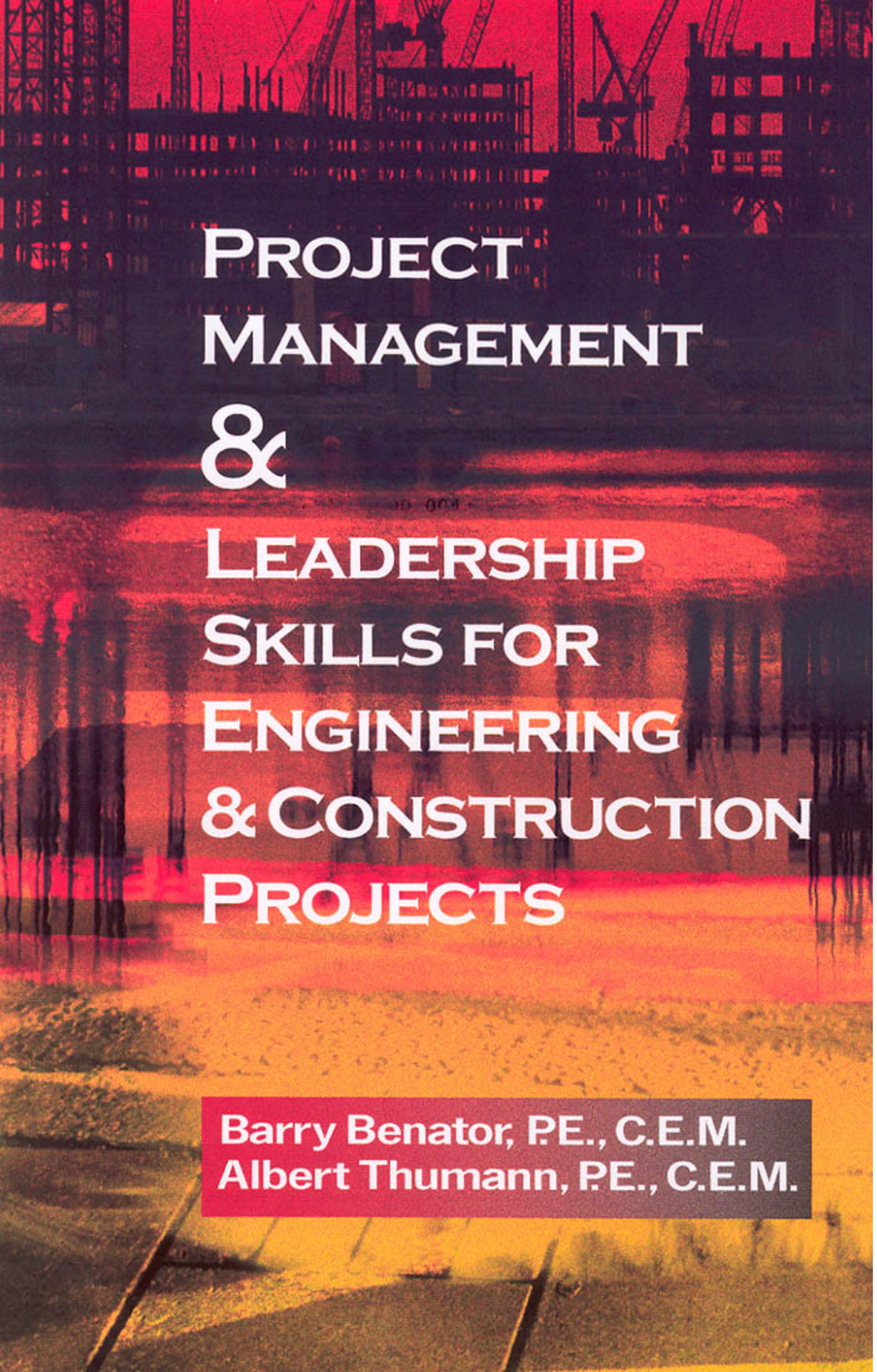
Project
Management
&
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Skills for
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Preface

A project can be defined as a large or important item of work, involving considerable expense, personnel, and equipment. It is typically a one-time endeavor, with a specific result or end-state envisioned. Examples of projects in the engineering and construction fields could include the upgrade of a building's heating, ventilating, and air-conditioning system, the design and construction of a new building, relocation of a manufacturing plant, or a comprehensive energy audit.

