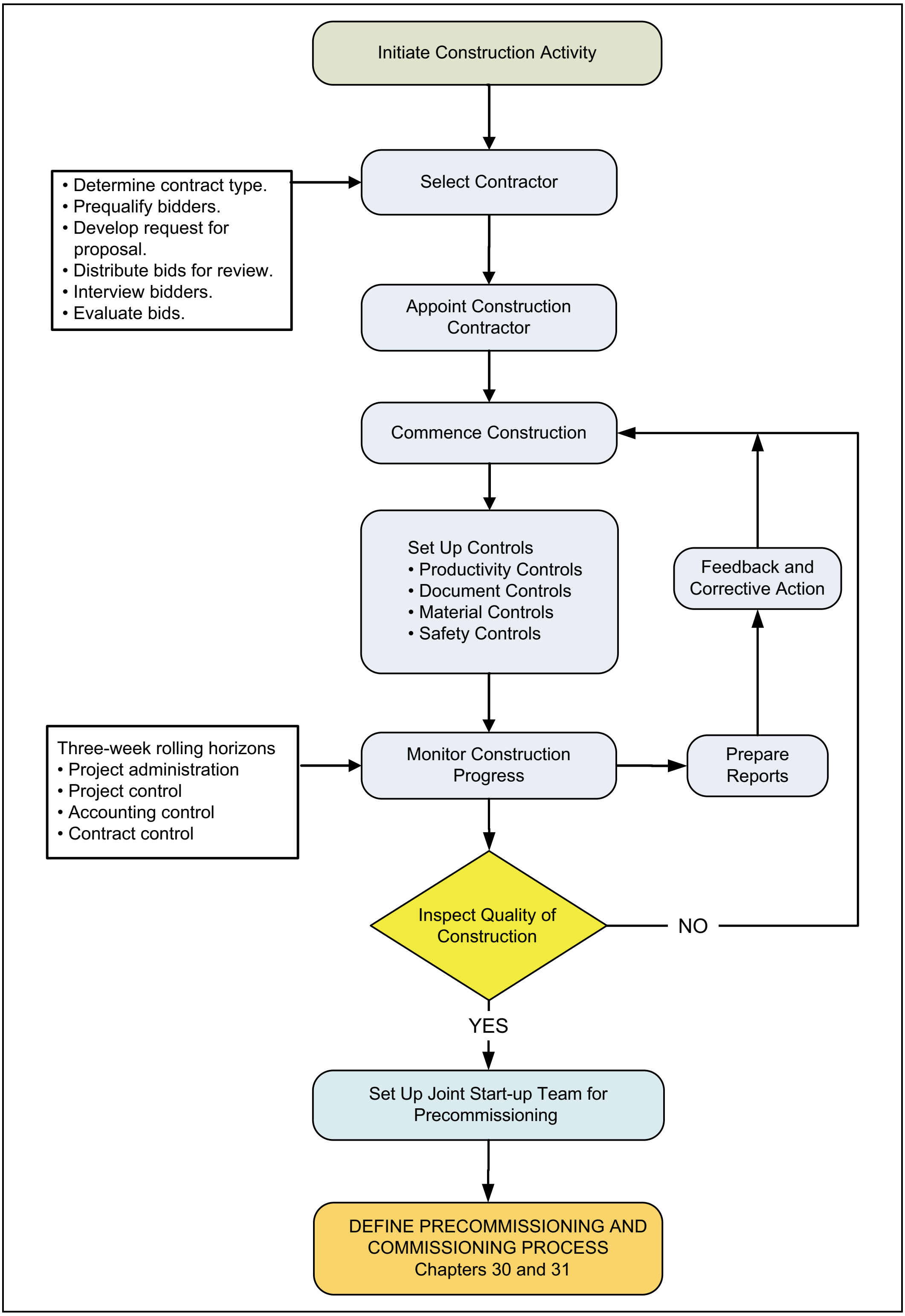
CHECKLIST 29.1 CONSTRUCTION

No.	Item	Status	Date	Initials
1	Scope of work (SOW) for construction stage—set			
2	Engineering or EPCM contractor—previously engaged			
	A. Greater than 50% of engineering drawings at IFC status—OK			
	B. Procurement of critical materials meets construction need—OK			
3	Construction strategy—fully developed			
	A. SOW broken into logical, manageable-size packages—done			
	B. Packages reflect how construction is to be controlled—OK			
4	Construction responsibilities—defined			
	A. Contracts administration—appointed			
5	Selection of construction contractor (if not EPCM)—undertaken (refer to Checklist 19.1)			
	A. Preferred contract type for SOW—determined			
	B. Prequalification of construction firms—met via RFQs			
	1. Experience, capability, availability, and location—OK			
	2. Compatibility, financial stability, and commitment—OK			
	3. Flexibility with respect to contractual Issues—OK			
	C. Request for proposal (RFP)—developed			
	D. RFP—distributed			
	1. Bidding instructions (specifying bidder deliverables)			
	2. SOW (including project schedule)			
	3. Project description and specifications			
	4. Form of agreement			
	5. Bonding and insurance requirements			
	E. Interview of bidders on project site—undertaken			
	F. Bid assessment: evaluation ranking form—completed			
	G. Winning contractor(s)—selected with Owner			
	1. Contract agreement—negotiated			
	2. Appropriateness of contract type—reviewed			
	3. Basis of compensation—established			
	4. Contract incentives and penalties—considered			
6	Construction contractor(s)—appointed, if negotiations are successful			
	A. Insurance certificates—provided by contractor(s)			
7	Preconstruction meeting with site contractors—conducted by project manager			
8	Construction plan—finalized			
	A. Possible modification of PEP—ascertained			
	B. Subcontractor management and work apportionment—fixed			
	C. Work rules and codes of conduct—established			
	D. Project goals—reiterated			
	E. Ultimate construction workforce size—determined			
	F. Level 4 Execution Schedule—issued for all contractors			
	G. Multiple Level 5 Detailed Short-Term Schedules—prepared			
	H. Quality compliance plan—in hand and being followed			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
	I. Risk management program—understood			
	J. Off-site preassembly, modularization, and fabrication—maximized			
	K. Advance site preparation work—undertaken			
	L. Temporary facilities—provided			
	M. Maximum number of work fronts—developed			
	N. Work site services and security—arranged			
9	Reporting program to monitoring and control work progress—established			
	A. Physical progress vs. plan using EVM			
	B. Labor complement and productivity monitoring vs. plan			
	C. Cost monitoring			
	D. Schedule adherence			
	E. Change management and control			
10	Material management control process—established			
	A. Site delivery times—continuously tracked			
11	Proper safety and health procedures—in place			
12	Requisite permits—obtained			
13	Environmental controls—in place			
14	Social acceptance and sustainability considerations—respected			
15	Document management and document control—established			
16	O&M manuals—all in place			
17	Procedures and team for operations start-up interface—established			
18	Punch list—produced, but clearance tied to precommissioning			
19	Mechanical completion—achieved by the constructor, but certification requires successful precommissioning verification for each system entity			
20	Construction contractual completion tests—acceptance certificate not issued by project manager until after successful commissioning			



FLOWCHART 29.1 Construction

Completion Stage

CHAPTER 30

Precommissioning

People do not do what the boss expects, but what the boss inspects.
— Ancient Chinese Proverb

OBJECTIVE

At the precommissioning stage, focus shifts from construction to commissioning and start-up of the project. While there is still construction work to be completed, starting the plant now becomes the primary aim. This chapter identifies the steps necessary to successfully complete the precommissioning stage and ensure a trouble-free initiation of the start-up steps.

Precommissioning is the preliminary dry-testing of individual units of the plant in isolation; that is, testing single areas or subsystems of a complete system without material load to ensure that the individual components can perform as anticipated. The precommissioning activities provide the Owner with the confidence that the plant has been fully and correctly completed prior to the Owner's acceptance of the facilities for the commissioning, start-up, and ramp-up work efforts that follow.

WHAT IS PRECOMMISSIONING (ALSO KNOWN AS DRY COMMISSIONING)?

Precommissioning has been defined by one mining company as "the testing, verification, and documenting that project installations are contract-compliant in preparation for commissioning." Precommissioning is the precursor to the process of starting up the plant. This step is frequently referred to as *dry commissioning*, because no ores or process fluids (other than water) are introduced in this stage.

The purpose of precommissioning is to confirm functional capability, reliability, and performance under the project's specified conditions. Precommissioning assures the project team that the constructed facilities are safe, ready, and in good working order before the commissioning step. Precommissioning comprises three activities:

1. **Verification checks of mechanical completion.**
2. **Manual dry commissioning.** Initial dry-run tests of individual pieces of equipment, subsystems, and systems (sometimes collectively referred to as unit systems) under conditions of no-load (i.e., without feedstock) and under manual control. Note: Not all systems can be run manually—some can only be run electronically, but those that can be run manually should be run first.

3. **Electronic dry commissioning.** Repeat of manual dry-run tests under electronic control (programmable logic controller [PLC], distributed control system [DCS], and/or expert systems), local and remote. Special care must be taken to ensure that all controls and instrumentation both test and function correctly.

WHO IS IN CHARGE OF PRECOMMISSIONING?

Precommissioning is the final project work step contractually under the control of the construction entity. Precommissioning ends with practical completion by the construction contractor and with *care, custody, and control* responsibility for the facility handed over to the Owner. That said, to have the best chance of success, the precommissioning phase needs to function under a joint Owner and construction contractor team mandate, with a specialty commissioning manager at the helm, though still under the contractual control of the construction entity. This ensures that the construction contractor stays legally bound to fix the issues that will inevitably arise in the precommissioning phase.

Because precommissioning activities are under the construction contractor's control, one could argue this phase should be part of the construction stage of the project. But this would be wrong. Precommissioning needs to be deliberately separated from construction and made part of the completion stage, managed by the commissioning manager on the project management team, as opposed to the team's construction manager. The reason for this is the totally different focuses of the two fields. Construction is solely focused on building the facilities as per design, achieving mechanical completion, and then leaving the site and moving on to the next job. The commissioning manager, however, is focused on the constructed facilities working properly before the construction contractors are ever allowed to leave, so that the Owner can enjoy a successful operations start-up. Thus the commissioning manager and his or her joint Owner and construction contractor team are the critical, specialty bridge between construction and site operations.

PRECOMMISSIONING REQUIREMENTS

Precommissioning requires the completion of specific steps:

1. **Development of a plan**—to take the plant from construction through precommissioning and into commissioning and start-up.
2. **Assembly of a special skills team**—to successfully precommission the plant, thereby ensuring the functionality of plant components.
3. **Shifting of the focus of the construction contractor's work effort**—from the previous mass construction work to completing the facility's individual systems. This focus change facilitates successful execution of precommissioning activities.
4. **Insertion of a quality assurance team**—to ensure, on behalf of the Owner, that the design output quality, as well as design quantity, is achieved. This is a specialized objective that will only be present on those projects that have a specific quality component in their original scope of work.
5. **Documented recognition of the achievement of practical completion**—as the last step of precommissioning. For a grassroots project, this is typically signified by the initial processing of fluids in the pipelines (the initiation of wet commissioning) and the introduction of product (e.g., coal or ore). However, there needs to be recognition (particularly by the construction contractor and the engineering, procurement, and construction

management [EPCM]) that in some unusual cases, the Owner may need to stage some limited processing of material before the real completion of the precommissioning stage. This could be for bank-loan satisfaction purposes, but this isolated event in itself should not be allowed to trigger a construction contractor claim for achievement of completion.

PRECOMMISSIONING TEAM

As stated earlier, the precommissioning stage needs to function under a joint Owner and construction contractor team mandate, with a specialty commissioning manager at the helm. The goal is to provide a team and process that will ensure that the focus is on systematically completing construction such that plant precommissioning moves smoothly through practical completion and into start-up.

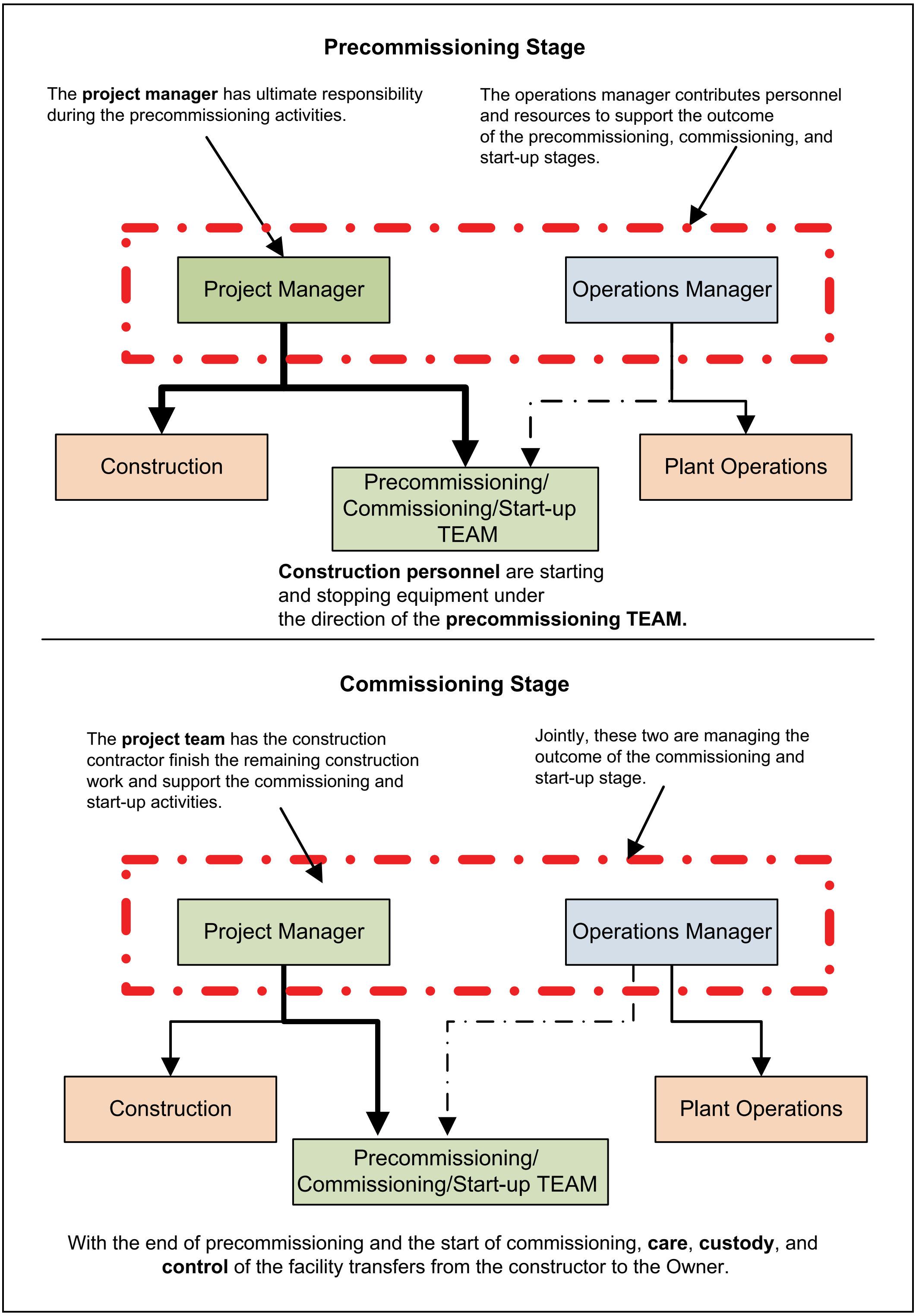
This joint precommissioning team (hereinafter referred to as the TEAM) is headed by a start-up specialist as the TEAM leader, who will generally have to be hired specifically for this task. The TEAM leader (typically called the "commissioning manager") assembles a specialist group supported by crafts personnel drawn from the on-site construction force, other precommissioning or commissioning specialists, and by key operations personnel who together will later become the operations start-up team.

The TEAM is organized and developed by the project manager and the commissioning manager working together, with support from the construction manager in the project management team. It is the project manager's responsibility to second key personnel from the construction contractors' and the Owner's rosters. The other specialist commissioning personnel on the TEAM (almost always brought in from outside; typically two to six persons with mechanical, electrical, instrumentation, and DCS and PLC commissioning skills) are a crucial component to enabling a successful start-up. Unlike Owner operations and maintenance (O&M) personnel, this team is used to the multitasking pace of commissioning, and they possess the requisite decision-making capabilities to stay on schedule.

During the precommissioning stage, the TEAM reports functionally through the precommissioning TEAM leader to the project manager, but at all times the Owner's operations manager (and the construction manager on the project management team) are kept fully involved via the "soft" joint leadership arrangement. This arrangement is illustrated in the upper portion of Figure 30.1. The precommissioning TEAM and the construction contractor are, as shown, together responsible for accomplishing the precommissioning of each system and subsystem within the project.

When the TEAM moves into the commissioning and start-up phase, the TEAM functionally switches over and reports to the Owner's operations manager (though still retaining a reporting line to the project manager), as shown in the lower portion of Figure 30.1, with the construction manager now assuming a much softer involvement role (mostly acting as a knowledgeable observer and advisor). This joint TEAM leadership approach is critical to the success of the start-up process.

The Owner's operations start-up team (typically an expansion of the Owner's operations members from the precommissioning group) is established prior to precommissioning, and the team's training takes place before and during precommissioning. The faster that operations become familiar, knowledgeable, and competent, the earlier the EPCM and the construction contractor can demobilize and the quicker the project books can be closed. The training of operators regarding the applicable environmental laws and regulations, as well as any other social obligation, must be included as part of the operations start-up training



The **project manager** has ultimate responsibility during the precommissioning activities.

The operations manager contributes personnel and resources to support the outcome of the precommissioning, commissioning, and start-up stages.

Construction personnel are starting and stopping equipment under the direction of the **precommissioning TEAM.**

The **project team** has the construction contractor finish the remaining construction work and support the commissioning and start-up activities.

Jointly, these two are managing the outcome of the commissioning and start-up stage.

With the end of precommissioning and the start of commissioning, **care**, **custody**, and **control** of the facility transfers from the constructor to the Owner.

FIGURE 30.1 Precommissioning and commissioning stages

Commissioning Manager

The commissioning manager is the TEAM leader and is responsible for all precommissioning and commissioning activities on-site. The commissioning manager prepares the commissioning criteria and is responsible for the production and execution of detailed precommissioning and commissioning plans based on these criteria. The plans describe the activities that must take place between completion of physical construction and the first use of the new project facilities. The commissioning manager works closely with the construction manager in the coordination of interfacing activities.

Project Manager Role

During the precommissioning and commissioning phases, the project manager's function is mostly to provide support for the commissioning manager, even though the commissioning manager reports to the project manager. The project manager provides engineering clarifications for the commissioning manager and assists with the precommissioning schedules and procedures. The project manager has to ensure that all requisite permits and certificates have been obtained and that there are no regulatory impediments to facilities use or occupation.

INSTRUCTION MANUALS

Different levels of detail are required in the various types of instruction manuals, as described in the next sections.

Operations and Maintenance Manuals

O&M manuals are needed as reference documents for the long-term operational life of the facility. The manuals are prepared during the engineering and construction phases. The manuals are used as starting points to develop detailed operating procedures as well as the training manuals. They should all be complete prior to precommissioning. The target date for completion of the manuals should be when construction is around 80% complete (i.e., when mass construction work is coming to an end).

The operation manuals should be written at a high level for experienced operators and supervisors. Procedures in these manuals are typically brief lists of steps, capable of expansion. The document control department typically assembles the data that go into these manuals. Document control personnel also assemble the maintenance manuals, mostly a compilation of information from vendors and suppliers.

Data compiled by the document control department for inclusion within the manuals are organized by equipment number for each item on the equipment, electrical, and instrumentation lists:

- Purchase order
- Data sheet(s)
- Relevant drawing numbers in the engineering drawing registry
- Engineering specifications
- Vendor specifications (if applicable)
- O&M manuals
- Vendor installation instructions
- Vendor brochures and catalog cuts
- Vendor drawings
- User manuals

The actual writing that goes into the manuals is not a task for document control personnel; it is generally assigned to a specialty contractor or, if the talent exists, to Owner operations.

Detail Operating Manuals

The detail operating manuals target operators with little or no operating experience. These manuals are almost always created by external specialty contractors. The manuals are important supplements to the precommissioning, commissioning, start-up, and ramp-up training content and activities.

Training Manuals

Training manuals are needed for implementation of the precommissioning, commissioning, start-up, and ramp-up phases. Thus they have to be produced before precommissioning gets underway, that is, prior to the end of the construction phase. Again, these manuals are usually created by external specialty contractors.

Many projects simply use the detail operating manuals as training manuals. The decision about whether to have separate detail operating and training manuals tends to be an Owner preference. The authors have seen successful start-ups either way.

If simulation programs are an Owner requirement (and they should be, whenever available), then these need to be acquired well before precommissioning so that the program training of the participants is fully complete by the time precommissioning starts.

SYSTEMS AND SUBSYSTEMS

To be able to manage the breadth of the precommissioning and commissioning tasks, the project is subdivided into discrete and definable systems and subsystems. This breakdown is accomplished by marking each system and subsystem on the piping and instrumentation diagram (P&ID) drawings.

A *system* is a usable or operable unit within the project facility, capable of being run as a stand-alone unit.

A *subsystem* is a logical unit of breakdown and organization of a system. A subsystem can be as small as an individual piece of equipment. The sum of the subsystems equals the total scope of facilities for the project.

PRECOMMISSIONING ACTIVITIES

Precommissioning of a system or subsystem encompasses confirmation that the following have been done:

1. All necessary materials and equipment for the system or subsystem have been installed by the constructors as per plans, drawings, and specifications; checked and tested for alignment, tightness, lubrication, rotation, hydrostatic, and/or pneumatic pressure integrity; and, where necessary, flow-tested on water.
2. All required quality assurance and quality control (QA/QC) safety and operability checks are complete and documented.
3. All necessary tests for mechanical integrity and continuity of electrical circuitry, piping, and process controls for the system or subsystem have been satisfactorily tested.
4. A punch list of incomplete items has been established and agreed to.

The precommissioning TEAM has the responsibility of defining the process checks and then determining if the process checks are functionally complete. The TEAM's mandate is to ensure that *practical completion* has been achieved and the facility is ready for the Owner's operations personnel to take care, custody, and control. The written precommissioning plan that facilitates turnover of the project's suite of systems to the Owner for care, custody, and control is prepared by the commissioning manager, working with the Owner, construction contractor, and EPCM.

Precommissioning TEAM activity within the plan comprises a number of connected preparation steps to allow turnover of the project's suite of system packages. A typical precommissioning progression sequence is as follows.