A project is distinguished from ongoing business activities by several characteristics:

Uniqueness. A project is typically a specific mission (design and build a new building or plant, upgrade a computer installation) as contrasted with ongoing business functions such as accounting, human resources, purchasing or manufacturing which are performed on a day-in, day-out basis, ideally with increasing productivity.

Duration. A project tends to be of finite duration with a defined start date and a planned completion date. Day-to-day business functions such as human resources, information technology support, accounting, word processing are typically in place before a project starts and will continue after the project is concluded.

People. People assigned to a project may come from any part of an organization or from outside the organization, and depending on the scope and budget of the project, may include engineering, construction, financial, scheduling, cost estimating and other professionals who can make the project a success. When the project is completed, these professionals will likely move on to other projects or back into line functions within the organization.

A project also shares several characteristics with ongoing business activities:

Budget. A project, like most line functions, has a budget.

Whatever the project is, the project manager will be responsible for managing his or her project to an on-time, technically sound result within the project budget.

People. A project is much more than engineering calculations or construction schedules. It involves people—nothing happens on a project without good people making it happen. The project manager will be involved in some or all of these people functions of project management—selecting, training, coordinating, leading, coaching, rewarding, disciplining, and supporting. A project manager deals with people all the time. If you are not willing to at least try to fulfill this responsibility, you should return his book now and get your money back. If you enjoy working with people or are willing to try, this book will help you succeed.

Relationships. Related to the people aspect of project management is the project manager's responsibility to manage relationships associated with the project. Internally, these include the people in your company who are members of your project team, your boss, your peers and supporting departments within your own company. Externally, they include your customer's people associated with the project, as well as any subcontractors and vendors who may be associated with the project.

Is Project Management for you? Is this book for you?

Do you take to the challenge of bringing together multiple and diverse resources to complete an engineering or construction project on-time, within-budget and to the customer's satisfaction? Are you are a successful engineer or construction manager seeking overall project responsibility? Do you enjoy working with people and helping them succeed through teamwork? Do you seek the professional opportunities and financial rewards of leading projects to successful conclusions?

If you answered yes to one or more of these questions, then this book is for you. It will give you, in straightforward and practical terms, information and guidance that will help you succeed in the real-world of engineering and construction project management. Let's get started!

Al Thumann, P.E. CEM
Barry Benator, P.E., CEM

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Chapter 1

Overview of Project Management

Barry Benator

If one word could describe the essence of project management it is ***responsibility***. The project manager (PM) is responsible for all that happens on a project. This doesn't mean the project manager should or could do everything associated with the project; it does mean the PM owns ultimate responsibility for the project, regardless of who is on the project team and regardless of the obstacles encountered along the way to successful completion. In other words, the buck stops with the project manager. If that sounds like an awesome responsibility, then you have grasped the concept of what it means to be a project manager. For many people, it's an **exciting challenge**. Because, in addition to the large responsibilities of project management, there are numerous **rewards** for successful project managers. This book will help you meet those responsibilities and attain the rewards of becoming a successful project manager.

Rewards of Project Management

There are a number of rewards associated with being a successful project manager. Listed below are a just few of them.

- The satisfaction of pulling together a diverse group of people from different organizations and creating a high performing project team that accomplishes the project's mission.
- The reward of helping these people perform their responsibilities and achieving success for themselves and the project.
- The reward of increased profits and enhanced cash flow to your company
- The reward of a satisfied and appreciative customer.
- The reward of repeat business from that customer.
- The reward of new business from other customers based on positive recommendations from your satisfied customer.
- The reward of enhanced career opportunities for you and your project team.

Good project managers are one of the few job functions which continue to be in demand by companies in almost every business sector. Good project managers have a bright future ahead of them. This book will help you achieve that brighter future.

The Project Manager's Responsibility

The technical knowledge and skills required to be a successful engineering or construction project manager are wide-ranging, but the good news is you don't need to be an expert in all of them. In fact, you don't need to be an expert in any of them; you do, however, need to have engineering or construction experience. However, as important as this technical experience is, even more important is the *will and commitment* to take on the overall responsibility for your projects. The fact that you are reading this book is a strong signal of your commitment to learn and practice good

leadership and management skills, which will help you fulfill your project management responsibilities and succeed as project manager.

A typical engineering or construction project will have many of the following disciplines associated with it:

- Electrical
- Mechanical
- Process
- Structural
- Architectural
- Civil
- Cost estimating
- Financial/accounting
- Purchasing
- Legal/contractual
- Insurance/risk management
- Purchasing
- Drafting/Computer Aided Design

The project manager's responsibility is to manage the financial, technical and schedule requirements of the project in such a manner as to bring the project in on-time, within budget and with a technical quality that meets or exceeds the contractual performance specifications.

Skills of a Successful Project Manager

While experience in engineering and construction is important, the critical skills you need to be a successful project manager (PM) are not technical. They are leadership and management skills—skills that will help you lead and manage the project in such a manner that the project's objectives are achieved.

While there are a number of definitions for leadership and management, we will use the following for the purpose of discussing project management in this book:

> ***Leadership***—*the process of influencing individuals or groups to accomplish an organizational goal or mission*

Management—*the process of planning, organizing, directing and controlling a project or activity*

Often the exercise of leadership and management overlap, but the general meaning and intent is typically clear, so there is no need to become overly academic about these terms. As a general statement, *leadership* implies a people-based set of activities such as communicating, coaching, setting a personal example, providing recognition and feedback, supporting, etc. while *managing* tends to imply a more systematic set of activities such as planning, organizing, directing and controlling.

Planning the Project

Perhaps the best way for us to obtain an overview of the project management process is to look in detail about how to plan a project. Then in subsequent chapters, we will delve into specifics about each of the skills and activities associated with turning a project plan into a successful project.

In the author's experience of managing more than 300 projects and teaching more than 200 workshops on project management and leadership, one of the activities project managers tend to like the least and avoid the most is *planning*. Reasons vary but they seem to fall in the realm of "planning is not fun." Engineering project managers and construction managers tend to enjoy *doing* things—designing, coordinating, negotiating, installing, solving problems, etc. Planning, on the other hand, requires a more contemplative, long-term view of the project, and may encompass planning for activities that are "over the horizon" in terms of when they will occur. It requires *more thinking than doing* and often receives insufficient attention because it's not hands-on or immediate in its urgency. Yet, ***good planning is a cornerstone*** of a good project. Careful planning, along with good execution, almost always leads to a successful project. Poor planning, on the other hand, even with good ex-

ecution, may lead to a successful project, but often one that is fraught with crises, stress and loss of opportunities because the PM and his or her team were bailing out the project instead of looking ahead for other opportunities.

So, what are the ingredients of a successful project plan? Details vary from project to project, but the following elements are part of virtually every good project plan.

Deliverables

What are the deliverables and when are they due? A deliverable is anything specified in the contract that the engineer, construction firm, vendor or supplier has agreed to deliver to the customer. Examples of deliverables include specifications, drawings, cost estimates, project schedule, equipment, buildings, systems, training, etc. In the planning phase of a project, it is important to identify these deliverables, when they are due, and who has prime responsibility for each deliverable (the PM has the overall responsibility for each deliverable). Oftentimes a table that extracts from the contract all the specific deliverables is a good vehicle for getting everyone on the same page as to what is to be delivered and when. See Figure 1-1 for an example of such a deliverable table.