Preparation

1. Well before construction completion the project facilities are divided into as many separate stand-alone operable systems (often containing multiple subsystems) as is reasonable and possible. The systems approach allows for an orderly turnover. The EPCM typically is the prime entity for identifying and defining these practical operational unit systems among the various project facility locales.
   - For a grassroots 100,000-tons-per-day (t/d) mill facility, one would expect to have about 250 to 300 stand-alone operable systems and subsystems.
   - For a grassroots 50,000-t/d leach facility, one would expect to have approximately 150 to 200 stand-alone operable systems and subsystems.
2. Next, the project precommissioning and commissioning work scopes are separated out into their two logical separate entities.
3. An evaluation of each installed piece of equipment, constructed system, and/or subsystem is then conducted, setting out when each is to be turned over from the construction team to the precommissioning TEAM.
4. The project manager (through the construction manager) ensures that the interfaces between construction and precommissioning activities are effectively facilitated. The constructors prepare handover procedures and documentation for precommissioning testing, including subsystem tie-in packages.
5. The construction manager coordinates the necessary construction shutdown periods necessary for completion of precommissioning (and commissioning).
6. The Engineer (generally through the field engineer) marks each unit system on the P&IDs, and then provides these along with 3D model shots and a line list to the precommissioning TEAM, the construction contractor, and the construction manager.
7. The individual test systems (piping, mechanical, electrical, and instrument) within each unit system have to be defined and marked on a copy of the P&IDs, single line diagrams, and loop diagrams for that unit system.
8. Checklist control documents have to be prepared as log sheets for organizing the monitoring of the precommissioning work and identification of potential problems.
   - Each piece of equipment, system, and subsystem is given a unique number to enable separate record logs for each equipment test and status.
   - Each instrument in the project facility is likewise given a unique number to enable the recording of each instrument's calibration test and status.

9. A scope of work is then developed for each separate unit entity, covering the following areas:
   - Equipment operation
   - System operation
   - Training of operations personnel
10. Specific precommissioning procedures need to be developed (typically by the EPCM) for the following:
    - Materials loading
    - Vessel inspection or closure
    - Hydro-blasting
    - Manual cleaning
    - Pipeline cleaning (water flush, steam or air blow, lube oil flush) and dry out
11. A time frame for the entire suite of precommissioning activities is developed that is compatible with the overall construction program:
    - Interfacility constraints or associations have to be identified.
    - Personnel requirements are identified.
    - The time frame for vendor representation on-site is identified.
12. An entity by entity schedule is laid out, and milestones for each of the systems and subsystems are identified. This schedule actually goes through precommissioning into the ramp-up and start-up phase, even though the schedule will almost certainly have to be adjusted after completion of the precommissioning effort. Interfaces and sequences should not materially change, however.
13. Agreement has to be reached on the sequencing priorities by all parties.
14. The sequencing and priorities for unit system by unit system completion are provided to the construction contractors. The proper turnover sequence from construction to precommissioning is
    - Safety systems first, followed by;
    - Utility systems;
    - Process systems; and
    - Nonprocess systems.

Safety Compliance Steps

1. All TEAM members undergo personnel safety orientation and general safety training sessions to promote safety awareness before undertaking any site work.
2. Construction notifies the precommissioning TEAM that a system is complete and ready for a pretest walk-down.
3. A walk-though and visual inspection is made prior to any testing or energizing activity.
4. The project manager arranges and coordinates the inspection of all systems where building permits are required from local regulatory authorities.
5. The system being precommissioned is isolated from the remainder of the plant.
   - Tag-out procedures are agreed to with construction contractors on-site.
   - Usage of safety lockout, tag-out protocols must be strictly enforced.
6. Verification that installations for blocking and/or locking are located correctly.
7. TEAM members need to maintain visual or verbal communication throughout.

Verification for Completion of Construction

1. The construction and precommissioning teams walk-down the unit system, comparing the actual installation to the project drawings and specifications. All deficiencies are cataloged, categorized, and recorded on the punch list.
2. The precommissioning TEAM verifies the mechanical completeness and functional ability of the process facility. All testing is performed by the construction contractor with the precommissioning TEAM witnessing. Checks include the following, among others:
   - Verification that equipment is installed correctly, as per design, and is clean
   - Verification that flow instruments, for example, gauges, are correctly oriented
   - Tests that bolts are correctly torqued
   - Confirmation that reservoirs are filled
   - Verification that equipment is properly lubricated and all nipples are greased
   - Tests that electrical grounds function properly
   - Corroboration that all guards are installed
   - Confirmation of power circuit availability
   - Confirmation of correct motor rotation (energize, bump, and couple)
   - Validation that equipment is properly leveled, aligned, and safe to use
   - Ratification of hydro-testing: leak checks
   - Instrument loop checks
   - Verification of electrical continuity (This is no small task, as it pertains not just to megger tests. With present-day DCS systems, this can frequently involve checking 10,000 inputs/outputs (I/Os) or more.)
   - Stroking of valves
   - Instrument calibrations (preset to initial set points)
   - Piping and vessel cleaning
   - Line flushing (water flushing and/or air blowing)—after the hydro-test

With the preceding complete, the system can be tagged as ready for preoperational testing.

Run of Individual Systems via Local Control

1. Simulated start and stop tests prior to actual start-up
2. When manual starts are possible, manual control runs of individual equipment, systems, and subsystems under no-load; checking for high temperatures, lubrication leaks, and/or mechanical problems
3. For the electrical and instrumentation systems, all testing, fusing, circuit-breaker adjustments, tagging, installation of covers, and so forth, completed before energizing
4. Verification of interlocks, safety devices, and alarms
5. Verification of the completeness of the process facility PLC and DCS systems to function as complete systems
6. Loop checking of energized equipment via the PLC system
7. Dry run of each stand-alone system from the programmable controller and the central panel to check protective devices, instrumentation, and support subsystems
8. No-load conveyor alignments
9. Initial no-load dry runs of short duration, then working up to a minimum of 4 hours

10. Equipment profiles taken; vibration signature, motor current, pressure drops, and so forth. Variable-speed equipment will require five or more profiles over the speed range.
11. Verification of system control logic
    - All digital I/Os checked to prove their functionality
    - Functional checks performed both locally and through the PLC system
12. DCS programming verified

Run of Individual Systems via Remote Control

1. Complete check is done of the operational aspects of the system, typically followed by an exercise stage for a grassroots facility where the precommissioning TEAM runs as much of the system as possible on innocuous materials (which generally means air or water). No reagents or ore are introduced in this stage.
2. For those systems that cannot be tested under a simulation of operating conditions, performance will need confirmation based on specific test procedures approved in advance by the vendor, contractor, Owner, and project manager, as applicable.
3. For electrical and instrumentation equipment, all the required work is done for energizing the system and equipment (or any of their parts) including calibration and testing.
4. Testing is done to confirm achievement of the design quality requirement. This is a series of integrated runs under full control without load. These are the final tests before commissioning and wet runs.

Throughout the exercise stage, TEAM members must witness the start and stop of equipment, the opening of valves, and so forth. They observe and contribute to the check of circuits and equipment to help ensure the end result is acceptable for operational purposes. During system checkout, the operations start-up personnel on the TEAM participate in a secondary role as witnesses to loop checks and to provide operational technical assistance with expert system, PLC and/or DCS programming.

Punch List

All incomplete or deficient items within a project are added to a punch list. Items that go on the commissioning punch list are necessary for a dry run of the system or subsystem, and must be completed and/or repaired before this precommissioning sheet can be signed off. In other words, they must be complete in order for commissioning to take place.

Miscellaneous cosmetic items not required for a dry run can be completed later (e.g., painting handrails), but important items (such as a main motor not functioning properly) must be corrected before the list can be signed off.

A commissioning punch list is *not* an inspector's wish list, but rather the remaining items that are required for the subsystem to run. Those project punch list items that are not contractually required but just items that the Owner would like to have (i.e., wish-list items) go on a separate list.

Correction of Punch List Deficiencies

The construction contractor has the responsibility of correcting the commissioning punch list deficiencies, and then notifying the precommissioning TEAM upon rectification. The TEAM should provide positive input to the progress of the contractor punch list work-off, not just monitor the contractor progress. Resolution of problems encountered includes resolving issues discovered during environmental checks and reviews.

The construction contractor and the precommissioning TEAM both have to verify that the deficiencies have been corrected, such that any previously incomplete tests can be undertaken again and declared complete.

Conclusion

The whole objective of precommissioning is to ensure that before commissioning is attempted, all the equipment, piping, electrical, and instrumentation systems have been installed; all adjustments and tests that are the responsibility of the construction contractor and subcontractors have been finished; and there is no remaining condition that could delay or complicate commissioning.

All recommended operations spare parts must be physically in place by the end of precommissioning. These are needed for the initiation of commissioning. The project's early completion target date is a good target date for spare parts' completeness on-site.

Completion of the precommissioning activities on any one operable system signifies mechanical completion of that one system (though not necessarily of the full project) and that the system is ready to receive product and ready for commissioning activities to commence.

For a major mine project involving multiple separate systems and subsystems, a precommissioning schedule duration can often extend 6 to 9 months.

MECHANICAL COMPLETION CERTIFICATION

Once the punch list items are cleared by the construction contractor and, when applicable, the regulatory inspection authority has accepted the complete operational system (or subsystem), the project manager can issue a Mechanical Completion Acceptance Certificate to the contractor, with copies to the commissioning manager and the Owner. Typically, the field engineer prepares the certificate and the construction manager delivers it to the contractor. With all the preceding items completed, the system can be tagged as ready for commissioning. Preoperations locks can be removed and Owner operations locks installed.

Acceptance of the certificate by the commissioning manager signifies that the system is now considered mechanically complete by the Owner (i.e., no longer just the constructor) and ready for commissioning. Thus practical completion has been achieved, and the care, custody, and control of the system can be transferred to the Owner.

RESPONSIBILITIES

In the precommissioning stage, the TEAM functions under a joint Owner and construction contractor mandate but is *under the control of the construction entity*. The TEAM has the responsibility of defining the process checks and then determining if the checks are functionally complete. The TEAM ensures that practical completion has been achieved and that each system within the plant is ready for the Owner's operations personnel to take care, custody, and control of it. The hiring of a start-up specialist commissioning manager to head up the TEAM for the precommissioning and commissioning phases in no way subverts the construction contractors responsibility to contractually perform.

The construction contractor throughout the precommissioning stage still retains full contractual responsibility for the facility; that is, the construction contractor has to perform his or her own checks to make sure each system within the plant is mechanically complete and ready for turnover to the Owner. At this juncture the transfer will only be viable if all the Owner operations personnel on the TEAM are in place, trained, and ready for their operations start-up roles.

The importance of specifically defining what constitutes construction completion at the front end of the contractor's contract becomes unquestionably clear at this stage.

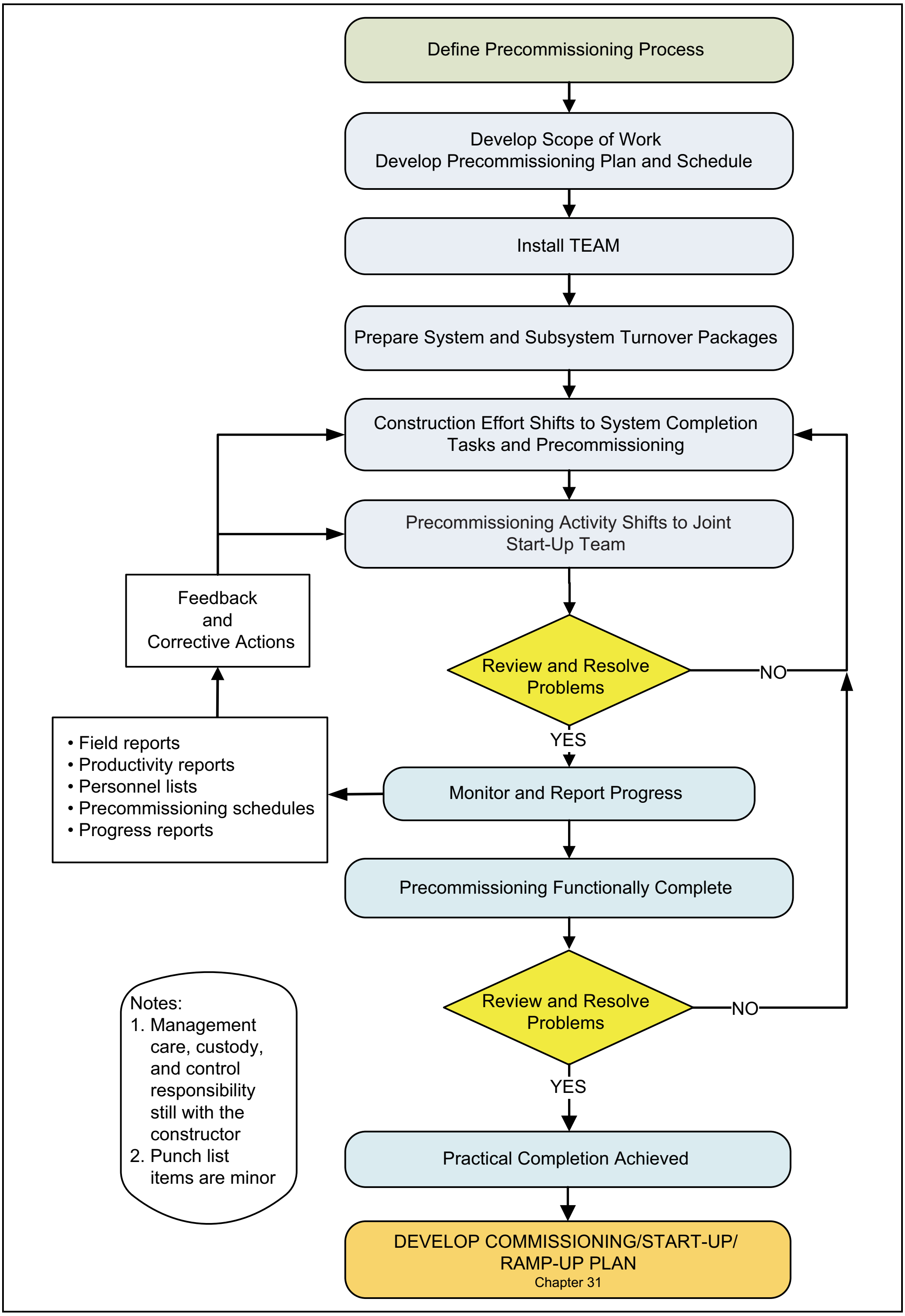
CHECKLIST 30.1 PRECOMMISSIONING

No.	Item	Status	Date	Initials
1	Commissioning plan, from construction end though precommissioning, commissioning, start-up, and ramp-up into operations—fully developed			
	A. Precommissioning scope of work—prepared			
	B. Quality assurance to ensure that operations output meets the project's design quality objectives—installed			
	C. Constructor focus is to complete individual systems—achieved			
2	Critical Owner operations personnel—all hired and in place			
	A. Manuals (operations, maintenance, and training)—all compiled			
	B. Operations training (including simulation programs)—complete			
	C. Environmental awareness indoctrination as to applicable environmental laws and regulations, as well as to permit conditions and social obligations—complete			
3	Precommissioning team (the TEAM)—assembled			
	A. TEAM leader (experienced commissioning expert)—hired			
	B. Commissioning specialists—engaged			
	C. Key construction personnel—assigned			
	D. Owner operators (future plant personnel)—hired and trained			
4	Precommissioning TEAM functionality:			
	A. Organized under joint construction and operations control—OK			
	B. Reports to project manager during precommissioning—OK			
	C. Plant facility care, custody, and control contractually under control of the construction contractor, who reports to project manager—OK			
5	Precommissioning plan—produced			
	A. Plant divided into logical systems and subsystems—complete			
	B. Entity-by-entity schedule of activities—developed			
	1. Scope of work for each individual entity—established			
	2. Checklists and log sheets for each entity—prepared			
	C. Milestones—set			
	D. Individual system turnover packages—prepared			
	E. Monitoring and reporting system—in place			
	1. Weekly summary reporting—established			
	2. Daily activity log—published			
6	Spare parts and requisite consumables—all purchased and in place			
7	Safety compliance of each individual system and subsystem—verified			
8	Mechanical completion—verified for each system and subsystem			
	A. Mechanical Completion Acceptance Certificates—issued			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
9	Precommissioning activities—conducted by the TEAM			
	A. Systems isolation for precommissioning testing—established			
	B. Manual dry commissioning—conducted			
	C. Electronic dry commissioning—conducted			
	D. Systems checkout and exercising on water and air—undertaken			
	1. No-load systems check on local control—run			
	2. No-load systems check on remote control—run			
	E. Punch list—produced			
	F. Problem identification and resolution process—derived			
	1. Punch list Items—Reduced to minor, or de minimis			
10	Owner operations personnel trained during precommissioning process			
	A. Witnessing, observance, and assistance provided by TEAM—OK			
11	Practical completion—achieved			
	A. Sufficient systems precommissioned to allow material to be processed through those systems			
	B. No conditions remaining that can compromise commissioning			
	C. Precommissioning TEAM has ensured that the plant is ready for Owner operations to take care, custody, and control.			
12	Plant ready for commissioning—ascertained			



FLOWCHART 30.1 Precommissioning

CHAPTER 31

Commissioning, Start-Up, and Ramp-Up

> *The first 90% of a project takes 90% of the time; the last 10% takes the other 90%. — The Ninety-Ninety Rule of Tom Cargill, Bell Labs, 1985*

OBJECTIVE

This chapter identifies the steps required to take the individual systems within the plant from initial receipt of materials to design product output for the entire project facility. Project commissioning, start-up, and ramp-up are the three intertwined phases that accomplish this, and they take place prior to project turnover and closeout. The contractual performance tests required of the process design engineer and the engineering and construction contractor are undertaken during these stages, but mostly during ramp-up.

Commissioning follows the completion of precommissioning. Commissioning involves running and testing all areas of the plant systems individually, then together with ore and process fluids (i.e., wet), to ensure the integrated systems can perform as anticipated and to correct any remaining problems before start-up.

Start-up is the beginning of actual plant operations. This chapter covers the start-up activities, then the ramp-up of the plant to full design operational throughput or output. The plant runs continuously under load with material and/or solution after start-up, delivering the mineral products (e.g., coal, copper, gold, molybdenum).

THE DIFFERENT CONNOTATIONS OF "COMMISSIONING" EXPLAINED

The *commissioning* of a project in the most commonly accepted mining terms is "the procedure whereby the installed equipment and systems are test run to confirm readiness for operations." But this definition is far too broad for a project to meaningfully convey the carefully choreographed suite of activities that take place on a mining project after the construction tasks are complete.

The nonproject world confusingly uses the word *commissioning* as a catch-all phrase to encompass any or all of the following three events.

Precommissioning (also known as dry commissioning) precedes actual commissioning, and it is composed of three activities:

1. Verification checks of mechanical completion
2. Manual dry commissioning—first dry-run tests of individual pieces of equipment, subsystems, and systems under conditions of no-load, with manual control

3. Electronic dry commissioning—repeat of manual dry-run tests under electronic control (programmable logic controller [PLC], distributed control system [DCS], and/or expert systems), local and remote (see Chapter 30)

Commissioning (also known as wet commissioning) is composed of three activities:

1. Manual wet commissioning—first test runs of individual pieces of equipment and subsystems under load, with manual control
2. Electronic wet commissioning—repeat of manual load run tests under electronic control (PLC, DCS, and/or expert systems), local and remote
3. Entire system commissioning—separate runs of each entire system, first manually, then under electronic control for multiple hours until all the bugs are out

Official commissioning (also known as grand opening) is a subsequent, unrelated step to actual commissioning, generally months after operations start-up, in which a "pretend" plant start-up ceremony is attended by dignitaries (see Chapter 32).

Within this book, precommissioning and official commissioning are *not* part of project commissioning; they are separate events, covered in separate chapters.

WHO IS IN CHARGE OF COMMISSIONING?

Commissioning is under the control of the Owner. Remember, *care, custody, and control* was transferred to the Owner from the construction contractor at the end of the precommissioning stage. Thus, the Owner is now legally responsible for both the new facilities *and* the operations and maintenance activities that take place during commissioning.

However, the same specialty commissioning manager who was at the helm of the joint Owner and construction contractor TEAM put in place for the precommissioning phase is still in place. The only difference is that with the commencement of commissioning, the commissioning manager (and the TEAM) now report functionally to the Owner's operations rather than to the construction contractor. This organizational arrangement is illustrated in the upper portion of Figure 31.1. Thus, the construction contractor can no longer perform any work on systems turned over to the Owner without the Owner's approval.

COMMISSIONING AND START-UP TEAM

The commissioning and start-up team is organized and composed in large part with the same joint construction and operations personnel who made up the precommissioning TEAM. However, the TEAM will need to be expanded, primarily with additional experienced operations personnel, but also with selected key construction specialists from outside the precommissioning TEAM who will, in all probability, need to stay on at the project facilities through the shake-down period. This will provide for a seamless transition from project status to operations, along with a smooth production start-up.

The construction personnel held over from mechanical completion to help rectify problem situations typically do not stay beyond 30 days or so. It is beneficial to bring in vendor representatives from the key equipment manufacturers, and process specialists with relevant start-up experience, to assist on-site during this critical phase. Key engineering, procurement, and construction management (EPCM) engineering personnel should also remain to provide technical support.