Resources

You will need a variety of resources to lead and manage successful projects. You will need:

- **People**—from your firm, your contractors, your consultants, your vendors and your customers.
- **Technology**—computers (for scheduling, budgets, word processing, calculations, drafting, project tracking, progress reports, e-mail, etc.), communications equipment (phones, pagers, faxes, etc.), Personal Digital Assistants (PDAs), etc.
- **Budget**—a clear picture of financial resources available to complete the project.

Figure 1-1. List of Deliverables (Example)

Deliverable	*Prime Responsibility*	*Date Due to PM/Customer*
List of Deliverables	Project Manager	
Project Schedule	Project Manager	
Bore Samples Report	ABC Soils Firm	
10% Drawings	Cognizant Engineers/Architects	
30% Drawings	Cognizant Engineers/Architects	
60% Drawings	Cognizant Engineers/Architects	
60% Specifications	Cognizant Engineers/Architects	
60% Cost Estimate	ABC Cost Estimating Firm	
90% Drawings	Cognizant Engineers/Architects	
90% Specifications	Cognizant Engineers/Architects	
90% Cost estimate	ABC Cost Estimating Firm	

100% Drawings	Cognizant Engineers/Architects	
100% Specifications	Cognizant Engineers/Architects	
100% Cost Estimate	ABC Cost Estimating Firm	
Complete Set Design Documents	Project Manager	
Complete Bid Package	Project Manager	
Announce Procurement	Project Manager/Customer	
Pre-Bid Meeting	Project Manager	

- **Equipment**—earth movers, cranes, electrical, mechanical, etc.
- **Internal Accounting Support**—accounting reports, invoicing, payments to contractors and consultants, etc.

Resource Conflicts

Your plan should anticipate potential resource conflicts, and to the best extent possible, indicate how these conflicts will be managed. Typical resource conflicts include those listed below. Subsequent chapters will discuss these issues in detail.

- **People**—good people are always in demand, and it is extremely rare that your ideal project team will just be waiting around for you to tap them on the shoulder and give them the privilege of working on your project. They may be working on other projects, on a company task force, on vacation, or not even hired yet. Coming up with a plan to handle these people resource conflicts that meets your needs and the needs of your company will be crucial to the success of the project.
- **Technology**—with the steady dropping of prices for technology (computers, printers, phones, etc.) technology conflicts are becoming rarer. However, in a cash flow-tight environment, this can be a challenge for a project manager. Alternatives can include rental, borrowing from other projects or borrowing from a pool of technology equipment in your firm, etc.
- **Equipment**—equipment conflicts can range from earth moving equipment to portable offices to portable potties.

Seasonal Impacts

Seasonal impacts to your project need to be reflected in your project plan. The seasons can affect your project in a number of ways.

- People—In Winter, people catch colds and the flu, and they miss work. In the Summer, they take vacations. In either case they are not available to work on the project. Sometimes they are snowed in at home or out of town. Similarly, in some locales, hurricanes can be anticipated to halt or slow down productivity on a project. The prudent project manager will plan for an appropriate number of vacation days, sick days, snow days, hurricane days, etc. and factor that into his or her project schedule. It is not difficult to approximate the number of non-work days that will take place due to these factors and it should be done.

- Site—Weather can affect the ability to perform work at the construction site. Again, this can be anticipated and estimates made for so many non-work days due to site conditions.

Budgets

Whether you work for a for-profit, nonprofit or government organization, there will be a budget for your project. You will be responsible for preparing the budget if you are the PM at the initiation of the project, and for managing to the budget if you are the PM during the project's execution. The level of complexity of the budget should be commensurate with the overall complexity of the project.

- **Scoping**—To prepare a good, realistic budget, it is important to break down or scope-out the work effort into phases, tasks or whatever you prefer to call specific units of work. This is performed by analyzing the project's statement of work (also called scope of work) and identifying the costs and revenues associated with each phase of the project.

- **Budget Tools**—Use a financial management tool to prepare your budget. This can be a specialized computer program specifically made for project financial budgets and analysis or a customized spreadsheet that you can use to develop your

budget. The power and complexity of the program you use should be commensurate with the scope and dollars and risk of the project.

Schedule

A project always has a planned end date. To help ensure that the end date coincides with the actual completion of the project, a detailed schedule must be prepared. This schedule must list key phases, tasks, and milestones. It should also list who is responsible for performing these tasks or meeting the milestones and show dependency relationships among tasks.

Scheduling Tools

Your schedule should be computer based. As with the budget tools, you can select a dedicated project management program such as Microsoft® Project, SureTrak Project Manager®, Primavera Project Planner® or another appropriate project management program. You can also choose to develop a spreadsheet-based schedule management tool. The actual choice should be based on the complexity of the project and the capabilities of the scheduling program. One caution: use of a computer-based scheduling program should not be a "wag the dog" situation where so much time is spent updating and tweaking the scheduling program that it takes valuable time away from other important project management activities.

Agreement

Once you have completed the project planning steps discussed in this chapter, it is crucial that you have the various project team members "sign off" on their commitments to signify agreement with what they are going to do and when they are going to have it done. This can be in the form of a contract, a signed program plan, a set of minutes with a signature sheet or some other vehicle that establishes a firm commitment by the project team members that they will honor their commitments to the project plan.

But Plans Change, Don't They?

Sure they do. And your project plan with all its elements at various times will need to be revised to reflect real-world conditions and "changes on the ground." This, however, does not mean a schedule should be revised just because of a problem or hitch on the project. Good project managers solve and work around the great majority of problems without changing a due date, an end budget or quality standards.

On the other hand, a change in project scope or a natural disaster could change deliverables, dates, dollars, etc. which could justify a revised project plan.

The Design of This Book

The design of this book is straightforward. In each of the chapters that follow, we provide specific, practical, real-world information that will help you learn and use effective project management and leadership skills. These chapters will expand on the topics discussed in this overview chapter. As you read each chapter, contemplate how you will use the information contained within it to help you be a better project manager/leader. If you are managing a project now, you will pick up valuable tools to help you right now. If you are slated to be a PM on an upcoming project, this book will help you when you pick up that project.

What happens after you complete this book is up to you. You are in charge of your own management and leadership behaviors. This book will help you succeed. Your colleagues will help you succeed. And your own experience in applying the principles contained in this book will help you succeed as a project manager. We wish you the very best in your project management career.

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Chapter 2

Staffing the Project Team

Barry Benator

There are a number of important factors that contribute to a successful project, but if one had to single out the most important factor, it would be *people*. Good people always find a way to make things happen—to overcome the many challenges inherent in any engineering or construction project. The project manager's ability to influence who is assigned to his or her project can have a significant impact on the success of the project. And over many projects, that influence can range from very little (e.g., he or she inherits the project team members and must forge a successful team with the people given to him/her), to being told he or she can pick the best people for the job at hand.

Typically, however, the actual amount of influence the project manager has in selecting his or her project team falls somewhere between these two extremes. As a result, the project manager must employ a number of different strategies to obtain the best people for his or her project, consistent with the overall objectives of the organization. In lining up people for the project team, the project manager must be flexible, persuasive and assertive. Determining which of these characteristics to call upon at any particular time in the staffing process requires a nice sense of judgment that you will develop as you employ the principles identified in this chapter.

The successful PM will invest the time necessary to assemble the best project team that the constraints of the project and the organization will allow.

Whom to Select

The Right Type of Expertise

The people whom you select for your project team will depend on the nature of the project. Since you are reading this book, you are now either a project manager or construction manager or someone who aspires to become an engineering or construction project manager. Whichever category you fall into, you will want to select the right engineering disciplines, construction trades, and support staff that will best help you lead and manage a successful project.