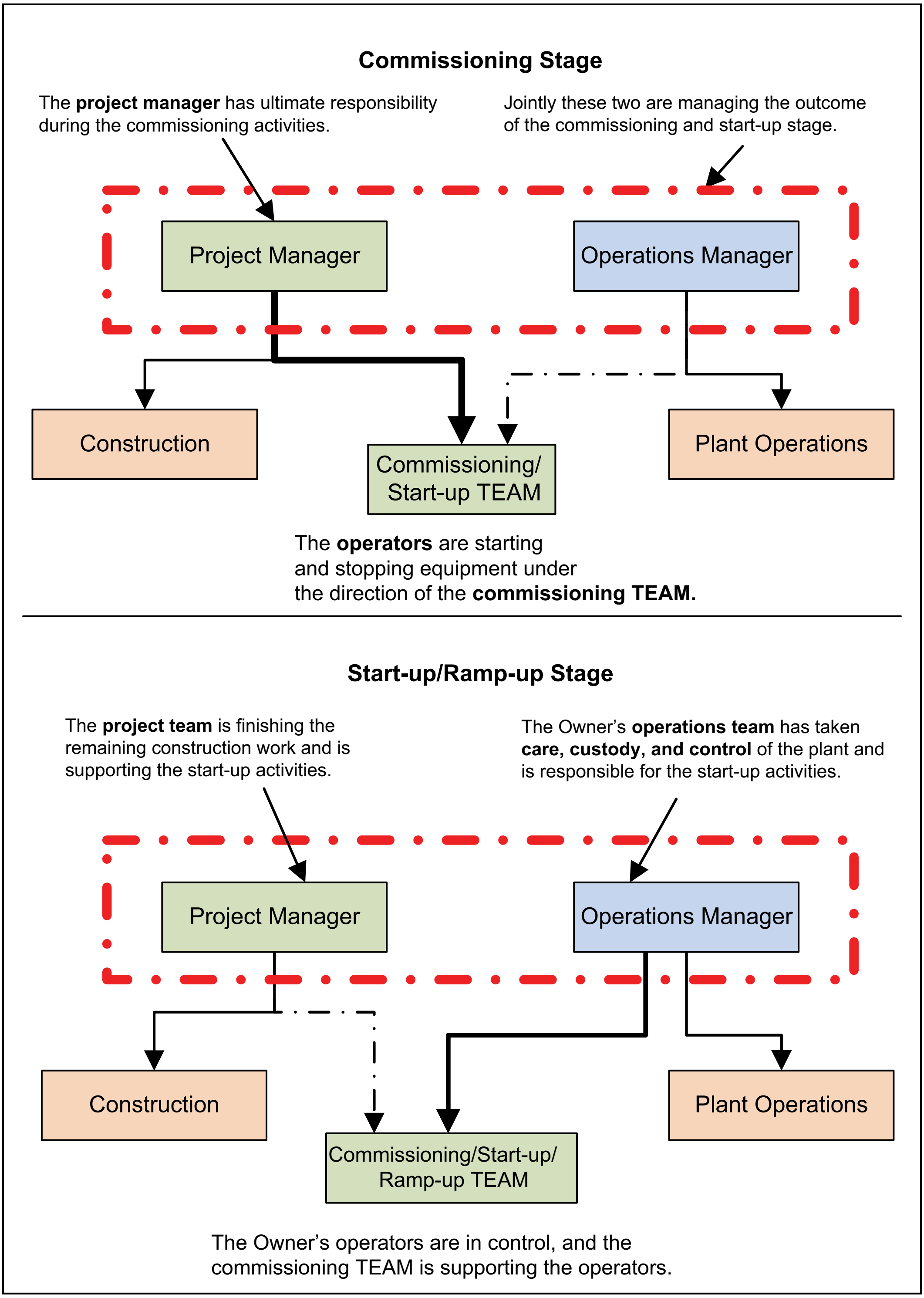


FIGURE 31.1 Commissioning, start-up, and ramp-up stages

The commissioning TEAM is responsible for the wet commission of unit systems, initially individually and then integrated as a single entity, such that the project can operate in accordance with its overall intended purpose. Whenever material is introduced into equipment or a system, sufficient personnel must be on hand to witness the operation of all critical components.

The project manager's role is now focused on working with the commissioning manager to complete commissioning, get through start-up and into ramp-up. Completion of these steps will accelerate achievement of the contractual performance tests and guarantees, and facilitate accomplishment of final turnover of the plant to the Owner.

OPERATIONS TRAINING

It is imperative that all operations personnel (operators, technicians, supervisors, and engineers) not only be on hand but also be fully trained and available by the start-up point. *Fully trained* means that all safety and environmental compliance training is also totally complete. A full complement of operations personnel needs to be ready to go, with all the necessary support personnel and operating and maintenance manuals on hand; that is, they need far more than just the key operations personnel from the commissioning TEAM. Amazingly, operations readiness is the exception rather than the rule. The project manager needs to thus work steadily and diligently with the Owner's leadership, far in advance of the commissioning phase, to make sure that operations readiness is truly happening on this project. The project's 80% construction completion milestone date is a good target completion date for operations personnel training, manual production, and equipment readiness.

Training provides Owner personnel with the necessary understanding of the project equipment and systems so that they can operate and maintain them safely. This includes start-up, normal operation, shutdown, emergency operations, and troubleshooting. Training is best conducted in both a classroom setting and on the job. Classroom training needs to be at a level suitable for operators and supervisors, using Microsoft PowerPoint or a similar type of presentation. On-the-job training is typically via task-based modules that cover all the tasks in a particular job, with performance assessments to be passed to signify qualification at the end of the module.

Simulator computer-based training is increasingly being offered and should be utilized to the maximum extent possible. Operators can train without fear of damaging expensive equipment. Simulator training produces more competent operators who create fewer accidents, are more aware of their surroundings, and operate their equipment according to good practice and correct procedures. It provides operators with a heightened comfort level as they take over the equipment and the facilities. The reduction in start-up errors will more than cover the cost of the simulators. Vendors and suppliers can often provide supplemental training packages and should be drawn upon for support.

Typical operator training can frequently run to 200 hours, with more than two-thirds being on-the-job training (and 80% of which should be simulator based if at all possible).

Process control training (e.g., DCS) for operators can take from 6 to 8 weeks in itself, and as control systems must be functioning for precommissioning to be undertaken, this means process control training must be scheduled to start *and* the process control system must be complete and functionally available at least 2 months prior to precommissioning start. Field trips to witness operating facilities using the same processes are worthwhile training additives.

The best additive of all is having the key start-up operators spend a couple of weeks in the field at a plant with similar processes. Some Owners with multiple plants can do this, and they certainly should. One owner in South America even paid for his start-up operators to spend 10 days at a competitor's facility, which is great if it can be arranged.

A team of training specialists is assembled for operations training:

- **The training supervisor** manages the on-site job training program, develops the task modules, and ensures that the classroom training is being accomplished effectively.
- **Training developers** produce the training manuals (and content). Typically, they are external specialists brought in solely to create the training protocols. They report to the training supervisor.
- **Training instructors** make the classroom presentations and provide on-the-job training support for new operators. Typically, these are skilled operations specialists with experience and hands-on know-how from similar processes who can "talk the language" to the new hires. These instructors report to the training supervisor.

COMMISSIONING ACTIVITIES

Commissioning starts when sufficient components of a stand-alone system have been successfully precommissioned dry and practical completion has been reached for that individual system, such that the feed ore material and/or process fluids can now be introduced for the first time into that system.

Wet commissioning of each operable stand-alone system thus begins following acceptable mechanical completion of each component within the system and practical completion of the entire stand-alone system. The commissioning activities are executed in the following sequence:

1. Safety and environmental systems are first.
2. Tie-in execution steps are second (wherever applicable).
3. The utility systems within the project are third. The utilities are always wet-commissioned up-front because they are needed for precommissioning with each of the process systems.
4. Pressure testing to verify pressure integrity in equipment is the fourth step, once utilities are available.

When these four steps are complete, then the rest of the facility can be wet commissioned.

The primary crusher is wet-commissioned using ore to build the stockpile, but all other parts of the plant are wet-commissioned with water. The process plant wet-commissioning sequencing is from the end of the tailings deposition system to the head of the grinding circuit, that is, opposite in direction from the process flows during operations.

The specific steps of the actual commissioning activities are generally conducted in the following sequence:

1. Develop a scope of work plan for each of the separate stand-alone operable systems that were previously broken out for precommissioning.
2. Set the time frame for the entire suite of commissioning activities. The entity-by-entity schedule and milestones that were laid out for each of the systems prior to

precommissioning are revisited and modified as necessary for the commissioning, start-up, and ramp-up phases.

3. Create task lists identifying the persons responsible for the various activities.
4. Prepare an operations checklist covering the availability of equipment operations and maintenance manuals, the need for any calibration procedures, special tools and fire protection, the adequacy of spares, the location of inspection points, and so forth.
5. Confirm that all recommended spare parts and all requisite consumables for commissioning are physically in place.
6. Provide all the necessary testing devices, with suitable calibrations.
7. Complete the training of all Owner personnel (including the use of simulation programs).
8. Isolate the system being commissioned from the remainder of the plant.
9. Verify the system's practical completeness and functional ability. Function tests include the following:
   - Verification of all wiring, relays, logic, and tripping devices
   - Verification that control valves open, close, and seal properly
   - Verification that all switchgear, breakers, transformers, and motor control centers operate properly
   - Verification that PLC and DCS instrumentation still function properly, and that the monitors, meters, and wiring into the PLC/DCS are ready for start-up
   - Review of prestart-up safety protocols to reconfirm that all safety, operating, maintenance, and emergency procedures are in place and are still adequate
   - Confirmation that all HAZOP (hazard and operability) recommendations have been implemented
10. Perform initial run-in of rotating equipment (turbines, motors, pumps, compressors, dryers, etc.) in accordance with vendor instructions to confirm readiness for use.
11. Initiate the commissioning safety systems *before* chemicals or reagents are introduced, and verify the operating availability of all fire detection, protection, and extinguishment systems.
12. Test the wet sector systems under air and water, along with any dry sector systems (under no-load) that are needed for complete system check.
13. Run the materials-handling systems conveyor belts empty to confirm alignment.
14. Undertake "first fill" loading of materials such as catalysts, reactants, desiccants, reagents, grinding media, and so forth, by the Owner into vessels following procedures developed by the vendors. Design circulations and levels have to be achieved before the introduction of any ore material feed.
15. Carry out a complete systems check, followed by an exercise stage for a grassroots facility where the commissioning TEAM runs as many of the separate systems and subsystems as possible singly using ore and/or reagents. (System checks under load need to run at least 4 hours—preferably more than 12 hours—to check that all drives operate as intended and that no leaks, hot bearings, etc., are present.)
   - Verification of all electrical interlocks including automatic start-up equipment
   - Verification of the functionality of the instrumentation and control systems
   - Verification that software displays are clear and accurate
16. Align the conveyor belts under load; adjust skirts, take-ups, feed ratios, and so forth.
17. Calibrate controls, weightometers, and the like.

18. Instigate initial operation of equipment, subsystems, and systems to achieve stable conditions, sufficient to verify flow, velocity, pressure, and other parameters.
19. Verify, via pneumatic and hydraulic tests, that the mechanical, piping, electrical, communications, control, environmental, and safety system interfaces for each system and subsystem perform in accordance with design and operating parameters for the entire plant.
20. Test to confirm achievement of the design quality requirement.
21. The operations start-up team participates during systems checkout in witnessing of loop checks and provides start-up team assistance with the tuning of expert system, PLC and/or DCS programming. Throughout the exercise stage, the commissioning TEAM, acting on behalf of the Owner, will be required to start and stop equipment, open valves, etc., so that the end result will be acceptable for operations personnel to reach the position of taking over control of the plant from the commissioning TEAM at the end of start-up.
22. Review and resolve problems encountered.
23. Gather performance data and write reports on commissioning progress, including environmental checks.

Note: Certain commissioning activities overlap and/or duplicate construction quality assurance and quality control (QA/QC) efforts. Project management has to coordinate such activities to avoid omissions and to minimize unnecessary duplication.

To achieve commissioning completion of a whole system, the system must be capable of continuous and safe operation with all instrumentation connected, the PLC/DCS fully operational, and all electrical and mechanical interlocks functioning correctly. Process fluids should be able to be pumped from vessel to vessel as per design; conveyors should run, track, and sequence properly; and feedstock should be capable of flowing through the entire system.

Wet commissioning for a major concentrator plant typically takes about 8 to 10 weeks and generally can be concurrent with the final month of precommissioning activities. Commissioning ends when each stand-alone system has individually reached its designated, predetermined percentage of design production performance. The importance of having a carefully planned, rigid protocol for commissioning cannot be overemphasized. Inadequate procedures on past projects have led to grave problems such as damaged equipment, explosions, fires, electrocution, runs of muck, overflowing reservoirs, major environmental spills, structural failure, and, sadly, even fatalities.

START-UP

The objectives of start-up are straightforward:

- No safety or environmental incidents
- No impact on surrounding community
- Production rates and quality at required specifications

The start-up phase continues to be managed by the same joint Owner and construction contractor TEAM that led the commissioning effort, still under the control of the Owner. This arrangement is depicted in the lower half of Figure 31.1. This TEAM prepares and develops the methodology of the introduction of raw material, and then sets up the data collection and recording systems to adequately control the process balance and comprehensively monitor and report on plant performance.

Start-up is accomplished with the future operating personnel. The Owner's workforce *must* learn to run the plant. The start-up plan identifies the planned sequence for each system and subsystem's start-up, shutdown, and operation, along with the equipment metrics in each system and subsystem that need to be achieved to demonstrate accomplishment of design performance.

Start-up occurs when sufficient stand-alone systems and subsystems have been successfully wet-commissioned such that the first introduction of feedstock material and/or process fluids through the full plant facility can occur; that is, substantial completion has been achieved. By definition, this also means practical completion has been reached, given that there would now be enough stand-alone systems for the full project facility to be operated.

After material is allowed to enter the process system, the plant runs continuously under load with material and/or solution, delivering the project's design mineral products. The process flow is checked under full-load conditions, so that bottlenecks can be identified and corrected. Field instruments are recalibrated. Control loops are fine-tuned; final conveyor and skirting adjustments are made under load.

Start-up continues until the complete project facility and all the process flows have been successfully tested with ore material and a final saleable product of acceptable quality has been produced. *Start-up is complete when the project installation is producing the contractually agreed-on specified product(s) at the contractually agreed-on rate; that is, there is verification of unit operational performance*. The end of start-up is coincident with the beginning of ramp-up.

PLANT ACCEPTANCE

Full acceptance of the plant by the Owner signals the release of the remaining construction personnel and the EPCM personnel, thus ending the start-up stage. Acceptance should be defined as the following:

- Mechanical completion has been achieved. (Contractors will always accept this language.)
- Practical completion has been achieved. (Owners must insist on at least this wording.)
- Substantial completion has been achieved. (Owners should always go for this language; it is the preferred goal.)
- Acceptable plant availability and productivity levels have been attained. (This is difficult to achieve.)
- First production output has been achieved. (Most contractors will agree to this concept.)
- Contract performance guarantees have been achieved. (Owners must insist on these accomplishments.)
- Contractual performance tests have been completed. (Owners should insist on these achievements.)
- Production has been achieved for a specified period. (Owners should negotiate this determination.)

The construction contractor duties that the Owner should require to accompany plant acceptance, all to be completed before authorization of contractor demobilization, include

- Delivery of all specialty tools to the Owner,
- Provision of a full charge of operations consumables to the Owner,

- Replacement of all utilized spare parts as per the project procedures manual,
- All punch list items completed to the Owner's satisfaction, and
- All requirements of all sections of the contract agreement fully complied with.

Acceptance does not necessarily require that the ramp-up period be over or that full design output has been achieved.

CONTRACTUAL PERFORMANCE TESTS

To ensure the plant's performance, certain performance tests for the plant need to be undertaken before the Owner allows full demobilization of the construction team. The purposes of completion performance tests are (1) to demonstrate that the project can be operated as required by the contract documents, and (2) that during such tests, operation is in full compliance with all applicable laws, permits, and safety standards. The actual scope of the performance tests must be agreed to at project kickoff. The tests may additionally include subsystem tests that demonstrate the capability of that particular system, but not necessarily the total integrated plant capability.

Completion of the performance test allows for final demobilization of the construction contractor and plant acceptance by the Owner. However, the process design engineering or EPCM firm will still be accountable for the plant's ability to attain design limits.

CONSTRUCTION DEMOBILIZATION

Demobilization of the bulk of the construction personnel is initiated during the start-up stage. Some of the personnel need to stay through plant acceptance, and just a few key personnel need to say through the satisfactory completion of the performance tests. The actual ramp-up to full production can require an extended period of time that is often well beyond the point where the last construction personnel are demobilized.

RAMP-UP

A detailed ramp-up schedule prepared at the initiation of precommissioning is revised and redefined as deemed necessary from precommissioning and commissioning activity results, and from the commissioning and start-up TEAM inputs. Approval of this ramp-up plan is then obtained from operations management and the project manager. Checks are established for the ramp-up team to monitor against this plan.

Ramp-up is the responsibility of the Owner's operations team. The Owner's operators now operate all the facilities in accordance with the desired production and operational targets. The duties of the joint Owner and construction contractor TEAM that led precommissioning and commissioning efforts essentially ended with the completion of start-up.

Ramp-up to full production directly follows start-up and continues until (1) commercial production is achieved and (2) all process-related goals are achieved.

The following activities take place as part of ramp-up:

- Final fine-tuning of control loops at set production rates
- Monitoring of equipment performance under varying loads
- Monitoring of unit operations against design criteria
- Detection and resolution of problem issues
- Generation of daily circuit performance reports

- Clearance of bottleneck issues
- Performance verification

Initial production will probably be erratic during ramp-up.

For a grassroots project, monies from product output are taken as a credit against the capital budget during the ramp-up phase, that is, product is not reported by operations as output. In an ongoing, operating, brownfield facility expansion project, however, there is no project credit for product output during ramp-up.

Ramp-up encompasses the conduct of all activities required for product output to satisfy the design and operational criteria goals contractually established for the project. Ramp-up ends when full production is consistently maintained.

Note: Commercial production is independent of the end of ramp-up. The end of ramp-up is the point at which the plant reaches full production; but commercial production occurs per accounting convention, which will vary from project to project and Owner to Owner.

One major international mining organization defines commercial production as "the point at which 70% of nameplate production (ore feed) capacity is achieved on a sustainable basis." However, most firms are not this precise; they utilize the tax laws to maximum advantage and thus set commercial production differently for each project, depending on the tax losses available, depreciation rules in effect, and the country of operation.

CARE, CUSTODY, AND CONTROL TRANSFER RAMIFICATIONS

The commissioning and start-up stages are under the legal control of the Owner's organization. While care, custody, and control are transferred from the construction contractor to the Owner at the initiation of commissioning, typically the Owner's project management team retains project responsibility though commissioning and start-up, and the Owner's operations group doesn't take over until the initiation of the ramp-up stage (see Figure 29.2). The exact handover point from project management team to the Owner operations team will vary, however, from Owner to Owner and project to project. Mature mining companies tend to have operations take over from project management immediately after start-up, but fledgling companies often prefer that project management retain control long into the ramp-up phase.

As stated, implementing the start-up stage also involves a change in the reporting relationship for the precommissioning TEAM members. Generally, precommissioning TEAM personnel transfer *en bloc* into the commissioning and start-up TEAM. In essence, the precommissioning TEAM members become commissioning TEAM members. This reporting change is a major responsibility shift within the project. What this means is that damage to the plant attributable to incorrect operation by the Owner's operators during start-up has become the Owner's responsibility.

However, the entities responsible for project construction still retain an *ultimate* overall project responsibility for satisfactory performance of the plant until such time that the facility meets its originally contracted performance tests; that is, until the project functions and operates as stated in the original contracts between the Owner and the construction contractor, and/or the Owner and the EPCM, depending on the specific contractual arrangements. Similarly, the process design engineers still retain a responsibility for the process to function as contractually agreed in their particular scope of work. This is particularly true for a coal project; coal companies use specialist outsource process design engineers much more frequently than do metal mining companies.

It is important that when the operator takes over care, custody, and control at the commissioning stage that nothing be done, said, or written to abrogate the contractor's responsibilities (Engineer or constructor). In addition, the insurance ramifications of the care, custody, and control of the project going from construction to operations must be fully communicated to the mining company's insurance department when it occurs. Nonnotification could have serious repercussions.

BELOW-PAR RAMP-UP PERFORMANCE

Unfortunately, the majority of project ramp-ups fail to meet design performance in the time period that was forecast in the feasibility study. On average, according to Charles River Associates, new mines achieve less than 70% of design capacity in Year 1 and take more than 2 years to achieve 90% of design. Full design is generally not met until Year 4 (Agarwai, Brown, and Katrak 1983).

The Charles River Associates data back up the earlier McNulty case history analysis of the start-up of 41 major mineral processing plants (McNulty 1998). McNulty showed that while a few plants do ramp-up to design performance in 12 months, most take more than 18 months to achieve 80% of design capacity, and the majority do not reach design until after 36 months (with a significant fraction *never* reaching design performance).

The good news is that this shortfall is rarely because of poor commissioning activities, though there is one significant exception, stemming from inadequate workforce training. The bad news is that better project management at project front end could have prevented most of the operational performance shortfalls. The prime causes of operational shortfalls in ramp-up to design production are the following, in reported order of significance:

1. Inadequate ore sampling for the process flow diagram design purposes:
    - Insufficient deposit drilling for correct characterization
    - Unrepresentative bulk sample preparation
2. Improper scale-up from the laboratory and pilot-plant stages
3. Inadequate grindability and liberation studies to properly determine recoveries
4. Poor engineering design leading to materials spillages, plugging, and bottlenecks
5. Insufficient workforce knowledge of the unique characteristics of the new plant

It is item 5 that can be overcome by better precommissioning and commissioning practices. Insufficient use is being made of the calendar time before commissioning to adequately train operators and maintenance personnel. Minor dollars are being imprudently saved via minimal training initiated too late in too many new projects, which contributes to the large cash-flow shortfalls from below-forecast ramp-up output.