Typical engineering and construction projects include some or all of the following engineering disciplines, construction trades and support staff:

- Electrical
- Mechanical
- Process
- Civil
- Structural
- Plumbing
- Energy Engineering
- Architecture
- Financial/accounting
- Purchasing
- Legal/contractual
- Insurance/risk management
- Cost estimating
- Purchasing
- Drafting/Computer Aided Design

Each project, with its own unique requirements, will determine how many and which types of these or other skills will be required to perform a successful project.

The Right Type of People

After you have determined what type of expertise is required for your project, you will want to find good people who possess the right kind of expertise needed on the project. This is where it is critically important that you do as much homework as possible on potential project team members.

Assuming you have some say in who will be assigned to your project (and you almost always will have some input as to

who will be on your project team—it just varies as to how much input you will have), you want to request the best possible people for your project. The best electrical engineer, the best draftsperson, the best electrical installer, the best heating, ventilating, air conditioning mechanic, etc. Good people solve problems before they become problems, because they typically do things right the first time.

Below are some things you can do to identify the best people for your project team.

- **Your own experience.** If you have worked with someone previously and know he or she performs good work, this is the best recommendation you can have because it's first hand.

- **Ask your boss**. Your boss, unless he or she is new in the job, will be able to suggest good people for your project team. In a recent engineering project managed by Barry for a client, he relied heavily on his client (to whom he reported) for staffing recommendations which turned out very well.

- **Recommendation of colleague or friend**. Ask people you trust whom they might recommend for the job. A good recommendation from a trusted colleague is very valuable, especially if that person knows the type of work to be performed better than you.

- **Recruit from outside your organization**. If there is no one within your organization whom you can recruit to fill an open project team slot, you may need to hire a person from outside your organization. The open position may be one requiring an experienced engineer, craftsperson, CAD operator, etc., or one which could be filled by a new college graduate, trade school graduate, union training program graduate or other entry level person. Special care must be taken in the recruiting process to ensure compliance with federal, state and local regulations governing recruiting and hiring. Otherwise, you could

end up with a lawsuit on your hands (just what you and your company don't need!). Recruiting from outside the organization is the riskiest of the staffing options and will be discussed in considerable detail in next section.

Staffing from Outside the Organization

Recruiting and hiring good people is one of the most challenging tasks of a manager. Oftentimes, all you start with is a one- or two-page resume that is designed to highlight the best in a potential candidate. Weaknesses are rarely mentioned. But before you even have a resume in hand, you need to reach out to potential candidates and make them aware you have a job opening you need to fill.

Recruiting

Depending on the size of your organization you will want to work closely with your human resources department (HRD) to have them help you find the right people for your project. If you have an HRD, by all means use it; if not, you will likely do most of the recruiting effort on your own. Either way, the steps in this section will help you find and hire the right people.

1. **Create a job description for the position you are seeking to fill.** List the duties and responsibilities of the position as well as the skills required to successfully perform in that position. Make it job-specific and leave out attributes such as gender, age, race, physical appearance, etc. which have no relevancy to the actual job and which could lead to a lawsuit. See Figure 2-1 for an example job description template.

2. **Identify your sources for the position you are seeking to fill.** Figure 2-2 provides a listing of potential sources. You can use these to help kickstart your search for that "right" em-

Figure 2-1.
Example Job Description for Project Electrical Engineer

The selected candidate will be responsible for performing the duties of project electrical engineer on building design and construction projects.

Duties. Responsibilities include:

- Preparation of building electrical calculations, specifications and plans;
- Liaison with internal and external project team members to prepare an integrated design meeting customer requirements;
- Liaison with the customer to understand customer needs and wants;
- Participate in design reviews and other meetings with customer, other design team members and construction firms;
- Review and evaluate electrical contractor bids for accuracy, suitability, price and constructability;
- Visit job sites and ensure electrical systems are being installed as designed and in accordance with good construction practices;
- Overnight travel and weekend work: approximately 25-35%;
- Other duties that may be assigned.