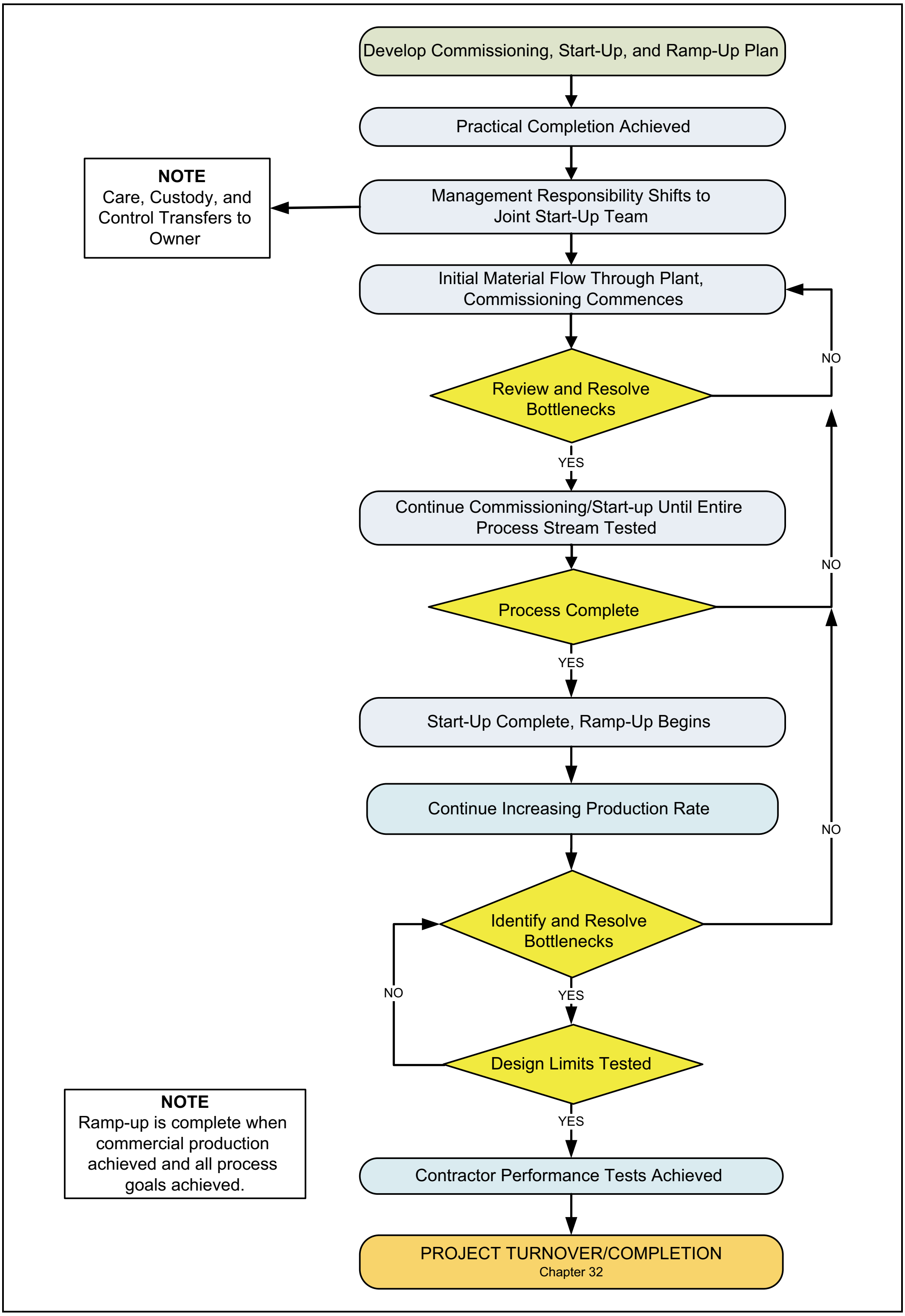
CHECKLIST 31.1 COMMISSIONING, START-UP, AND RAMP-UP

No.	Item	Status	Date	Initials
1	Commissioning plan, from construction end though precommissioning, commissioning, start-up, and ramp-up into operations—fully established			
	A. Commissioning and start-up scope of work—prepared			
	B. Manuals (operations, maintenance, and training)—all compiled			
2	Commissioning and start-up TEAM—still in place from precommissioning			
	A. TEAM leader and commissioning specialists—continue as is			
	B. Key construction personnel—held over			
	C. Owner operators (future plant personnel)—hired and trained			
	1. Operations personnel training—complete			
	D. Vendor representatives—added to TEAM			
3	Commissioning TEAM functionality:			
	A. Organized under joint construction and operations control—OK			
	B. Reports to project manager during commissioning—OK			
	C. Plant facility under care, custody, and control of Owner—OK			
	D. Constructor retains responsibility for plant to function—OK			
4	Commissioning plan—produced			
	A. Scope of work for each stand-alone system—established			
	1. Checklists and log sheets for each system—prepared			
	B. Spare parts and requisite consumables—confirmed in place			
	C. Testing devices—provided, with suitable calibrations			
	D. Schedule—modified by precommissioning feedback			
	E. Methodology for introduction of raw product—developed			
	1. Process balance requirements—identified			
	F. Performance monitoring and reporting—in place			
5	Safety compliance of each individual system and subsystem—re-verified			
6	Commissioning activities—conducted by the TEAM			
	A. Each individual system's isolation from rest of facility—verified			
	B. Practical completion and functional ability—system confirmed			
	C. Wet-commission each system with no load (i.e., air, water)			
	1. Safety and environmental systems—commissioned			
	2. Utility systems—commissioned			
	3. Alignment runs of materials-handling systems—performed			
	4. Controls, weightometers, etc.—calibrated			
	D. First fills of reagents, grinding media, etc., before ore introduction			
	E. Wet-commission each system under load (ore and reagents)			
	1. Stable conditions for each system—achieved			
	2. Operational parameters (flow, velocity, rate, etc.)—verified			
	3. Operational design performance—consistently achieved			
	4. Tests to confirm design quality achievement—performed			
	5. Controls system programming and tuning—conducted			
	F. Performance data—gathered, analyzed, and reported			
	G. Problem identification and resolution process—in place			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
7	Owner operations personnel trained during commissioning process:			
	A. Witness, tuning, and stop–start assistance provided to TEAM—OK			
8	Commissioning completion—achieved when each stand-alone system individually reaches its designated continuous safe operational performance using feedstock, with all controls functioning as per design			
9	Start-up activities—accomplished mostly by future operations personnel:			
	A. Support personnel (construction, EPCM, and vendors)—on hand			
	B. Sufficient systems individually successfully commissioned to allow processing of raw material through the full facility—OK			
	C. Raw material processed though entire facility—achieved			
10	Substantial completion achieved:			
	A. The full facility has successfully run continuously with material at design load delivering the project's design quality products.			
	1. All design parameters—met or exceeded			
	2. All bottlenecks—identified and corrected			
11	Plant acceptance—requires documented verification that project can produce the contractually agreed and specified quality products at the contractually specified rate for the contractually agreed-on minimum period:			
	A. Mechanical completion, practical completion, and/or substantial completion—all certified as achieved			
	B. Plant availability and productivity—at specified levels			
	C. Contractual performance tests and guarantees—all met			
12	Demobilization of EPCM and construction—follows acceptance by Owner			
13	Ramp-up—accomplished entirely by future operations personnel			
	A. Schedule modified by commissioning and start-up feedback			
	B. Ramp-up to full production continues until:			
	1. Commercial production is achieved			
	2. All process-related goals are achieved			



FLOWCHART 31.1 Commissioning, start-up, and ramp-up

CHAPTER 32

Turnover and Closeout

It ain't over 'til it's over. — Yogi Berra, July 1973

OBJECTIVE

The formal turnover step establishes that project completion has taken place. This final project stage records the level of success achieved in meeting the project's objectives and ensures that the project Authorization for Expenditure (AFE) is closed out. The project accomplishments, including lessons learned, are documented as part of this stage.

The project turnover and closeout process is actually a multiple-step process that starts to happen during the commissioning phase. By the time the turnover and closeout stages arrive, the project has been constructed and production is underway.

PROJECT TURNOVER

Project turnover activity must be complete before project closeout can be achieved. Some demobilization elements are initiated during commissioning, but most of the activities of turnover (and closeout) take place while ramp-up is ongoing and are generally complete long before steady-state operations are achieved in the project facility.

Full project turnover to the Owner's operators is achieved when the following conditions have been met:

- Facility is substantially ready for its intended use, with all key components operable.
- The Owner confirms that the engineering, procurement, and construction management (EPCM) site responsibilities have ceased:
  - Work scope is satisfactorily complete.
  - Start-up is complete (though ramp-up can still be in progress).
  - Performance tests have been completed.
- The final punch list has been developed, worked off, and accepted by the Owner.
- Piping and instrumentation diagrams (P&IDs), as-built drawings, and revisions are all final and have been delivered to Owner.
- All inspection and test records have been delivered to the Owner.
- List of necessary operational spare parts has been provided to the Owner.
- Equipment warranties and guarantees have been documented and formally handed to the Owner.
- Construction inventory has been handed over to the Owner.

- Facility is clean and free of construction equipment and debris.
- Construction effort of EPCM is completed and closed out.
  - All site issues between the constructors and the Owner have been resolved.
  - Settlement of all claims, invoices, and holdbacks is initiated.
  - Determination of incentives or penalties (to either pay or collect) is complete.

PROJECT CLOSEOUT

Surprisingly, one of the toughest steps for a project is to finish it—to get it out the door and close the project number. Well-managed projects frequently go adrift and blow their schedule and budget after the project has entered its final 10%. Causes of this undesirable "project drag" include

- The "excess perfection syndrome"—the craving to continually improve the project;
- Burnout from the intensity of project life and loss of focus as the intensity wanes;
- Lack of another project for team members to begin work on; and
- Personnel involvement in another project, to the detriment of the present one.

Project drag has to be proactively forestalled. Project wrap-up can be made easier by viewing it as a mini-project of its own. This will keep the project team focused on the one important task, that is, finishing. Project closeout is more than demobilizing the construction contractor, gathering up project loose ends, and making final marks on project checklists. Project closeout is achieved when the project manager delivers the final work products as specified within the contract.

Closeout requires all the following activities to have been accomplished:

- Final punch list is complete; all outstanding construction rectification items have been dispensed with.
- Settlement of all the gray areas in scope has been reached with operations management.
- Document turnover: As-built drawings and designs are complete and have been formally handed over to the Owner.
  - This includes all technical documents, data, and information, whether internally produced by the EPCM or externally supplied to the EPCM.
  - Any general reference information such as maps, files, and the like, borrowed from or gathered on behalf of the Owner during the course of the project have been returned to the Owner.
- Computer disk data files have been purged of all but the latest version of data. The disks need to be clearly labeled and stored along with their corresponding project data files.
- Computer-aided design (CAD) files that have been updated with the latest version of data are clearly labeled and stored using standard guidelines. CAD drawings that have been manually edited since delivery to the Owner should have ideally been updated by revising the computer data files. If these revisions are extensive and updating the CAD file is economically impractical, the CAD file should be so identified as not containing the latest manual field revisions.
- Owner's project personnel have all been reassigned; no one remains on the project payroll.
- All project payments have been made; all outstanding receivables owed to contractors have been paid.

- All claims have been settled; all construction contractor contracts and suppliers orders have been closed out and each individually notified of the commencement of their warranty periods.
- Project incentives and penalties have all been paid or collected.
- The EPCM contract with the Owner has been closed out and all payments and holdbacks made. The Owner needs to receive a final letter from the EPCM stating the project is complete in accordance with the contract. That cements the project status.
- Project AFE number has been closed and can no longer be charged against.
  - To close the AFE, a *work stop* order from the project manager giving the formal closure date will need to go to all team members and contractors, as well as the accounting departments of the Owner and the EPCM.
  - A few expenses will still be incurred after the closure date, such as vehicle rentals, monthly telephone and office bills, late-submitted travel expenses, and so forth, but these should have a final acceptance date, for example, 45 days after formal closure.
- Formal project accounting closeout has taken place to the satisfaction of the Owner's assets accounting representative, that is,
  - Capital property, plant, and equipment ledger handed over;
  - Asset register handed over;
  - Depreciation schedule handed over; and
  - Underage or overage to the AFE fully documented. (Note: For most mining companies, any overage beyond 10% of the original AFE budget requires a supplemental AFE prior to actually going 10% over budget. Project management *cannot* spend unauthorized funds.)
- Early or lateness of project completion against original schedule has been documented.
- Achievement of project goals has been assessed and documented.
- Exit interviews of senior project staff have been conducted and lessons learned documented.

Operations should be producing an acceptable quality, marketable product at an output rate as intended in accordance with the original approved design parameters. Metal production is now part of operating earnings, that is, taxable income. Metal production can no longer be taken as a credit against project capital.

Throughput rate could be less than the ultimate full design operating rate, if ramp-up is still ongoing. Some scheduled ramp-ups can continue for a few years. Production should, however, be in excess of 50% of design throughput by now and ramp-up progressing in a positive direction.

On some projects there may be some exceptions where closeout takes place prior to total completion, for example, where a specifically defined, original scope item that is not a key operational component cannot be closed out with the rest of the plant. Special arrangements for this late component completion have to be agreed to between the project manager and the Owner. An example could be a source test for an air quality permit.

ENVIRONMENTAL COMPLIANCE

Responsibility for the compliance with all environmental permits and their associated operating conditions (see Chapter 8) is transferred to the appropriate Owner's representative at closeout. As noted, the air permit source test is generally one of the last components of project completion; the test is not possible until operations are at full design output levels.

DOCUMENT CONTROL

Ownership of the project documents resides with the Owner at the end of the project, not with the EPCM firm or the project team (though the EPCM firm and the project team can, and should, retain copies of at least the major documents). It is the responsibility of the project team to ensure that the Owner ends up with a complete record of the project, including all supporting documentation (final as-built drawings, design criteria, equipment specifications, etc.). The records are needed for a wide range of future purposes, for example, add-on engineering work, equipment operation and maintenance, redress of deficiencies, or tackling similar projects elsewhere in the company.

As-built drawings need to reflect all the changes made to the installations on-site by the engineer, construction contractor, subcontractors, vendors, and/or suppliers. Markups should typically be expected in all of the following items, among others:

- General arrangement drawings and plot plans
- Underground installations and gravity drains
- P&IDs
- Electrical installations, schematics, single-line and instrument wiring diagrams
- Instrument loop diagrams and instrument lists
- Programmable logic controller (PLC) and/or distributed control system (DCS) wiring diagrams and layouts
- Operating manuals

GRAND OPENING

The built facility's grand opening (sometimes inappropriately termed the "official commissioning") is a step that is unrelated to the actual project commissioning. It generally occurs months after project turnover and operations start-up. It typically entails a sham plant start-up ceremony attended by local and corporate dignitaries. With a myriad of VIPs on-site, it makes sense to schedule the event well after ramp-up is successfully in hand; this way, the chairman of the board, CEO, or the host country dignitary given the honor can be assured that conveyors will start and pumps will run when he or she presses the "big red button."

LESSONS LEARNED AUDIT

A final, formal project audit is undertaken when the majority of project turnover tasks has been accomplished but full closure is not quite complete. The audit is generally best conducted by the mining company's own specialty project management group personnel, but it could be undertaken by an external specialty project audit firm such as the Rygnestad Group or even the EPCM.

The aim should always be to complete the audit within 2 months of attaining the project goals. Performing the audit simultaneously with project completion ensures that lessons learned are captured while the persons knowledgeable about project performance are still accessible. Evaluations take time and effort. During the demands of day-to-day work, that time often seems not to exist. Yet, taking the time to meet and think through the project and suggest improvements may be some of the most valuable time spent.

This final project closeout step needs to be a complete and candid evaluation of the project and the process that brought it into being. A closure audit report summarizes budget and schedule information, gives the status of closeout actions, and serves as a means to document lessons learned from the project. Looking back at each completed job can greatly improve productivity, effectiveness, and profitability (for both the Owner and EPCM) and will help avoid repetitious mistakes.

Typically, closure audits include separate questionnaires and evaluations by key project team members and the Owner. The personal interviews inquire not only about the project execution steps and the project outcomes but also about the Owner's satisfaction with the EPCM and the contractors, and vice versa. The focus of the interviews and evaluations should always be to identify causes of problems and methods for avoiding similar mistakes in the future.

Lessons learned audits should be conducted on both successful and unsuccessful projects to learn not only what was done incorrectly, but what methods were particularly effective. Ideally, lessons learned would be reported to all key Owner and project management personnel (including the EPCM and contractors) and then incorporated as updates to the mining company's internal generic project management manual (if such a document exists—and ideally it should).

PROJECT FINANCIAL COMPLETION

Project financial completion is achieved when all contractual terms required of the Owner have been met and the project debt becomes nonrecourse to the Owner. (A nonrecourse debt is a loan that is secured by a pledge of collateral—typically real property such as the project and its facilities—for which the borrower, the Owner company in this case, is not personally liable.) For a financial loan to go nonrecourse generally entails the project facilities meeting certain technical, operational, financial, and legal tests and/or requirements over various specified periods. These can range from 7 to 90 days for the operational parameters and are generally "life of debt" for the legal requirements.

The senior debt project financing completion stage generally does not occur until long past project closure, sometimes as many as 7 or 8 years after. Thus a lot of the financial institution completion requirements will not involve the project manager, who will be long gone before then. But it is still important for the project manager to become familiar with the specific performance tests that the project Owner will ultimately have to meet. After all, if these tests are not eventually met, the project will never be deemed successful. Typical financial completion test requirements will likely involve confirmation of several items, similar to those described in the following sections.

Technical

- Proven and probable reserve tonnages and grades are at or above feasibility study figures.
- Strip ratio (for open pits) are at or below feasibility study figure.
- Ore grade in each of first 5 operating years is at or above feasibility study forecasts.
- Independent metallurgical tests have been undertaken confirming feasibility study recoveries.

Physical Facilities

- All physical facilities are complete and commissioned as depicted in feasibility study.
- Owner certifies to the construction contractor that no material defects exist.
- Owner certifies that all project facilities are fully operational.
- A minimum of 120 days of consumables and maintenance supplies are on-site and paid for; and adequate capital spare parts, as defined in the feasibility study, are on hand.
- The full complement of managerial, technical, and operations personnel is in place, with appropriate qualifications and training, as outlined in the feasibility study.

Operations Production Certification

- Over a period of 7 consecutive days, all major equipment systems run continuously at the design capacity specified in the feasibility study or at a higher rate.
- While over a period of 90 consecutive operating days, the mine and plant production are at not less than 95% and not more than 115% of the tonnage (ore, overburden, and waste) shown in the feasibility study, the following conditions must be met:
  - Average ore grade to be not less than 95% and not more than 115% of the grade shown in the feasibility study
  - Average metallurgical recovery to be not less than 95% and not more than 115% of the grade shown in the feasibility study
  - Product output to be not less than 95% of output in the feasibility study
  - Product quality to be at or above the quality shown in the feasibility study
  - Average cost per unit of product output to be not greater than 105% of feasibility study forecast
- Four consecutive product shipments have been sold for not less than 98% of market price.

Efficiency Certification

- Average power consumption for project facilities is not greater than 105% of feasibility study forecast for each ton of product output.
- Average reagents consumption per ton of product output is not greater than 105% of feasibility study forecast.

Legal

- All necessary concessions, rights of way, contracts, production, and environmental permits and licenses are in place.
- All required insurance coverages are in place.

While the preceding requirements are by their nature generic (extracted from several projects of the authors), they provide the reader a flavor of what is typically required.

EPCM FOLLOW-UP WITH OWNER

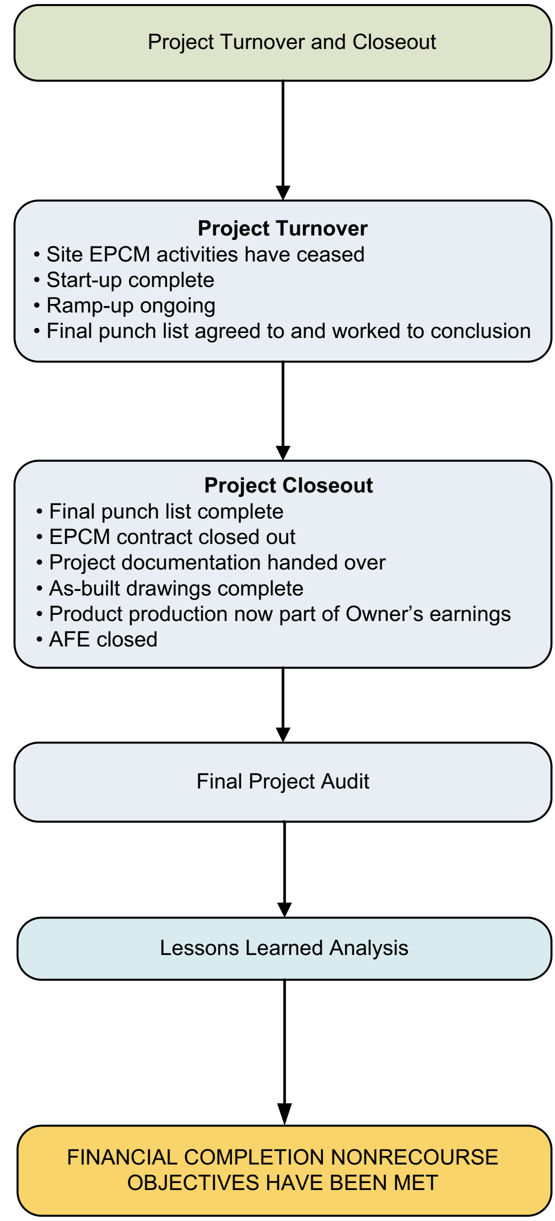
A good EPCM will maintain contact with the Owner. Follow-up contacts by EPCMs normally are made within 30 days, then 4 months, and finally 1 year after project completion. The initial contact is typically under the guise of a client satisfaction survey and typically involves the project sponsor and possibly the EPCM quality manager, but generally not the EPCM project manager. Most Owners appreciate such attention, and the EPCM will have the opportunity to build on the client relationship established during the project. From an EPCM viewpoint, continued good relations can be a great asset in securing work from former clients.

Follow-ups sometimes reveal that certain operating procedures have not been understood by the Owner, or that small but irritating problems have arisen with the constructed facility.

If defects become evident during the warranty period (typically 1 year, but it could range anywhere from 30 days to 2 years), the Owner should authorize the EPCM (and/or the responsible contractor or vendor) to investigate in order to determine what, if any, work is required. Depending on the warranty terms, such an investigation during the warranty period may or may not be charged as an additional service. The fixing of any defect found would be strictly controlled by the warranty.

CHECKLIST 32.1 TURNOVER AND CLOSEOUT

No.	Item	Status	Date	Initials
1	Project turnover:			
	A. Formal acceptance by Owner for constructed plant—finalized			
	B. EPCM site responsibilities—concluded			
	C. Final punch list—worked off and accepted by project manager and Owner			
	D. Construction inventory—handed over to Owner			
	E. Equipment warranties—provided to Owner in a formal document			
	F. As-built drawings—final revisions delivered to Owner			
	G. Computer disks—labeled and purged of all but the latest data			
	H. Construction and commissioning efforts—complete			
2	Project management closeout:			
	A. Project site—clean and free of construction debris			
	B. All constructor contracts and supplier invoices—closed out			
	C. Final invoices and holdbacks—approved			
	D. All claims—settled			
	E. Amounts of incentives and penalties to pay or collect—determined			
	F. All Owner and EPCM personnel—off the project payroll			
	G. Re-assignment of all Owner project personnel—complete			
	H. Gray area items (in or out of scope)—finalized with operations			
	I. Environmental compliance—responsibility transferred to Owner			
	J. Project execution AFE—closed			
3	Project accounting closeout:			
	A. All invoices and holdbacks—paid			
	B. Project incentives and penalties—paid or collected			
	C. Project AFE—closed out by Owner's accounting department			
	D. Underage or overage to capital AFE budget—documented			
	E. Capital property, plant, and equipment ledger and asset register—handed over to Owner			
	F. Depreciation schedule—handed over to Owner			
4	Final project audit—undertaken			
	A. Achievement of project goals—assessed and documented			
5	Exit audit with key project personnel—conducted			
	A. Lessons learned—documented			
6	Project financial completion—determined			
	A. Financial completion tests—all achieved			
	B. Senior project debt—goes nonrecourse to Owner's company			
7	Grand opening ceremony—scheduled by Owner's CEO			
8	Production—now a part of Owner's Operational earnings			
	A. Start-up complete, but ramp-up can be ongoing			



FLOWCHART 32.1 Turnover and closeout

CHAPTER 33

Operations Readiness

Operations keeps the lights on, strategy provides a light at the end of the tunnel, but project management is the train engine that moves the organization forward. —Joy Gumz, 2012

OBJECTIVE

This chapter provides guidance for preparation of the individual functional operational readiness plans that together constitute a complete project operations readiness plan (ORP).