Education/Skills/Advantages:

- Degree in electrical engineering from an accredited college or university, or equivalent work experience
- Five years experience in design of building electrical systems, including load calculations, lighting calcs, familiarity with common building codes, and other related building design requirements
- Five years experience in field review of building construction practices
- Excellent verbal and written communication skills
- Team player—seeks to support the team mission whenever possible
- Professional Engineer—Electrical license a plus

ployee for the job. Your actual approach will depend on your specific needs, the size of your human resources department, and other factors unique to your organization.

Figure 2-2. Search Sources and Methods

External Sources of Potential Employees	*External Methods for Recruiting*
• Employment agencies/ recruiters	• Advertising (radio, television, Internet, newspaper, trade journals)
• Temporary agencies/ job shops	• Job fairs—Open houses
• Professional and trade associations	• College placement offices (including minority colleges to take advantage of the business benefits of having a diverse workforce to serve a diverse customer population)
• Colleges and universities	
• State agencies	
• Former employees	
• Employee referrals	

3. **Receive and evaluate applications/resumes.** After advertising the open positions, you or your HRD will begin to receive a lot of resumes. Often, and especially in a tight job market, you will receive resumes from people who do not remotely fit your position description. If possible, use HRD to prescreen the resumes before they send any to you. Some organizations will have an HRD person review the applications/resumes and send to you only those candidates that appear to warrant your further review. This will free you to concentrate on revenue-producing activities for the company

if you are a for-profit firm or other mission-related activities if your organization is nonprofit or governmental.

In evaluating resumes, use a system with which you are comfortable. Your organization may have a system already in place which you are required to use. If so, understand that this system may seem over the top in terms of detail required, but it may have the benefit of protecting you and the organization from equal employment opportunity (EEO) or discrimination suits. You may choose to use a matrix to evaluate and rank potential candidates based on their resume. Whatever system you use to rate the candidates, ensure it is based on bona-fide job requirements. After your initial review, we recommend putting the resumes into three stacks:

— **Follow-up** by you or HRD

— **Possibles**—if the Follow-up list does not produce a desirable candidate

— **Return to HRD** for a no-thank-you letter

Whichever method you use, you will arrive at a list of people who have made the second cut (the first being the ones that HRD reviewed and sent on to you).

4. **Call the people in your follow-up stack.** To further winnow out potential interview candidates, we recommend you call the candidates in the follow-up stack and discuss their interests and capabilities as related to your open position. You can use this call to clarify any issues the candidates may have and reiterate potential show-stopper job requirements such as travel or irregular hours ("The job requires about 50% overnight travel. Will that be a problem?" or "The job will require some evening, weekend and night work. Will that be a problem for you?"). This phone call will help you avoid wasting your and the candidate's time in a face-to-face interview when you and the candidate already know he or she

cannot meet a fundamental requirement of the job. If your call results in this knowledge, thank the candidate for his or her interest in your organization and wish him or her well in their job search. Then process the resume in accordance with your organization's policies.

Note: Throughout the life-cycle of the hiring process, ensure you and others in your organization respect the confidentiality of the candidate. Obtain the candidate's written permission to verify information on the resume or job application and hold in confidence that information.

☐ **5. Setting up the interviews.** Now that you have completed your phone screening, you are ready to invite the candidates in for an interview with you and 2-3 members of your project team. Set up a convenient time and place for you and your interviewee/candidate. Although typically held at your office, an interview can take place almost anywhere—restaurant, airport, hotel lobby or conference room, convention, etc.