Preparation of individual readiness plans for each operations department will certainly help to ensure a smooth start-up and ramp-up, but just as important is the development of operational capability within the operations organization. This chapter addresses the key elements that can bring about this desired human capability. Ideally, an outline of the ORP should be prepared as part of the documentation for the Authorization for Expenditure (AFE) submission to the board at the end of the project viability stage (see Chapters 14 and 15).

PURPOSE OF AN OPERATIONS READINESS PLAN

An ORP is the document that spells out how the project will be phased into the operating business. It describes what will be done, how it will be done, in what sequence it will be done, and who will do it. The main objective of the ORP is to ensure that all future operational functions have fully considered and planned for the personnel, training, systems, processes, and services required to start-up and run a complete operating facility.

In its final form, the ORP document is a well-thought-out, integrated consolidation of the individual functional (departmental) operational readiness plans created for the project. Functional leaders from within the mining company are typically tasked with preparing these individual readiness plans for each of the future operations departments that will exist. To arrive at operational readiness, first the appropriate path to achieving operational capability at the facility has to be agreed on and set. The path will be unique for every project, but some elements are always common.

OPERATIONAL CAPABILITY DEVELOPMENT

The key component in creating a new, sustainable, and profitable mine is the development of *operational capability*, which entails the organizational aspects of people, procedures, systems, information, and support infrastructure (Blayden 2001). This is not an insignificant task; it requires

1. Development of the ORP to identify the integration and sequencing of the work required and to provide a framework for monitoring, managing, and reporting the required outcomes relative to the agreed scope, schedule, and cost restraints;
2. Specifying the requirements for organizational capability, community responsibility, regulatory compliance, business performance, and quality standards compliance (e.g., ISO 9001 and ISO 14001 standards);
3. Identification of the interfaces between contributing parties to minimize risk and ensure effective business integrity in achievement of the required outcomes; and
4. Recruitment of the appropriate people to become an effective core team for the development of the operations organization. The core team should have experience and capability from involvement with similar operational start-ups. They should be brought in early enough in the project execution program for them to leverage their knowledge effectively to the other operational hires and thus help create the appropriate organizational capability.

Figure 33.1 shows a generic schedule for the development of the various components needed within an ORP for a greenfield mine.

If the mining or metallurgical processes at the project facility are new within the mining company, then policies and procedures specific to the project have to be developed, typically drawing on existing industry practices. When possible, the project ORP should leverage similar systems in place at existing company operations. When the project is located within a mature district, the plan's focus is more on how to integrate the project into the existing operation rather than in developing new systems.

STRATEGIC OBJECTIVE

The underlying objective of the ORP is to enable a smooth and successful start-up and ramp-up into steady-state operations. To achieve this positive outcome, all issues and problems identified during construction and precommissioning must have been resolved before the initiation of start-up. Without resolution of such issues, a rapid and trouble-free start-up will almost certainly not be possible.

Surprisingly, the most challenging alignment issue among the three entities of company senior management, project team, and operations is not the fixing of project problems. Rather, it is to reach agreement on the minimum requirements for operations readiness prior to start-up, and then to agree on what should be the time for implementation of those requirements. The project team's urgency to get operational personnel hiring and training underway is rarely shared by operations (almost always to operations' later regret).

COMMISSIONING AND START-UP PLAN

Operations readiness planning has to address commissioning and start-up from the *future operations perspective*. The operations readiness commissioning and start-up plan is thus a complement to the separate commissioning and start-up plans assembled by the project team (see Chapter 31). The goal is a seamless transition from project to operations mode.

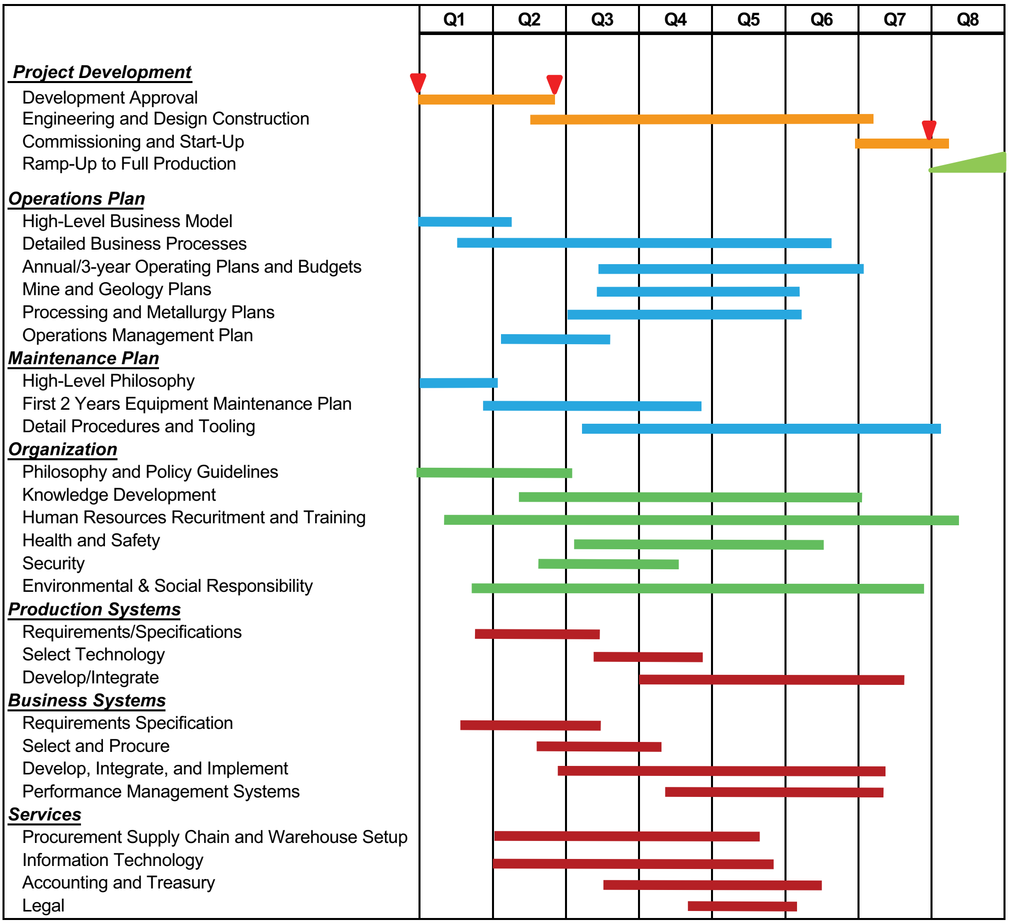
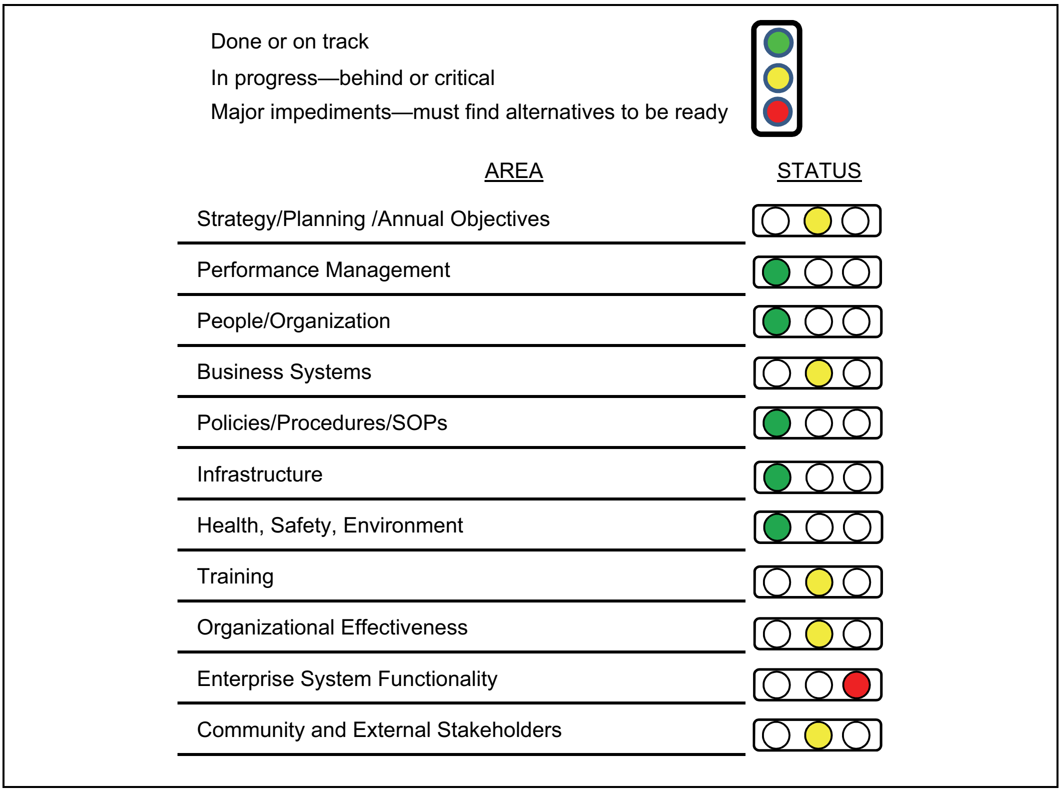


FIGURE 33.1 Development of operational capability

Getting the mine and process plant suitably prepared is the main focus of the commissioning and start-up component of any ORP. Issues requiring coverage include

- Human resources bringing in the key process operations and maintenance (O&M) personnel in a timely way, to be trained and available for the dry precommissioning and wet commissioning of the process equipment, systems, and infrastructure;
- The progressive handover of plant and infrastructure from construction to operations. This will require a significant segment of the operational and maintenance workforce being in place for a period of several months prior to the full facility start-up date;
- The progressive ramp-up of the entire operations roster into the new facilities during the start-up exercise, with all its site-specific task and safety training complete;
- Confirmation that all systems and procedures described within the ORP are in place;
- Collection of equipment baseline data (vibration signatures, initial motor control center [MCC] readings, thermography, etc.) during commissioning for the benefit of future operations; and
- Provision of all tooling, initial plant spares, and workshops prior to start-up.



Done or on track 🟢
In progress—behind or critical 🟡
Major impediments—must find alternatives to be ready 🔴

AREA	STATUS
Strategy/Planning /Annual Objectives	○ 🟡 ○
Performance Management	🟢 ○ ○
People/Organization	🟢 ○ ○
Business Systems	○ 🟡 ○
Policies/Procedures/SOPs	🟢 ○ ○
Infrastructure	🟢 ○ ○
Health, Safety, Environment	🟢 ○ ○
Training	○ 🟡 ○
Organizational Effectiveness	○ 🟡 ○
Enterprise System Functionality	○ ○ 🔴
Community and External Stakeholders	○ 🟡 ○

FIGURE 33.2 Operations readiness by overall property

An operations readiness table displaying readiness indicators for overall property, as illustrated in Figure 33.2, will assist project management in determining operations preparedness to take over after precommissioning.

The project precommissioning or commissioning team (also known as the TEAM; see Chapter 30) needs a full understanding of the project construction timeline, the operations readiness timeline, and any ongoing associated mine development timeline. The ORP has to be synchronized with the Project Execution Plan (PEP) and master schedule.

Operations readiness development is a timeline that cannot slip. The only way to achieve a successful operations start-up is to find the resources and get them hired (or contracted) for when the construction phase turns into precommissioning. It is crucial that the operations readiness process be essentially complete and the TEAM ready to go by this time. To this end, the TEAM needs to have completed their alignment session(s) prior to any commencement of precommissioning.

For operations to be in a position to both support precommissioning and commissioning *and* be capable of actually running the new plant, the operations component of the TEAM (i.e., the mining operations, plant operations, and maintenance personnel) must

1. Be ready by precommissioning start to support and fully integrate into the TEAM;
2. Be a party to the development of the ORP in order to position its operations colleagues appropriately when start-up commences;

3. Understand where any ongoing parallel phases of operations preparation (e.g., mine development) fit in with the precommissioning, commissioning, and start-up activities;
4. Know the actual status of the different facets of the parallel operations development so that the TEAM can forestall interface issues and seize any opportunities;
5. Be cognizant of the timing for hiring the rest of the operators, maintenance, purchasing, and warehousing personnel along with the timing of the installation of the processes and procedures that these personnel will be using; and
6. Be ready by start-up date to transition into the start-up team and run the new plant.

COMPONENTS OF THE OPERATIONS READINESS PLAN

Execution of the ORP should be handled as a project; that is, define the scope, obtain the resources, execute to schedule, and report progress weekly against schedule. Typically, the operations person heading up the ORP will create an activities table such as Figure 33.3 to capture the key activities that need to be undertaken by operations before project takeover. The table identifies the person responsible for each activity and a readiness goal target date. Figure 33.3 was extracted from a Nevada gold mine project start-up that the authors were associated with in 2012.

The component tasks to be completed as part of the ORP can be broken down into three basic categories: personnel, tasks, and systems, as shown in the next three sections.

Personnel

- Recruit, hire, and develop the entire organization, that is, the management team and workforce necessary to operate the mine, plant, and related support facilities.
- Hire the key staff early to organize, train, and integrate personnel for the TEAM.
- Define the roles and responsibilities for the shift from commissioning TEAM to operations.
- Develop the operations procedures and standards, including training procedures.
- Train all the operations personnel. Include crisis and safety management training.
- Link the training timing to the construction contract schedule wherever possible.
- Have the entire plant operations team in place, trained, aligned, and capable of operating as a single entity before the plant needs to start up.
- Complete the training of all personnel and management so they function as a cohesive organization, even though there will not yet be a facility built to work within.
- Ensure that all hired personnel are organized into effective working units, capable of executing their departmental duties and interacting with other departments.
- Establish an organizational culture with employees fully engaged, top to bottom.

Tasks

- Mobilize a fully functional mining group that has completed prestripping, finished the development of any required tailings facility, has all operating procedures in place, and has mine operations ready with ore to feed into the plant.
- Procure the full complement of commissioning spares, the first 2 years of repair materials, general supplies, first fills, and capital spares; and make sure that they are all fully cataloged.
- Create a functioning warehouse with staff, systems, and operating supplies in place.

No.	Requirements Metric	Department Responsible	Readiness Status/Readiness Goal
1	Applicant Screening & Interviews	HR	Offer letters all sent, subject to background checks by ?/?/?
2	Hiring of Workforce	HR	Physicals and onboarding at 100% complete by ?/?/?
3	Operations and Maintenance Manuals	Processing	Documents complete and all approved by ?/?/?
4	Standard Operating Procedures	Mine/Process.	Documents complete and all approved by ?/?/?
5	Training	HR	All training (on- and off-site) to be complete by ?/?/?
6	Enterprise Resource Planning (ERP)	IT	*SAP* installation and training to be complete by ?/?/?
7	ERP Integration	IT	*SAP* populated by equipment list, A/C & PM schedules by ?/?/?
8	Process Information (PI) System	Process./Met.	*Outokumpu* installation and training to be complete by ?/?/?
9	Data Historian	IT/Process./Met.	All tags determined/PI system integration with *SAP* by ?/?/?
10	Metallurgical Accounting Control	Process/Met.	To be developed by Met. Dept. and in place by ?/?/?
11	Design Flows	Processing	Achieve design flows through all systems by ?/?/?
12	Assay Lab Software	Metallurgy	In place for exploration; updated for mine/plant analyses
13	DCS	Processing	*Honeywell XX* system to be developed and installed by ?/?/?
14	Emergency Rapid Response	H&S	Make necessary changes to project's rapid response program
15	Spill Clean-Up Program	H&S/ESR	ESR to produce spill cleanup SOP (plant & leach pads) by ?/?/?
16	Health & Safety (H&S) Management Plan	H&S	Update health, safety, and loss prevention plan as required
17	Security System	Security	Update the in-place project security program as required
18	Main Gate Access Control	Security	IDs, parking, and access turnstiles all operational by ?/?/?
19	Env. & Social Responsibility (ESR) Plan	ESR	Update the project ESR management plan as required
20	Permits	ESR	100% compliance with all operations permits by ?/?/?
21	Mine Operations Monitor & Control	Mine Operations	*Jigsaw* already in place. Update to add new mine destinations
22	Ore Control Software	Mine Engineering	*Modular Mining* installation & training to be complete by ?/?/?
23	Reserve Software	Geology	Add another user license to the in-place company agreement
24	Geotechnical Software	Mine Engineering	*C&N* installation and training to be complete by ?/?/?
25	Hydrology Monitoring	ESR	Already in place; data being used by project team
26	Equipment Mine Maintenance Shop	Mine Operations	Order and supply equipment & tools to all be in place by ?/?/?
27	Equipment Plant Maintenance Shop	Processing	Order and supply equipment & tools to all be in place by ?/?/?
28	Reagents Supply	Purchasing	First fills all delivered by ?/?/?
29	Warehouses	Purchasing	All warehouse facilities and infrastructure setup by ?/?/?
30	Spare Parts	Purchasing	All parts stocked and appropriate min/max set by ?/?/?
31	Bulk Consumables	Purchasing	All supplier agreements for consumables in place by ?/?/?
32	Plant Commissioning	Project Manager	Plant 100% commissioned and all punch list items fixed
33	Commercial Production	Operations Mgmt.	Achieve 80% of design production by ?/?/?
34	Design Production	Operations Mgmt.	Achieve 100% of design production by ?/?/?

FIGURE 33.3 Operations readiness activities table—example

Systems

- Put in place all procedures for mining, processing, maintenance, support services, and administration, along with the necessary business systems.
- Put in place all operating plans (monthly and annual).
- Have the maintenance and planning systems for both mine and process facilities in place.
- Have the technical tools, physical tools, and support systems in place and working.
- Have all enterprise resource planning systems installed, operational, and fully tested. Make sure that the teams are trained in their use.
- Ensure that the purchasing and accounting systems are fully operational.
- Have the management reporting and control systems in place. These are the key enablers of operational readiness planning and execution. Reporting needs to be dynamic, so that as commissioning approaches start-up, the system is able to provide real-time data for analysis and troubleshooting.
- Have a communications system functioning for all entities within operations.

Because no data exist to identify where problem areas are going to arise, there is always a degree of uncertainty regarding system reliability and performance in any operations ramp-up plan.

Other components of the ORP that need to take place before start-up include (1) monthly review sessions of the progress of the ORP status and progress and (2) third-party gap analyses to ensure that all areas are being covered.

ROLES FOR OPERATIONS READINESS

Start-Up TEAM Role

The project manager is responsible for integrating the TEAM into a functioning joint unit from precommissioning all the way through start-up and into ramp-up of the process facilities. The TEAM, as stated in Chapter 30, is composed of commissioning specialists, project management personnel, key contractors held over, and O&M personnel hired early. The role of the TEAM is to do the following:

1. Fully understand its tasks and responsibilities.
2. Function according to the stated objectives of the integrated team.
3. Operate within a totally open and integrated joint organization.
4. Ascertain that systems, procedures, materials, and equipment for start-up are in place.

Project Management Team Role

The project management team's role is, in essence, to perform all the project execution duties that have been covered in this book to this point in time, that is, to

- Engineer, procure, construct, and precommission all facilities and then support operations for commissioning and start-up; and
- Ensure that the TEAM organization is adequately staffed, trained, and organized.

Typically, the project manager will keep track of the status and progress of operational readiness by using tables that display readiness indicators for each department, similar to the overall property status previously illustrated in Figure 33.2. Figure 33.4 shows an example of a departmental operational readiness status table used by a Canadian mining organization to give an instantaneous view of whether the various departments of operations are truly prepared to assume command after precommissioning.

Operations Role

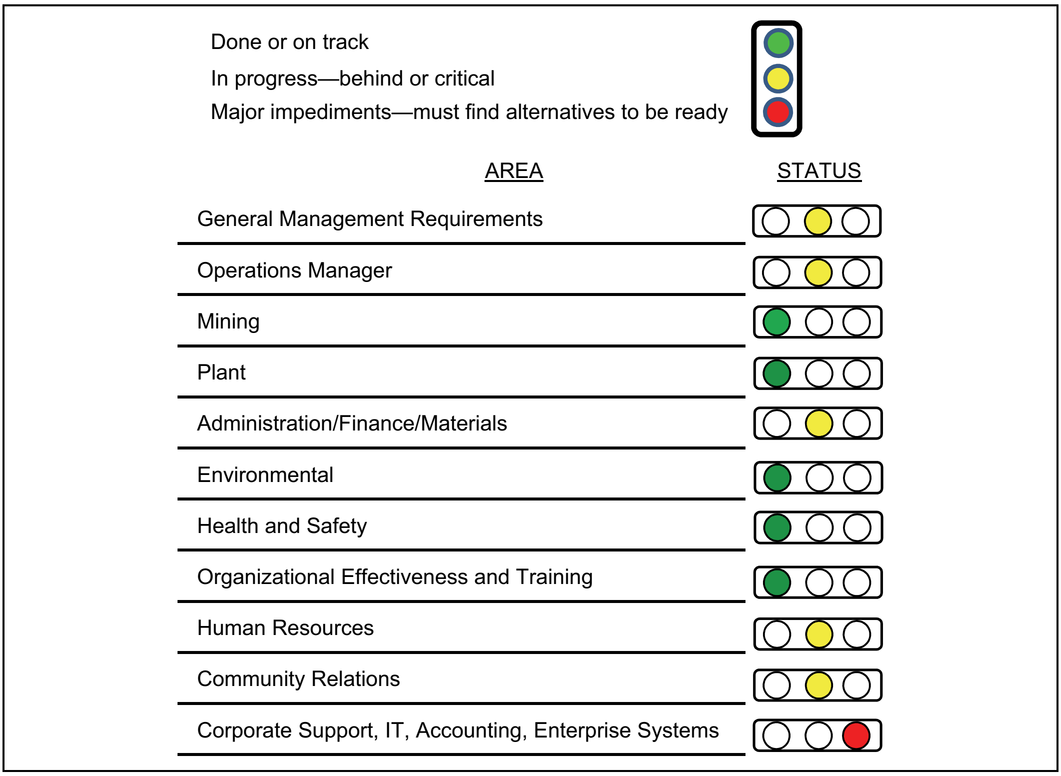
- Hire the O&M personnel in a timely way (prior to precommissioning).
- Be prepared to take care, custody, and control of the facility after precommissioning.
- Support project management and the TEAM efforts as they work toward start-up.

Corporate Support Services Role

Corporate support services provides operations with legal, procurement, accounting, invoicing, payroll support, and so forth.

OPERATIONAL READINESS RISKS AND OPPORTUNITIES

Any risks or opportunities identified during project execution that could impact operations start-up need to be added to the project risk register, addressed within the ORP, and then managed. Equipment damage and/or inefficient operation due to new employees working with unfamiliar processes, along with insufficient operational training, are generally the most prevalent risks that the ORP will need to address and avoid.



Done or on track 🟢
In progress—behind or critical 🟡
Major impediments—must find alternatives to be ready 🔴

AREA	STATUS
General Management Requirements	○ 🟡 ○
Operations Manager	○ 🟡 ○
Mining	🟢 ○ ○
Plant	🟢 ○ ○
Administration/Finance/Materials	○ 🟡 ○
Environmental	🟢 ○ ○
Health and Safety	🟢 ○ ○
Organizational Effectiveness and Training	🟢 ○ ○
Human Resources	○ 🟡 ○
Community Relations	○ 🟡 ○
Corporate Support, IT, Accounting, Enterprise Systems	○ ○ 🔴

FIGURE 33.4 Operations readiness by department

PREPARATION OF THE OPERATIONS READINESS PLAN

The project manager is responsible for the management of the overall operations readiness effort, providing guidance to each of the contributing functional departments as well as cross-functional interfaces and integration. The project manager provides the ORP objectives and then monitors the execution, with particular focus on risks and opportunities. The project manager is thus the collector and keeper of the individual operations readiness plans in the quest to complete the overall ORP document.

Typically, a member of the project manager's staff is assigned as a liaison to the project staff and maintains the ORP schedule for the project manager (this liaison is often a future operations department head). This is good protocol, but it must not dilute the project manager's accountability.

Key aspects for the project manager to focus on with the management of the ORP are the following:

- **Monitoring**—The project manager monitors the development of individual functional operational readiness plans, with a focus on the mitigation of any cross-functional risks or opportunities. Potential deviations to the approved execution plan have to be managed. Figure 33.5 shows a departmental operational readiness status monitoring tool used by a Canadian project team to yield a quick overview of an operations department progress.
- **Reporting**—Functional leaders report their weekly progress to the project manager. The project manager then updates the ORP progress monthly for the project stakeholders.
- **Change control**—The project manager is the only person authorized to make changes to approved segments of the ORP and/or changes in the implementation schedule. Any changes will normally also be subject to approval of the Owner.
- **Document control**—The latest version of the ORP is maintained in the project files for all to access.

PROJECT MANAGER RESPONSIBILITIES

The following duties capture the main activities and responsibilities of the project manager with regard to the ORP:

1. Be accountable for the project's ORP.
2. Be responsible for the development and management of the ORP.
3. Promote and support company policies and procedures within the ORP.
4. Lead the project management team to ensure support of ORP objectives.
5. Work with the mining company's corporate office to appoint functional leads capable of timely delivering the individual functional operational readiness plans.
6. Manage the functional leads to timely generate the project's requisite individual operational readiness plans replete with the necessary processes, procedures, systems, and controls.
7. Identify links and dependencies of activities and requirements across functions.
8. Monitor ORP development progress, with the focus on cross-functional issues, and facilitate communication among functions, Owner, and project team.
9. Resolve and/or escalate any critical issues, risks, or opportunities. Facilitate the mitigation of any action or mitigation plans.
10. Ensure that the ORP is in sync with the PEP.

FUNCTION	STATUS	%	COMMENTS
Safety and Health	🟢 ○ ○	70	• Safety Supervisor – critical hire • Policies and Procedures
Environmental	🟢 ○ ○	90	
Mining	🟢 ○ ○	90	
Concentrator Plant	○ 🟡 ○	30	• Organization and Hiring • Maintenance Readiness
Administration	○ 🟡 ○	70	• Payroll • Reporting and Enterprise Resource Planning
Supply Chain	🟢 ○ ○		
Human Resources	○ 🟡 ○	70	• Recruiting • Employee Relations • Training and Onboarding • Culture

FIGURE 33.5 Operations readiness department status

11. Approve changes to the ORP and schedule as appropriate.
12. Ensure that the ORP schedule stays fully integrated with the project master schedule. Update the ORP and schedule through the project controls group.
13. Continuously track, update, and report on ORP progress to project stakeholders.
14. Conduct ORP readiness check reviews at narrowing increments as the project nears start-up (typically, four of five reviews will be needed over the course of the project).
15. Follow up on action items from ORP reviews. Note: Actions are normally implemented by the functional leads.

FUNCTIONS COVERED IN THE OPERATIONS READINESS PLAN

The individual components of the ORP should all be initiated at least 6 months before commissioning. Standard operating procedures (SOPs) need to be solidly in place before start-up. The individual functions covered within the ORP should include the following:

1. Geology
2. Mine engineering, mine operations, and mine maintenance
3. Metallurgy and processing
4. Human resources (HR) and training
5. Health and safety, and loss prevention
6. Security
7. Procurement
8. Information technology (IT)
9. Environmental and social responsibility (ESR)
10. Accounting
11. Legal
12. Operations management
13. Services

Geology

For most mining companies, the geology ORP component merely involves adaptation of existing company processes, procedures, systems, and duties already in place elsewhere in the corporation, and then applying these in the operations start-up on the project site.

Mine Engineering, Mine Operations, and Mine Maintenance

The primary aim of most mining ORPs is to locate, provide, and prepare people, systems, and procedures to meet the mine ramp-up schedule in the most cost-effective manner. Issues to address include the timing of the provision for materials, tools, vehicles, and equipment to support the mining operations. The postconstruction plans for maintenance of roads, drainages, and sediment ponds also need to be addressed.

Metallurgy and Processing

The metallurgical and processing ORP component focuses on preparing people, systems, and procedures such that all items related to process, plant maintenance, and metallurgy for the project are understood and fully functional in time for operations start-up. If new processes and/or procedures have been introduced, the metallurgy and processing component of the ORP needs to demonstrate a solid grasp of what metallurgically has to happen to properly control project start-up.

The success of the project will be measured by the success of its start-up, that is, the progressive ramp-up to design rate, and the overall metallurgical results achieved. An ever-present risk in the process area concerns the ability to hire the necessary experienced process operators to meet the start-up headcount requirements. Transferring skilled operators from other company operations should always be aggressively pursued, but such transfers will likely only partly suffice. Intensive training will undoubtedly be needed.

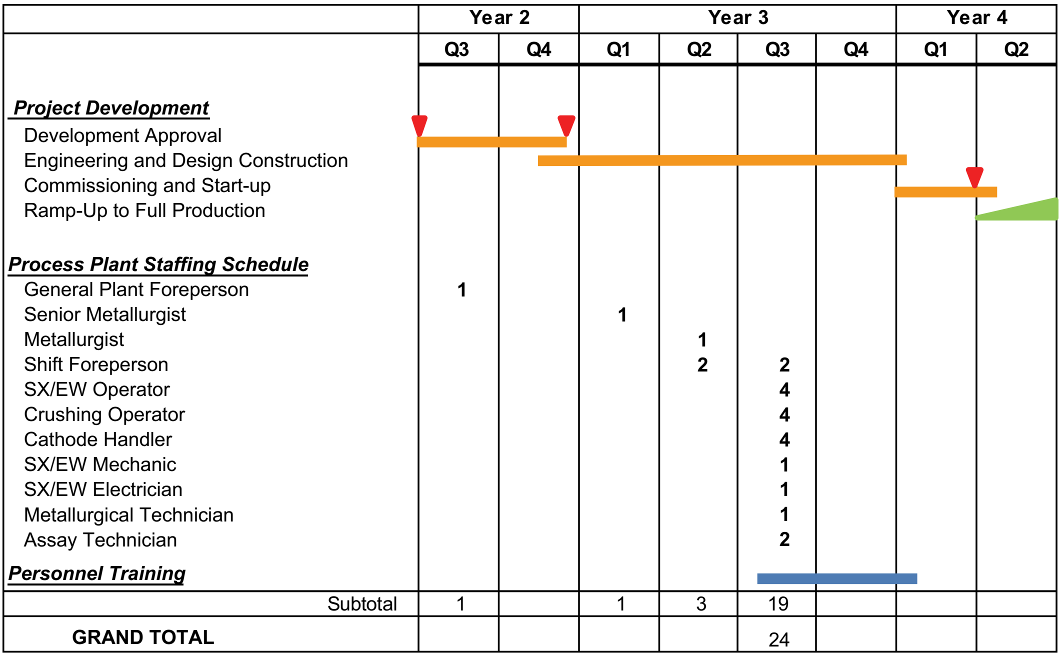
This training will need to be preceded by the development of the operating and training manuals. Preparation of manuals by in-house professionals is the first preference, but this is rarely the reality, so typically external consultant expertise has to be brought in if the task is to be timely accomplished.

If the project is a brownfield project located within an existing operating property, the overall strategy will be to utilize the existing systems and procedures as much as possible. But if the process is a first of its kind, then a host of entirely new operational, maintenance, and training plans must be developed from scratch. The plans have to establish long-term performance-monitoring protocols for both equipment and process conditions such that they enable prediction and proactive control assurance of operational performance.

During start-up and beyond, process performance will primarily be measured through plant-operating data as reported daily and monthly in the metallurgical balance. A process information data historian will need to be installed to capture plant data and to generate daily reports and trends to manage key metrics. Additionally, the analytical lab should be prepared to perform a likely escalating suite of support tests.

Human Resources and Training

The HR ORP component covers HR organizational, training, and systems readiness. The additional personnel required have to be individually identified by position and their training and support needs to be documented. The recruitment strategy for new hires (advertising, job



	Year 2		Year 3				Year 4	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Project Development								
Development Approval								
Engineering and Design Construction								
Commissioning and Start-up								
Ramp-Up to Full Production								
Process Plant Staffing Schedule								
General Plant Foreperson	**1**							
Senior Metallurgist			**1**					
Metallurgist				**1**				
Shift Foreperson				**2**	**2**			
SX/EW Operator					**4**			
Crushing Operator					**4**			
Cathode Handler					**4**			
SX/EW Mechanic					**1**			
SX/EW Electrician					**1**			
Metallurgical Technician					**1**			
Assay Technician					**2**			
Personnel Training								
Subtotal	1		1	3	19			
GRAND TOTAL					24			

FIGURE 33.6 Process plant staffing timing

fairs, usage of search companies, employee referral bonuses, etc.) needs to be spelled out in the HR plan.

To properly understand these future operations staffing and training needs, the HR plan requires creation of a comprehensive organizational chart for the overall future operation, as well as intermediary charts for each implementation stage (see Figures 18.3 and 18.4). The organizational charts need to show the exact timing of the hiring and training of each member of the operational workforce, along with the preferred source (i.e., external recruit, internal company transfer, project employee transfer, construction contractor transfer, etc.).

HR works with each department to arrive at individual staffing schedules for that department, coordinated with the project completion, as shown on the master schedule. Figure 33.6 shows the staff timing buildup for a solvent extraction and electrowinning (SX/EW) copper facility in Peru in 2011 as construction was approaching completion.

HR's plan should initially focus on developing the appropriate organizational culture through targeted recruitment and development of people motivated to work together. Effective learning programs that facilitate knowledge sharing and foster capability development in alignment with the operations business purpose are the goal.

Training of new recruits is typically first provided at existing company operational sites. If the operations process being introduced at the project site is completely new for the company, then specific process training for a couple of weeks for each key process operator (typically 4 to 10 individuals) at off-site facilities should be added. If not available at company or competitor sites, then vendor training can be a good substitute. Employees who undergo off-site training at an operating facility become an excellent resource for training of the remaining new employees. Operating, maintenance, and training manuals need to be developed and in hand prior to on-site training taking place.

A key tool available today for equipment training is the simulator. For the mine equipment operator, the simulator can mimic the same equipment on the exact terrain that the operator will encounter on-site under a range of conditions, including nighttime operations. For the process operator, these simulators put a myriad of real-world situations onscreen in front of the operator for the exact equipment process flow diagram that the operator will have to deal with on-site. While expensive, these simulators have enhanced, rapid start-ups and have resulted in net savings in numerous projects worldwide.

Health and Safety, and Loss Prevention

While the health and safety, and loss prevention plan created for the project execution phase focuses almost entirely on the construction effort, it has the same underlying tenet needed for the operations phase, that is, ensuring that all personnel go home every day without injury.

Thus, invariably the project health and safety standards and systems, and the loss prevention procedures already in place on the project site will mostly suffice for operations. An extra person or two may need to be hired, and a specialized outsourcing company may need to be brought in for some of the specialized training requirements. This specialized training of the future operational personnel should include the following:

- Electrical safety
- Conveyor safety
- Cranes certification
- Basic first aid and firefighting
- Basic industrial hygiene (including personal protective equipment [PPE] training)
- Hazardous materials, that is, HAZMAT (chemicals, acids, caustic solutions, etc.)

An emergency response plan has to be created whereby all foreseeable circumstances can be managed with minimal risk to the safety and welfare of the people involved, the community at large, and the integrity of the plant and the equipment. The emergency response plan developed for the new plant will need to include HAZMAT management and fire suppression protocols. Monitoring protocols for liquid, gas, and/or vapor releases will also likely be needed.

Security

Security practices and procedures that already exist elsewhere in the Owner's organization are typically applied to the project, for both construction and operations. Consequently, any security systems in place on the project should already be in accord with company standards. Thus, it is frequently possible for the project security services to just be extended for operations, rather than having to create a whole new system from scratch.

The person assembling the security ORP components will need to ascertain whether 24/7 external guard services are mandated by the company's insurance providers. (This is becoming increasingly common, particularly for precious metals facilities.)

Procurement

The facilities and infrastructure required for the operations procurement function (warehouses, storage yards, offices, etc.) are typically provided as project deliverables. But the equipment and tools to operate the facilities need to be specifically identified in the ORP for the procurement supply chain (along with the requisite staff and training). The different types of consumables needed for operations have to be identified along with any special storage requirements for HAZMAT and the like. The appropriate amount of spares, materials, and other consumables inventory must be individually established.

Information Technology

The IT plan component should select technologies that best fit the future requirements of the operations. Functions to address within the plan for IT adequacy include the following:

- Telephone—Identify a system that can provide the necessary service. On a brownfield site with an existing service, identify the physical extensions required.
- Network—Identify the extent of the IT system that will be needed. List the locations and capacities of the servers, infrastructure, switches, and devices to be provided.
- Wireless—Identify the areas of the project that will need to be covered.
- Radios—Specify the system to be installed and the coverage required.

The specific training requirements for the IT equipment to be deployed need to be shown. Routine procedures need to be in place for systems administration, including data quality management, data archiving, and systems backup.

Environmental and Social Responsibility

The ESR ORP component focuses on obtaining the new permits necessary for operation of the installed facilities, as well as in anticipating the rules and procedure modifications to the construction permits that will maintain compliance for operations.

If an ISO 14001 certification already exists on the project site, this will need to be checked to determine whether any modifications for operations are necessary. It is likely that the new environmental aspects of the plant have already been identified and listed by the ESR personnel as part of the preparation for the construction project's environmental compliance procedures, databases, controls, and contingency plans. If additional environmental compliance activities are required for the laws and regulations that affect operations, these will undoubtedly involve creating quality assurance and quality control (QA/QC) lab protocols and providing additional legal support services.

Start-up will require demonstration of permit compliance, certainly for air-quality-monitoring compliance and possibly for demonstration of water pollution prevention. Specialist contractors may need to be brought in for these compliance-proving efforts. An external consulting firm may also need to be hired to develop the closure plan.

Accounting

The financial and accounting services needed by the operating facility are usually put together by the mining company's corporate management working in conjunction with its IT group. Typically, the systems and software needed already exist elsewhere in the Owner organization; thus the project manager's role is mostly ensuring that all these systems are installed in a timely way prior to the start-up phase of the project. Appropriate procedures need to be in place for budgeting, costing, and financial control.

Legal (Including Land Management)

Legal support services that already exist elsewhere in the Owner's organization are typically applied to the project, for both construction and operations. Thus the legal support in place for the project should mostly suffice for operations. But this needs to be confirmed, not assumed.

Operations Management

The management structure of the operating facility is typically put together by the mining company's corporate management working in conjunction with its HR group (possibly bolstered by external management recruiters). On a brownfield site, the management systems already in place are utilized to the extent that is practical. The project manager's role is then mostly monitoring the implementation of the plan, to ensure that operations can smoothly take over the project following start-up.

The operational philosophy for the new operations needs to be developed. This philosophy should set out the organizational intent for the way that each departmental business function is expected to perform as part of the whole organization. Communication links and processes sustain the operational philosophy; these links have to be addressed within the operations management plan. Processes for both internal and external communications have to be set that sustain relationships across all functions and stakeholders.

Almost certainly in today's mining world, the operations management plan will include the installation of an enterprise resource planning (ERP) system. An ERP is a cross-functional computerized system driven by an integrated suite of software modules that supports key internal data transfer processes within the mining company's operations. ERP systems (e.g., SAP, Ellipse) can run on a variety of computer hardware and network configurations, typically employing a database as a repository for information.

The ERP allows operations to have an integrated real-time view of its core business processes (production, inventory management, etc.) The ERP system will track resources and metrics (cash, supply materials, and production capacity) and commitments made by the operation (such as purchase orders and employee payroll), no matter which department (operations, purchasing, sales, accounting) enters the data in the first place. ERP facilitates information flow between all functions inside and, if desired, outside the organization.

Any ERP system put in place must enable efficient and effective capture, storage, recall, and management of information, and allow auditing and support risk management. This requires integrated and compatible data-coding hierarchies across all business systems if information is to be found when needed.

Services

Service agreements that support the individual operational functions previously listed have to be put in place before actual start-up. On an established site these will mostly be modifications to existing agreements rather than new contracts. Service agreements typically needed include

- Employee transportation—to and from the site, and possibly internally on-site;
- Camp accommodations—typically cover, lodging, food, laundry, and recreation;
- Septic—external removal services are generally the most cost-effective;
- Janitorial—external janitorial services are frequently cheaper than internal;

- Uniforms—in certain acid environments, fresh uniforms may need to be supplied, and for security reasons some gold plants require complete clothing changes for gold room personnel;
- Vending machines—becoming a necessity for today's "grazing" employees;
- Potable water—drinking water for employees (and possibly ice in some locales);
- Process water—in some locales "fresh" service water will have to be provided; and
- Environment monitoring—for regulatory agency credibility, noncompany monitoring is often needed.

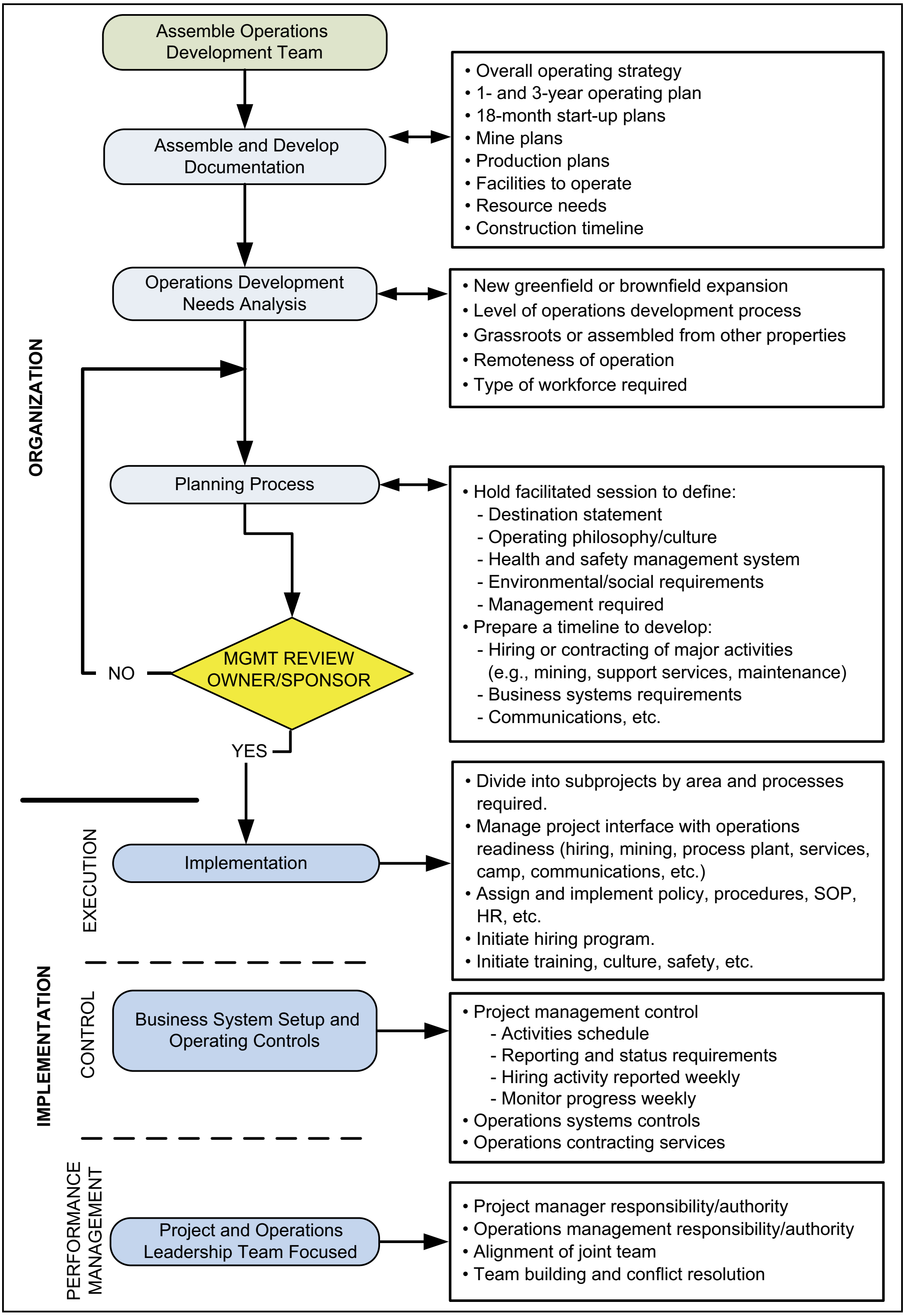
CHECKLIST 33.1 OPERATIONS READINESS

No.	Item	Status	Date	Initials
1	Strategy for development of operational capability—established			
	A. Minimum requirements—agreement reached with Owner			
	B. Implementation timing—set with Owner			
	1. Operational capability development to be complete 3 months before precommissioning takes place			
2	Core operations management team—recruited and in place in a timely way			
3	Operations readiness plan (ORP)—developed			
	A. ORP elements aligned to match project start-up goals			
	B. Project Execution Plan (PEP)—in hand (for schedule alignment)			
	1. Project commissioning and start-up plan—available for reference			
	C. Operations plan (annually for initial 3 years)—complete			
	1. Production systems requirements—specified			
	2. Maintenance plan and tooling requirements—set			
	D. Organization recruitment program—approved by Owner			
	1. Hiring team—in place with a defined timeline			
	2. Employee handbook (for operations)—published			
	E. Organizational training program—prepared			
	1. Operations training—conducted ahead of start-up			
	F. IT systems to support operations—in place			
	G. Business system requirements—identified			
4	Department and function plans, SOPs, and policies—developed			
5	Individual departmental readiness plans—prepared			
	A. Geology			
	B. Mine engineering, operations, and maintenance			
	C. Metallurgy and processing			
	D. Human resources and training			
	E. Health and safety, and loss prevention			
	F. Security			
	1. Security systems—taken over from project			
	G. Procurement			
	1. Warehousing needs—established			

(Continues)

(Continued)

No.	Item	Status	Date	Initials
	H. Information technology			
	I. Environmental and social responsibility			
	1. Responsibilities—assigned			
	J. Accounting			
	K. Legal			
	L. Operations management			
6	Support services requirements—services agreements identified			
7	Project and operations alignment session—conducted			
	A. Culture establishment—facilitated by project manager (PM) and Owner			
8	ORP links and dependencies between functions—identified			
	A. Communications between functions—facilitated by PM			
9	Operations risk and opportunities review—conducted			
10	ORP status reporting—initiated at project execution kick-off			
	A. Program development monitoring—responsibility of PM			
	B. Readiness check reviews—conducted at set intervals			
	C. ORP changes—authorized by PM (with Owner approval)			



FLOWCHART 33.1 Operations readiness

CHAPTER 34

Epilogue

Don't compromise yourself. You are all you've got. —Janis Joplin, 1943–1970

OBJECTIVE

The compilation of this book has been a multiyear pleasure for the authors. We will close this undertaking with two personal truths for our readers.

1. Utilization of the collected wisdom within these pages can deliver project success.
2. If you take on the position of project manager for a major mining project, you will experience the most satisfying role that a person can undertake within our industry.

SUCCESS CREDIBILITY

Deployment of the practices cataloged in this book has already delivered successful mining projects to numerous corporations in a variety of locales around the world. Real-world results from 10 consecutive projects managed by the authors over a 14-year period are shown in Figure 34.1. These are presented here to demonstrate that the best practices within this book truly do yield successful bottom-line results.

PROJECT MANAGEMENT FULFILLMENT

One of the authors came to his first project manager position following mining experiences as a longwall coal operator, underground roof bolter, walking dragline mechanic, open-pit driller, carpenter, tractor driver, development miner, grouter, laboratory technician, mine engineer, surveyor, chief engineer, shift boss, general foreman, industrial engineer, project engineer, mine superintendent, and general manager. While all these jobs helpfully exposed the author to the breadth of the mining world, none of the roles fully revealed the intensity and the fulfillment that lies within the project management life.

To lead a mining undertaking from inception to completion, to see the fruits of one's efforts produce real metals in the field, and to hold in one's hand gold bars that were once just concepts and numbers on paper will yield an unparalleled satisfaction experienced only by the few who tackle and succeed in the rigors of project management.

But the journey is not for the faint of heart. To get there, one needs to be prepared to work 80-plus hours a week for years on end, give up weekends with family, miss out on children's scholastic and sporting events, and reside in the humblest of dwellings, frequently with the barest of necessities. Mother Nature and humankind will continually challenge one's will to

	CAPITAL COST, $ thousands		
Constructed Project	**Actual**	**Forecast**	**Project Deliverer**
FREEPORT-MCMORAN (1986–1993)			
DOZ/DOM Underground, 20 kt/d, Indonesia	128	126	Owner – Freeport Indonesia
Grasberg Open-Pit Mine, 38 kt/d, Indonesia	161	172	Owner – Freeport Indonesia
Grasberg Phase 1, 52 kt/d, Indonesia	507	511	Fluor Daniel
Grasberg Phase 2, 90 kt/d, Indonesia	812*	812	Fluor
Subtotal Freeport-McMoRan	1,608	1,621	
CYPRUS AMAX (1993–1999)			
Cerro Verde Leach, Peru	225	240	Fluor
El Abra, Chile	1,029	1,048	Bechtel
Fort Knox, Alaska	373	397	Morrison-Knudsen
Henderson, Colorado	154	169	Fluor
Kubaka, Russia	242	246	Kvaerner
Willow Creek, Utah	165	134	CEntry
Subtotal Cyprus Amax	2,188	2,234	
TOTAL	**3,796**	**3,855**	

* Reported figure (unverified)

Source: Adapted from Hickson 2000c.

FIGURE 34.1 Hickson and Owen project performance—1986 to 1999

complete the journey. Mining projects are not found in pristine, comfortable city downtowns; they reside in the waterless Atacama desert, the –50°C bone-chilling cold of the Russian arctic, the 17,000-foot oxygen-starved elevation of the Peruvian Altiplano, the scorching heat of southern Death Valley, and the 400-inch annual rainfalls of the Indonesian jungles.

Projects rarely come with endorsements from outside society. It will frequently feel like the entire spectrum of humankind wants you, and what you are trying to accomplish, to fail miserably. But for those project managers who are willing to brave the hurdles of the project path, and who have the fortitude to take the slings and the arrows, and who have the wherewithal to bring the project to the desired end, the fulfillment will be boundless.

So, readers, please absorb the wisdom that we have gathered herein, and then go forth into the project world with the knowledge that the success you seek for your mining enterprise is achievable and the journey to your project endpoint will be amazingly worthwhile.

Glossary

AACE International: An abbreviation for Association for the Advancement of Cost Engineering International.

acid mine drainage (AMD): *See* acid rock drainage.

acid rock drainage (ARD): Produced by the exposure of sulfide minerals (mostly iron pyrite) to air and water, resulting in the oxidation of the contained sulfur, the production of acidity, and elevated concentrations of iron, sulfate, and other metals. Also known as acid mine drainage (AMD).

ACostE: An acronym for Association of Cost Engineers.

actual cost (AC): Total costs actually incurred and recorded in accomplishing work performed during a given time period for a schedule activity or for a work breakdown structure (WBS) component. Also referred to in earned value management (EVM) terminology as actual cost of work performed (ACWP).

AIA: An acronym for American Institute of Architects.

ANSI: An acronym for American National Standards Institute.

ASPE: An acronym for American Society of Professional Estimators.

ASTM International: The new name for the American Society for Testing and Materials.

authority: The right to apply project resources, expend funds, make decisions, and give approvals.

Authorization for Expenditure (AFE): The corporate approval document for capital projects and major expenditures. Generally an AFE is only required for expenditures higher than a certain minimum level (e.g., $10,000) and/or an expected life of above a minimum number of years (typically set somewhere between 1 and 3 years). The form can also be used for soliciting, recording, and communicating approvals for expenditures among a company's management responsibility levels.

"bankable" feasibility study: A study demonstrating project operational and economic viability that has sufficient engineering detail and a high enough accuracy that it can withstand rigorous third-party technical and financial institution review, to be capable of commanding nonrecourse external financing for funding of the requisite project capital.

basis of estimate (BOE): The BOE is a clear, unambiguous statement of the underlying scope basis, pricing basis, methods, references, qualifications, assumptions, inclusions, and exclusions that were used to develop the cost estimate. The BOE describes how the estimate was derived and how the expected funding will be spent to achieve the given objective.

basis of schedule: The basis of schedule is a complete, clear, and unambiguous statement of the underlying principles, basis, facts, assumptions, references, qualifications, and exclusions that are required to develop the project schedule.

benchmarking: The process of comparing the cost, cycle time, productivity, or quality of a specific process, method, or project to another that is widely considered to be an industry standard or best practice.

bid: A proposal or offer to perform the task of work for a determined amount of money.

bid bond: A bond secured by the bidder that guarantees that the bidder making the bid will perform the work for the price in the bid if the bid is accepted.

bill of quantities (BOQ): A document used in tendering within the construction industry in which materials, parts, and labor (and their costs) are itemized. By itemizing all the work required by the terms of the contract, the contractor is able to price the work being bid.

budget: The planned and approved cost of the project.

budget at completion (BAC): The sum of all budgets established for the work to be performed on a project or a work breakdown structure (WBS) component. The BAC is the total planned value for the project carried through to completion.

budgeted cost of work performed (BCWP): An earned value management (EVM) term. *See* earned value.

budgeted cost of work scheduled (BCWS): An earned value management (EVM) term. *See* planned value.

CAD: An acronym for computer-aided design or computer-aided drafting.

capital expenditure (CAPEX): Made to create future benefit. A CAPEX is incurred when money is spent to accumulate fixed assets, add to the value of an asset, or extend the useful life of an asset.

Certified Associate in Project Management (CAPM): An entry-level certification from the Project Management Institute (PMI) for project practitioners. Designed for those with little or no project experience to demonstrate an understanding of the fundamental knowledge, terminology, and processes of effective project management. A precursor to Project Management Professional (PMP) certification.

CIF (cost, insurance, and freight): A procurement trade term meaning that the seller is required to arrange for the carriage of goods by sea to a port of destination and the buyer is provided with the documents necessary to obtain the goods from the carrier.

CII: An acronym for Construction Industry Institute.

code of accounts: Any numbering system used to uniquely identify each component of work in the work breakdown structure (WBS).

commissioning: Commissioning (also known as wet commissioning) starts when enough components of a stand-alone system are mechanically complete and have been successfully precommissioned dry, such that *practical completion* has been reached for that individual system. Feed ore material and/or process fluids can now be introduced for the first time into the system.

completion bond: A guarantee by a bonding company that a contract will be completed according to specifications and will be clear of all liens and encumbrances.

constructability: The optimum use of construction knowledge and experience in all project phases, from concept through execution.

construction work package (CWP): A well-defined scope of construction work that terminates in a deliverable product or completion of a service. It requires management as a unit, and it logically reflects the way the construction effort will be controlled.

constructor: A construction contractor organization responsible for actually carrying out the physical construction works and/or services in the field.

contingency: A specific provision added to a base estimate to cover indefinable items that have historically, by actual experience, been required but cannot be specifically identified in advance. These undefined elements are fully expected to occur in the forecast value of cost and/or schedule, but the exact nature and timing of their occurrence is indeterminate. It is not intended to cover scope changes or project exclusions.

contractor: The private-sector party or parties contracted by the entity responsible for the project to deliver various parts of the project.

corrective action: Documented direction for bringing the expected future performance of the project work back in line with the plan.

cost estimate: A prediction of the probable cost of a project, for a given and documented scope, to be completed in a defined location and at a future point in time. A cost estimate is not a budget until it has been converted to the detail necessary for control and has been approved by an AFE (Authorization for Expenditure).

cost of quality (COQ): A method of determining the costs to ensure quality.

Cost Performance Index (CPI): An earned value management (EVM) measure of cost efficiency on a project. It is the ratio of earned value (EV) to actual costs (AC). CPI = EV/AC. CPI > 1 is good (under budget).

cost reimbursable: A contract pricing method under which all allowable and reasonable costs incurred by a contractor in the performance of a contract are reimbursed in accordance with the terms of the contract. Such contract types include cost plus (time and materials), fee plus, and schedule of rates.

cost variance (CV): An earned value management (EVM) measure of cost performance on a project. It is the difference between earned value (EV) and actual cost (AC). CV = EV – AC.

critical chain: The sequence of both precedence- and resource-dependent terminal elements that prevent a project from being completed in a shorter time, given finite resources.

critical chain project management (CCPM): A method of planning and managing projects that puts the main emphasis on the resources required to execute project tasks. CCPM uses a schedule network analysis technique to modify the project schedule to account for limited resources. This is in contrast to the critical path method (CPM), which emphasizes task order and rigid scheduling.

critical path: The sequence of project network activities that add up to the longest path through the project. The critical path generally equates to shortest time possible to complete the project and, as such, is a prime determinant of the project's duration.

critical path methodology (CPM): A process for determining the project activity or string of activities that is critical to the timely completion of the project. The CPM network analysis technique determines the amount of scheduling flexibility (the amount of float) on the various logical network paths in the project schedule to determine the minimum total duration.

CSI: An acronym for Construction Specifications Institute.

cutoff grade (COG): When calculating ore reserves or mining plans, the grade at which the mineral resource is no longer worthy of extraction is termed the cutoff grade. In most situations this is the break-even grade, that is, the grade at which the mineral resource can no longer be processed at a profit, but this does not have to be so; it may be set higher or lower than the break-even grade depending on the particular goals of the resource owner.

dashboard: A management information control tool that uses software to display all the key critical information about a project on one screen, thus allowing project stakeholders to easily review basic project metrics such as schedules, tasks, and issues. The dashboard is a project-monitoring tool that provides transparency on the critical economic and technical areas of project execution. The dashboard provides an online view of project status.

defect: A deficiency in a project component that does not meet requirements or specifications and needs to be fixed, repaired, or replaced.

definitive estimate: A cost estimate produced once engineering is 75% to 80% complete and after a majority (normally more than 90%) of the equipment has been ordered, all project controls are firmly in place, and construction is over 25% complete.

de minimis: A Latin expression meaning minimal or insignificant.

Department of Energy (DOE): The U.S. government's Department of Energy.

discounted cash flow return on investment (DCF-ROI): The discount rate at which the net present value (NPV) is zero. The DCF-ROI is also referred to as discounted cash flow rate of return (DCF-ROR) or the internal rate of return (IRR).

distributed control system (DCS): A computerized system controlling the production lines of a process (or any kind of dynamic system) in which the controller elements are not central in location but are distributed throughout the system, with each component subsystem regulated by one or more controllers.

document control: The controlled management of documents through their entire life cycle. Document control is much more prescriptive than document management. A document control system demands a much higher degree of reliability for security, version control, review cycle, visibility, availability, and a controlled audit trail than does a document management system.

document management: The storage and retrieval of documents. A project document management system encompasses the safe electronic storage, indexing, access, search, retrieval, archiving, version control, and deletion (if necessary) of all documents and records.

duration: The total number of work periods (not including holidays or other nonworking periods) required to complete a schedule activity or work breakdown schedule (WBS) component.

earned schedule (ES): A new, emerging extension of earned value measurement (EVM) that tracks schedule variance in units of time as well as currency.

earned value (EV): The value of the work performed expressed in terms of the approved budget assigned to that work for a schedule activity of a work breakdown schedule (WBS) component. EV is the budgeted cost of work performed (BCWP). EV = % complete × budget at completion. EV is the same as BCWP.

earned value management (EVM): A project management technique for objectively measuring project performance and progress. EVM combines the measurements of scope, schedule, and cost in a single, integrated system to provide key project trends and insight.

EDC (Export Development Canada): Canada's export credit agency. EDC is a Crown corporation wholly owned by the government of Canada that provides financing and risk management services to Canadian exporters and investors.

engineering, procurement, and construction (EPC): The engineering, procurement, and construction function of work, most often applied to the contract scope delivered by engineering and construction contractors who use their own direct-hire personnel for execution of the construction work element.

engineering, procurement, and construction management (EPCM): The engineering, procurement, and construction management functions of work. The term is most often applied to the single-contractor entity employed by the Owner to provide the three core project functions of engineering and design, procurement of materials and equipment, and management of field construction, all on behalf of the Owner.

enterprise resource planning (ERP): A cross-functional, computerized system driven by an integrated suite of software modules that supports key internal data transfer processes within a company's operations. ERP systems can run on a variety of computer hardware and network configurations, typically employing a database as a repository for information.

environmental assessment (EA): A first-order environmental review sometimes mandated by U.S. regulatory authorities. A second-order environmental review for Canadian regulatory authorities.

environmental impact statement (EIS): A second-order environmental review sometimes mandated by U.S. regulatory authorities.

environmental and social impact assessment (ESIA): A second-order environmental review generally mandated by European and World Bank regulatory authorities.

Equal Employment Opportunity Commission policy statement (EEOC policy statement): A statement required to be posted by all employers in the United States to serve as a reminder to all employees of their rights and responsibilities under the law and how to seek assistance if they believe they have been the subject of employment discrimination.

ESR department: An abbreviation for environmental and social responsibility department.

estimate at completion (EAC): An earned value management (EVM) term for the expected total cost of a schedule activity, work breakdown schedule (WBS) component, or the defined scope of the total project at completion. The EAC may be extrapolated based on performance to date, in which case EAC = budget at completion / Cost Performance Index or estimated by the project team based on other factors, in which case it is called a revised EAC.

estimate to complete (ETC): An earned value management (EVM) term for the expected cost needed to complete all remaining work for a schedule activity, work breakdown schedule (WBS) component, or the total project. ETC = estimate at completion minus the actual cost.

European Bank for Reconstruction and Development (EBRD): A multilateral development bank, using investment as a tool to help build market economies.

Ex-Im Bank (Export-Import Bank of the United States): The official export credit agency of the United States. The mission of the bank is to create and sustain U.S. jobs by financing sales of U.S. exports to international buyers.

expression of interest: An inquiry request (formal or informal) as to whether the recipient of the inquiry would be interested in undertaking the services necessary for an upcoming scope of work (SOW).

fast track: A project schedule compression technique that changes network logic to overlap phases which should properly be done in sequence, or to perform activities in parallel that should normally be done sequentially.

feasibility study: An evaluation and analysis of the potential success of a proposed project, using extensive investigation and research to enable a decision to be made about whether to fund and execute the project. Feasibility studies aim to objectively and rationally uncover the strengths and weaknesses of the proposed venture. The two prime criteria to judge feasibility are the cost required and the value to be attained.

finish-to-finish (FF): The logical relationship in which completion of the work of the successor activity cannot be achieved until the completion of work of the predecessor activity.

finish-to-start (FS): The logical relationship in which initiation of work of the successor activity depends on the completion of work of the predecessor activity.

float (free): The amount of time that a schedule activity can be delayed without postponing the early start date of any immediately following schedule activities.

float (total): The total amount of time that schedule activities may be delayed from their early start dates without deferring the project finish date.

FOB (free on board): An acronym always used in conjunction with a port or a location on the goods transportation route. “FOB port” or “FOB Lima warehouse” means that the seller pays for transportation of the goods to the named port or location, plus loading costs. The buyer pays for all costs beyond that point (including any further marine freight transport, insurance, unloading, and transportation from the named port or location to the final destination). The passing of risks occurs when the goods arrive at the named port or location.

forecast: An estimate, projection, or prediction of conditions and events in the project's future based on information and knowledge available at the time of the forecast. A forecast, as defined in this book, refers to an adjustment of the original estimated budget and/or schedule. The forecast (i.e., restatement of original base budget or schedule) is based on the project's actual past performance, performance to date, actual or expected future commitments, improved knowledge of scope and design quantities, and/or expected future performance, including all known information that could impact the project in the future.

Gantt (bar) chart: A graphic display of schedule-related activity. Schedule activities are listed down the left-hand (vertical, *y*-axis) side of the chart; dates are listed along the bottom (horizontal, *x*-axis); and activity durations are shown as date-placed horizontal bars.

general arrangement drawing (GA): A layout drawing, as opposed to a detail drawing.

general contractor: The main (or primary) construction contractor responsible for the physical construction of the whole project facility (or the substantial portion thereof). The general contractor may or may not be authorized to hire subcontractors to deliver portions of the project services.

guaranteed maximum price (GMP): A cost-type contract where the contractor is compensated for actual costs incurred plus a fixed fee subject to a ceiling price, which the contractor guarantees not to exceed. The contractor is responsible for cost overruns, unless the GMP has been increased via a formal change order. Savings resulting from cost underruns are returned to the Owner.

hazard and operability (HAZOP) review: A structured and systematic examination of the planned project processes and facilities conducted at least once (preferably twice) during the engineering phase of the project. A HAZOP review is a qualitative technique based on guide words and is carried out by a multidisciplinary team (including all the engineering discipline leads and key Owner operations and maintenance personnel) within a set of structured meetings led by a specialist facilitator to identify any potentially hazardous operations or conditions in the finished facility.

HAZMAT: An acronym for hazardous materials.

HR: An acronym for human resources.

HVAC: An acronym for heating, ventilation, and air conditioning.

indemnification: The part of an agreement that provides for one party to bear the monetary costs, either directly or by reimbursement, for losses incurred by a second party. It is a generalized promise of protection against a specific type of event by way of making the injured party whole again. Indemnification language frequently appears in a contract document as an agreement clause of *not* to sue a certain party for damages, an agreement between two parties *not* to hold one of them liable for future legal action or fines.

input/output (I/O): A communication link between an information-processing system (such as a computer) and the outside world. Inputs are the signals or data received by the system, and outputs are the signals or data sent from it.

internal rate of return (IRR): A rate of return used in capital budgeting to measure and compare the profitability of investments.

International Organization for Standardization (ISO): An organization that has developed and published a series of standards that define, establish, and maintain an effective quality assurance system for various industries. ISO 9001 deals with the fundamentals of quality management; ISO 14000 is a family of standards related to environmental management.

International Society for Automation (ISA): Provides data sheets and standards accepted globally as reflecting the consensus experience and insights of automation experts for process measurement and control instruments.

issued for construction (IFC): Drawings that have reached Rev 0 status and are ready to be used by constructors in the field.

issued for design (IFD): The revision that releases all disciplines to proceed in confidence with detailed design and drawing preparation. Drawings termed IFD are ready for final design.

IT: An acronym for information technology.

Joint Ore Reserves Committee (JORC) Code: This code regulates the publication of mineral exploration reports on the Australian Stock Exchange. *The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code)* is broadly comparable to Canadian National Instrument classification NI 43-101.

key performance indicator (KPI): A measurement taken of a process or function. The KPI is used as an indicator of the health or effectiveness of that process or function.

lag: A modification of a logical relationship that directs a delay in the successor activity.

lessons learned: The knowledge gained from the process of performing the project.

level of effort (LOE): A support activity that customarily does not lend itself to ultimate establishment via measurement. LOE activity is undertaken to support other work activities. It usually consists of short amounts of work that must be repeated periodically. Examples of such an activity are project budget accounting and customer liaison.

Since an LOE activity is not itself a work item directly associated with accomplishing the final project product or result, but rather one that supports such work, its duration is based on the duration of the discrete work activity it is supporting. As a result, an LOE activity should never be on the critical path of the project schedule, as it never of itself adds time to the project.

lien: A form of security interest granted over an item of property to secure the payment of a debt or performance of some other obligation.

long lead time (LLT): Lead time refers to the period of time from the point when the order is placed to the time of delivery on project site. LLT items are those items with critically long delivery times.

lost time accident (LTA): The event that occurs when an individual cannot return to work for his or her next regularly scheduled shift as a result of an on-the-job injury.

lump sum: A specific type of fixed-price contract under which the buyer or purchaser (Owner or client) agrees to pay the seller, provider, or contractor a fixed total amount for completing work within set battery limits or delivering a well-defined product, generally without requiring a cost breakdown.

management reserve: A monetary provision held by senior management (typically the corporate executive committee) for possible changes in the project scope or quality. Management reserve is an allowance over and above contingency and escalation that reflects project-specific risk (e.g., physical, social, and economic change that may impact the cost estimate after it was properly prepared using appropriate thoroughness and professional standards).

Management Review Submission: The support documentation for an AFE (Authorization for Expenditure) form prepared in the study stages of the project outlining the scope and project parameters, and which ultimately forms the basis for the Project Execution Plan (PEP).

master schedule: A summary-level project schedule that identifies the major deliverables, work breakdown structure (WBS) components, and key schedule milestones.

material requisition for purchase (MRP): A package assembled by the engineer for the procurement group to solicit a vendor or supplier for a price quotation for use in deciding whether to purchase the product.

material requisition for quote (MRQ): A package assembled by the engineer for the procurement group to solicit a vendor or supplier for a price quotation for use in studies, value engineering, comparative analysis, and so on.

material takeoff (MTO): A term used in engineering and construction that refers to a list of materials with quantities and types (such as specific grades of steel) that are required to build a designed structure or item. This list is generated by analysis of a drawing or other design document. The list of required materials for construction is sometimes referred to as the material takeoff list (MTOL).

mechanical completion: Mechanical completion is achieved when the key process components of a stand-alone individual project system, subsystem, or single piece of equipment (i.e., a unit system) within a project facility are fully constructed and complete enough for the unit system alone to mechanically, electrically, pneumatically, and hydraulically start (as the case may be) and operationally perform a test run. Minor work that does not interfere with operation, such as punch list and touch-up work, may still remain.

milestone: A significant point or event in the project; checkpoints in a schedule.

milestone schedule: A summary-level schedule that identifies the major schedule milestones within the project.

mining industry sector: Any mining company, mining media publication, mining association, mining chamber of commerce, and/or mining society.

Monte Carlo simulation: A computer-based statistical program that randomly generates thousands of probable performance outcomes based on probability distributions for cost and schedule on individual tasks. The outcomes are used to generate a probability distribution for the project as a whole, from which a most probable result can be calculated for any selected confidence level.

motor control center (MCC): An electrical device that serves to govern in some predetermined manner the performance of one or more electric motors. An MCC has one or more enclosed sections with a common power bus and can include variable frequency drives, programmable controllers, and metering capability.

MSHA: An acronym for Mine Safety and Health Administration.

net present value (NPV): The difference between the present value of cash inflows and the present value of cash outflows.

NGO: An acronym for nongovernmental organization.

NI 43-101: Canadian National Instrument 43-101, *Standards of Disclosure for Mineral Projects*, a mineral resource classification scheme used for the disclosure of information related to mineral properties. NI 43-101 mineral classification rules were developed by Canadian securities exchange administrators as a means of preventing public mining companies from releasing fraudulent information to potential investors.

Notice to Proceed (NTP): The official approval to begin work.

O&M: An acronym for operations and maintenance.

operating unit: An operational mine or a definable part of an operational mine administered by the Owner's mining company.

operations readiness plan (ORP): The project document that describes how the project will be phased into the operating business at project completion.

OPEX: An acronym for operating (or operations) expenditure.

organizational chart (org chart): A document that graphically depicts the organization's team members and their interrelationships for a specific project, task, or function.

Overseas Private Investment Corporation (OPIC): The U.S. government's development finance institution. It finances projects and mobilizes private capital to help solve critical development challenges and, in doing so, hopes to advance U.S. foreign policy.

Owner: The authority (individual, client, company, or group) that commissions the project and makes the legal commitment to provide payment for it. Within the context of this book, the Owner appoints the project manager.

P10: Denotes a 10% probability of an event happening.

P90: Denotes a 90% probability of an event happening.

partnering: The bringing together and aligning of project-related personnel to obtain joint buy-in of the project development process and responsibilities.

patent defect: A flaw that is noticeable during visual inspection, that is, a defect that could be recognized upon reasonably careful inspection or through the use of ordinary diligence and care.

PDF (portable document format): An electronic file format used to present documents in a manner independent of application software, hardware, and operating systems. Each PDF file encapsulates a complete description of a fixed-layout flat document, including the text, fonts, graphics, and other information needed to display it. Adobe Systems created this format in 1991 and made the PDF specification available free of charge in 1993. PDF was a proprietary format, controlled by Adobe, until it was officially released as an open standard on July 1, 2008, and published by the International Organization for Standardization as ISO 32000-1:2008.

PE: An acronym for professional engineer.

performance bond: A bond secured by the contractor that guarantees payment to complete the project if the contractor defaults for any reason.

performance measurement baseline (PMB): An approved earned value management (EVM) integrated scope-schedule-cost plan for the project work against which actual project execution is compared to measure and manage performance. Technical and quality parameters may also be included.

periodic project review document (PPRD): The PPRD presents an in-depth review of the project measured against the base control document and the project objectives. This periodic review is typically produced every 6 to 12 months during the project life.

personal protective equipment (PPE): Equipment worn by workers to minimize exposure to serious workplace injuries and illnesses.

piping and instrumentation diagram (P&ID): A diagram that shows the interconnection of process equipment and the instrumentation used to control the process. P&IDs are the primary schematic drawings used for laying out a process control installation.

planned value (PV): The authorized budget assigned to a scheduled work activity or work breakdown schedule (WBS) component. PV is also referred to in earned value management (EVM) as the budgeted cost of work scheduled (BCWS).

PMBOK Guide (*A Guide to the Project Management Body of Knowledge*): The project management manual and guide published by the Project Management Institute.

PMI: An acronym for Project Management Institute.

PO: An acronym for purchase order.

potential deviation notice (PDN): A form used in change management control to capture potential changes. PDNs are used for both trends and trends that become change orders.

practical completion: The point in a project when enough necessary construction work has been done, and enough systems have been successfully precommissioned and certified complete and free from patent defects, that the process system can begin to function as per the design flow sheet; that is, ore can enter the plant, and first processing of ore material and/or process fluids (start-up) can occur through the plant facilities. The term *practical completion* is mostly used for when first processing takes place but not all systems are yet operationally capable, for example, when only one process line of a multiline mill facility is complete. The term *substantially complete* is more typically reserved for the full project, that is, when all systems have achieved practical completion.

precommissioning: Precommissioning (also known as dry commissioning) is the testing, verification, and documentation showing that project installations are contract-compliant in preparation for commissioning. Precommissioning is the first step in the process of starting up the plant. The mandate of the precommissioning step is to provide the Owner with comfort that the plant has been correctly constructed and checked for operational functionality prior to start-up. The precommissioning team ensures that the plant is ready for the Owner's operations staff to initiate commissioning and take "care, custody, and control."

prefeasibility study: A preliminary study undertaken to determine if it would be worthwhile to proceed to the feasibility study stage. The prefeasibility study is a more extensive study than the original scoping evaluation, but it does not meet the more rigorous requirements of a feasibility study. One of the prime purposes of the prefeasibility study is to undertake all possible alternatives and trade-offs that can be sensibly postulated for achieving the project goals, so that the follow-on feasibility study can pursue the one identified optimal path.

Preliminary Economic Assessment (PEA): A PEA, as redefined in Canadian National Instrument 43-101 *Standards of Disclosure for Mineral Projects* in August 2012, is an early stage document for public disclosure of the results of conceptual economic studies. A PEA is deliberately kept separate and distinct from the more comprehensive prefeasibility and feasibility studies. A PEA could be a component of a scoping evaluation as defined in this book, but in itself a PEA would not normally be sufficiently encompassing to qualify as a scoping evaluation.

prequalifications (prequals): The responses received from would-be bidders to a request for qualifications (RFQ) or a request for an expression of interest.

process flow diagram (PFD): A diagram used in chemical and process engineering to indicate the general flow of plant processes and equipment. A PFD displays the relationship between the major equipment of a plant facility but does not show minor details such as piping details and designations.

process information (PI) system: Commercial data historian software used to capture, process, analyze, and store any form of real-time data.

programmable logic controller (PLC): A digital computer used for automation of electromechanical processes.

project: A time-limited, goal-directed undertaking requiring a combination of human, mechanical, technical, and financial resources brought together in a temporary organization to achieve a specified purpose. Within this book the term *project* covers the whole life cycle of a capital investment starting from and including initial evaluation, alternatives assessment, feasibility study, the production of full business cases for the go/no-go decision, design, engineering, the procurement process, field construction delivery, and on to the final transition of commissioning and exit.

project contingency: A specified amount of money for goods and services that, at the current state of project definition, cannot be accurately quantified, but that history and experience show will be necessary to achieve the given project scope.

project controls manager: The individual responsible for managing project controls on the project; typically a person with specialist project controls background who reports directly to the project manager.

Project Definition Rating Index (PDRI): Introduced by the Construction Industry Institute (CII) as a front-end project-planning aid to measure a project's completeness with regard to concept, feasibility, and scope definition.

project design basis document: A formal document that contains all project design criteria, specifications, and quality mandates required of the engineer and construction contractors. It includes sufficient description, data, flow diagrams, and test support to fully capture all facets of the project design.

Project Execution Plan (PEP): A documented description, in narrative and logic network format, that describes and coordinates the sequence of activities necessary to engineer and execute a project in the field as well as the responsibilities and strategy to timely meet project objectives relating to those activities. It defines responsibilities and sets out the project strategy in relation to the selection and usage of appropriate outside assistance, for example, engineering, procurement, and construction management (EPCM) contractors and others.

project governance: The management organization framework within which project decisions are made to ensure the effectiveness of projects.

project management: In its simplest form, the application of knowledge, skills, tools, processes, and techniques to meet the project objectives. Within this book, project management is given a more focused definition: It is the process by which a team of people guide a project using the elements of planning, analyzing, directing, monitoring, problem solving, and communicating to take an idea from the opportunity stage through development to the achievement of specific, established corporate objectives within set cost, schedule, and quality constraints.

Project Management Professional (PMP): The Project Management Institute's most important certification for project managers. Globally recognized, the PMP credential demonstrates a minimum level of experience, education, and competency to lead and direct projects.

project manager (PM): The person assigned by the Owner organization to achieve the project objectives.

project procedures manual (PPM): A formal document that captures all the project policies, procedures, protocols, and requirements in one place, referring to either the actual procedure itself or the specific location of the procedure.

project risk: An unforeseen event or activity that can impact the project's progress, result, or outcome in a negative way.

project schedule: The planned dates for performing schedule activities and for meeting schedule milestones.

project scope: The work that must be performed to deliver the products, services, and results with the specified features and functions as described in the Project Execution Plan (PEP) and its accompanying approved Authorization for Expenditure (AFE).

property, plant, and equipment: Long-term fixed assets that are recorded in the general ledger for tax purposes.

provisional acceptance: The acceptance of the project systems and facilities by the Owner for operation, subject to completion of outstanding punch list items.

quality assurance (QA): Focuses on reducing the potential for error within a project. QA encompasses the planned and systematic activities that ensure the quality requirements for the project will be fulfilled. QA requires systematic measurement of the process. It relies on comparison with standard monitoring processes and associated feedback loops that prevent error.

quality control (QC): Focuses on process output for a project. QC embraces all the techniques and activities that fulfill the project requirements for quality, including observation, checking, and verification.

quality management plan: The plan that describes how the project management team will deliver the quality requirements of the Owner. The quality management plan and its quality assurance and quality control (QA/QC) elements form a component of the Project Execution Plan (PEP).

ramp-up: Follows the start-up period and takes the operating facility to its full target production design capacity.

RASCI chart: A responsibility assignment matrix chart that describes the participation by various roles in completing tasks or deliverables for a project. It is especially useful in clarifying roles and responsibilities. RASCI stands for

R = Responsible—the person responsible for delivering the project or task successfully;
A = Accountable—the person with ultimate accountability and authority (R reports to A);
S = Supportive—the person or team of individuals needed to do the “real work”;
C = Consulted—someone whose input adds value or whose buy-in is needed for implementation; and
I = Informed—persons notified of results or actions taken but are not part of the decision.

red flag: An event or circumstance that raises the awareness of a possible problem that will require special attention during the execution of the project.

request for proposal (RFP): A formal document requesting a proposal and cost to perform the services necessary for a defined scope of work (SOW).

request for qualifications (RFQ): A request to contractors to gauge whether or not they possess the necessary qualifications to participate in a competitive bidding (request for proposal [RFP]) process.

request for quotation (RFQ): A request for the cost of supply for a clearly specified item of equipment or material.

resource leveling: A technique in which scheduling decisions (start and finish dates) are adjusted based on resource constraints (e.g., limited resource availability) with the goal of balancing demand for resources with the available supply.

RFI: An acronym for request for information.

risk: The possibility of harm or loss, such as from an uncertain event or condition that, if it occurs, has a negative effect on project objectives.

risk management: Process of identifying, quantifying, and managing the risks that can prevent an organization from achieving its objectives.

risk mitigation: A risk response planning technique that seeks to reduce the probability of occurrence or impact of a risk to below an acceptable threshold.

risk register: The document containing the results of the quantitative and qualitative risk analyses and the risk response planning. The register details all identified risks, including description, category, cause, probability of occurrence, impact, proposed response, owner of the risk, and current status.

risk tolerance: The degree, amount, or volume of risk that a project, organization, or individual will withstand.

root cause: The basic underlying reason that causes a variance, defect, or risk.

schedule: A time sequence of tasks, activities, and events that represents the project execution implementation timetable.

schedule of values (SOV): A list of elements, systems, items, or other subdivisions of the work, establishing a value for each, the total of which equals the contract sum. The SOV is used for establishing the cash flow and contractor payment schedule of a project.

schedule performance index (SPI): An earned value management (EVM) measure of schedule efficiency on a project. It is the ratio of earned value (EV) to planned value (PV). SPI = EV/PV. SPI > 1 is good (ahead of schedule).

schedule variance (SV): An earned value management (EVM) measure of schedule performance on a project. It is the difference between the earned value (EV) and the planned value (PV). SV = EV – PV.

scope: The sum of the products, services, and results to be provided by the project. *See* project scope.

scope change: A conceptual change to the Project Execution Plan (PEP) and its accompanying approved Authorization for Expenditure (AFE). A scope change almost always requires an adjustment to the project cost or schedule.

scope creep: Adding features and functionality to the project scope without addressing the effects of time, costs, and resources, or without obtaining Owner approval.

scope of work (SOW): A document that describes the physical and temporal boundaries of the project. The SOW defines what the project will and will not deliver. It contains the project goals and tasks, and the work required to accomplish them. SOW is also known as statement of work.

scoping evaluation: A preliminary exercise or research that is meant to define the scope of a project. It is a first-pass, order-of-magnitude estimate of the project, based on the minimal data available, to assess whether the opportunity afforded by the project is potentially economically viable.

SEC Form 10-K (U.S. Securities and Exchange Commission Form 10-K): An annual report required by the SEC that gives a comprehensive summary of an exchange-listed company's financial performance.

slack: Another term for float. *See* float.

SOP: An acronym for standard operating procedure.

South African Mineral Resource Committee (SAMREC) Code: The committee that prepared *The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (The SAMREC Code)*, which is broadly comparable to Canadian NI 43-101.

SpecText: A proprietary master guide specification system for writing technically correct engineering specifications for projects.

stakeholder: Persons and parties who are participants in the project (active or passive) with a legitimate interest (business, legal, social, or ethical) in the outcome of the project. Stakeholders include project proponents, project management, project team, project contractors and consultants, project customers, the project Owner, future project employees, and affected (or potentially affected) members of the local community. In other words, stakeholders are the persons or organizations actively involved in the project or whose interest may be positively or negatively affected by the execution or completion of the project. A stakeholder may also be one who exerts influence over the project and its deliverables.

In the context used within the text rarely, if ever, would the term *stakeholder* include project regulators (i.e., governmental persons) or project neighbors (outside persons not materially affected by the project)—these entities are more "interested bystanders" than project participants.

start-to-finish (SF): The logical relationship where completion of the successor schedule activity depends on the initiation of the predecessor schedule activity.

start-to-start (SS): The logical relationship in which initiation of the work of the successor schedule activity depends on the initiation of the work of the predecessor schedule activity.

start-up: The process whereby the plant is taken through the steps from first material entering the plant through first product output. Start-up initiates when sufficient stand-alone systems and subsystems have been successfully (wet) commissioned such that that the first introduction of feedstock material and/or process fluids through the full plant facility can occur; that is, substantial completion has been achieved, there being enough stand-alone systems functioning correctly for the full project facility to be operated.

Start-up continues until the complete project facility and all the process flows have been successfully tested with ore material and a product of acceptable quality has been produced. Start-up is complete when there is verification of operational performance for the project installation. The end of start-up coincides with the beginning of ramp-up.

statement of work: *See* scope of work.

subcontractors ("subs"): An entity under contract to a contractor for completion of a portion of the work for which the contractor is responsible.

substantial completion: The point in the progress of the project work when the project or designated portion thereof is sufficiently complete, in accordance with the contract documents, such that the Owner can beneficially occupy the project or a portion thereof for its intended use. The term *substantially complete* is more typically reserved for the full project, that is, when all systems have achieved practical completion.

subsystem: A logical unit of breakdown and organization of a system. A subsystem can be as small as an individual piece of equipment. All of the subsystems equal the total scope of facilities for the project.

sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

sustaining capital: The periodic addition of capital that is required to maintain operations at design levels for the predicted life of the mine.

system: A usable or operable unit within the project facility, capable of being run as a stand-alone unit.

TEAM: The joint mandate precommissioning, commissioning, and start-up team. Typically, a start-up specialist is appointed as the TEAM leader (generally, this person is hired specifically for this task). The TEAM leader (typically designated as the "commissioning manager") assembles a specialist force of other precommissioning and commissioning specialists, supported by early hired, key operations personnel and by staff drawn from the on-site construction force.

terms and conditions (T&Cs): General arrangements, provisions, requirements, rules specifications, and standards that form an integral part of an agreement or contract.

Terms of Reference (ToR): Terms that describe the purpose and structure of the project. A ToR document defines the project scope and how it will be developed and verified. It provides a documented basis for making future decisions and for confirming or developing a common understanding of the scope among stakeholders.

TIC: An acronym for total installed cost.

time and materials (T&M): A standard type of contract used in construction in which the buyer agrees to wholly reimburse the contractor for the work performed to complete construction by the contractor's employees and subcontractors, and for the materials used in the construction (plus the contractor's markup). T&M is in contrast to a fixed-price contract in which the buyer agrees to pay the contractor a set lump sum for fulfillment of the contract no matter what the contractor pays his or her employees, subcontractors, and suppliers.

total value basis: Encompasses the total value that the purchase of a product or service brings to the project as opposed to just the transaction price. Total value basis looks at shipping cost, delivery schedule, installation support, purchase terms, functionality, reliability, product life, after-market service, warranty provisions, compatibility with existing equipment and skills, and so on, as well as transaction price.

trend analysis: An analytical technique that uses mathematical models to forecast future outcomes based on historical results.

turnkey: Denotes a facility, process, or equipment that is built, supplied, and installed or delivered in a completed state, ready to operate.

U.S. Gulf Coast Labor Productivity Norms: Worker-hour norms widely used in construction-related companies within the United States. A labor productivity norm is the number of labor hours (work effort) required to complete a defined construction activity.

value engineering: A process whereby the project is evaluated on a financial basis by technical specialists with the intent of reducing cost without compromising usability or quality of construction. Within this book, value engineering is synonymous with the term *trade-off.* The value engineering process is based on studies in which alternative processes, design, criteria, equipment, size, throughput, schedule, locations, routes, and concepts are examined, reexamined, compared, contrasted, and optimized as necessary to find the most cost-effective means of achieving the desired result.

VAT: An acronym for value-added tax.

vendor data requirement (VDR) sheet: A document used by procurement personnel when soliciting equipment for possible purchase that outlines for the vendor exactly what information needs to be included with the vendor's quotation. This information needs to accompany a vendor proposal or quotation, as it is needed by the project should the vendor be the successful bidder.

warranty: In contract law, a guarantee or promise that provides assurance by one party to the other party that specific facts or conditions are true or will happen. This factual guarantee may be enforced regardless of materiality, which allows for a legal remedy if that promise is not true or followed.

work breakdown structure (WBS): A deliverable-oriented hierarchical decomposition of the project work to be executed to accomplish the project objectives and create the required deliverables. Within the WBS, the project scope of work (SOW) is broken down into distinct controllable size elements. Each element is assigned a distinct cost. The WBS organizes and defines the total scope of the project.

workaround: A response to a negative risk that has occurred. It is distinguished from contingency plan in that a workaround is not planned in advance of the occurrence.

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Note: *f.* indicates figure

Project Management for Mining

Handbook for Delivering Project Success

by Robin J. Hickson and Terry L. Owen

Opening a successful new mine is a vastly complex undertaking entailing several years and millions to billions of dollars. In today's world, when environmental and labor policies, regulatory compliance, and impact on the community must be factored in, you cannot afford to make a mistake.

So the Society for Mining, Metallurgy & Exploration has created this road map for you. Written by two hands-on, in-the-trenches mining project managers with decades of experience who bring some of the world's most successful, profitable mines into operation on time, within budget, and ethically, *Project Management for Mining* gives you step-by-step instructions in every process you are likely to encounter.

Beginning with a discussion of mining ethics and governance, this clearly written handbook walks you through all the project management steps—defining the scope, performing prefeasibility and feasibility studies, gaining societal acceptance, minimizing the impact and risks, creating workable schedules and budgets, setting in place the project execution plan, assembling the human resources, hiring the contractors, and establishing project controls—and then on into the delivery of the engineering and design, construction, progress reviews, pre-launch commissioning, and ramping up for operation. Each chapter includes several useful aids such as figures, checklists, and flowcharts to guide you through every step, from conception through successful opening.

About the Authors

Robin J. Hickson started his 50+ years in mining as a laborer. Moving up through the ranks to eventually lead companies, Hickson has been involved with more than 100 underground and surface mines in 25 countries, for such companies as Freeport-McMoRan, Gold Fields, and Cyprus Amax. The 15 grassroots mines and 9 brownfield plant expansions he's built—including two that were the largest in their category—were all completed on time and within budget, and all operate at their designed capacities. This is his fourth book.

Terry L. Owen has put his 35 years of mining engineering and project management experience into the development and turnaround of $7 billion worth of projects, including increasing the capacity of one facility by almost 1,800% (from 6,800 to 125,000 tons per day). Owen brings special expertise in working with multiple cultures in remote settings and is recognized for his introductions of best practices into numerous greenfield mines, and for successful leadership within the mining industry.

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The Society for Mining, Metallurgy & Exploration (SME), advances the worldwide mining and minerals community through information exchange and professional development. SME is the world's largest association of mining and minerals professionals.

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