Wherever the interview is held, ensure there are no avoidable interruptions, the interviewee is comfortable and sufficient time is allowed—4-6 hours is typically enough time for a visit to the organization, with about 45-90 minutes per interview. Be respectful of the interviewee's time and don't keep him or her waiting longer than necessary to see the next person.

6. Preparing for the interview. In order to ensure you gain the information you seek from each interview, you should plan carefully how you will conduct the interview. This includes reviewing the Position Description of the job you are seeking to fill and preparing questions that will help you determine how well qualified a particular candidate is for that position.

In preparing your questions, keep in mind that typically the best indication of a person's future performance is his or her

previous performance. So you will want to develop questions that will help you evaluate how well the candidate has performed in previous situations typical of the ones he or she will face in your workplace. This is called "behavioral interviewing" because it focuses on the candidate's behaviors rather than fuzzy indicators such as gut feel or hypothetical questions that may only reflect how good the interviewee is at saying what you want to hear.

We recommend you use the STAF technique in formulating your questions and the candidate's answers. STAF means:

- **S**ituation
- **T**ask
- **A**ctions
- **F**inal result

The way you use this technique is to ask behavioral-type questions that are related to your job needs. For example, you might ask a candidate for a mechanical engineering position:

"Mary, your resume says you have performed several DOE 2.1 energy analyses. Tell me about one of those analyses." Tell me about the **S**ituation (e.g., customer and facility), the **T**ask (e.g., run three scenarios for different HVAC systems), the **A**ctions you took (Actions are what people do—e.g., plan takeoff, data entry, ran the program for the three scenarios, evaluated the results and recommended/selected the optimum HVAC system), and **F**inal Results (e.g., selected an HVAC system that met load requirements and resulted in lowest life cycle costs for the customer)

Note: In the above example, the items in parentheses are prompts you might use to help the candidate give you a complete answer. Allow the candidate time respond to your questions—remember, you have spent time preparing behavioral interview questions and have a good idea of what information you are seeking. The candidate may have never been asked these questions. So, allow the candidate sufficient time to recall a specific instance which he or she can relate to you. You should record the responses to your questions on a form similar to the example shown in Figure 2-3 or another document that you can review at a later date.

Figure 2-3. Example Interview Form

Job Title _____ Name of Job Applicant _____

- **Introduce yourself**: name, job title, your relationship to job being considered

- **Establish rapport** (Easy questions—traffic, weather, etc. Offer coffee, soft drink, water, etc.)

- **Describe the interview process** (Establish the framework for the interview. "We're getting together to talk about the position of mechanical engineer. I'm going to be taking notes as we go along. It's just my way of making sure I get all the information so that I can make a fair evaluation. I hope that won't bother you." "You should feel free to take notes also." "Feel free to ask questions about the job or our organization whenever you think it's appropriate" "We'll spend about __ minutes together," etc.)

- **Explore background** (Tell applicant about job, ask questions about application or resume, and discuss general information. "Why don't you describe your current situation or a typical day")

  E.g., Describe the job and related requirements. Job hours, dress code, wear beeper, on-call 24 hours, 50% travel, etc. Have you ever done that? Would you have difficulty doing or arranging that?

  Explore applicant's resume and job application. To encourage frank responses, use subtle TORC (Threat of Reference Check)—"John, when I call your prior supervisor and ask about your performance on your current or previous job, what will he or she tell me?" Or, "Mary, when I call your school, is this the right school and is this the right degree?"

- **List knowledge and skills needed for this job.**

(*Continued*)

Figure 2-3. Example Interview Form (*Continued*)

Knowledge (What knowledge is important?)
e.g., B.S. Mechanical Engineering
e.g., Uniform Building Code
e.g., PE license—mechanical (desired)
e.g., DOE 2.1 or Trace Energy Program
e.g., Spreadsheets

Skills (What skills are important?)
e.g., HVAC load calculations
e.g., Specification preparation
e.g., Problem solving
e.g., Field construction supervision
e.g., System layout for draftsperson
e.g., Excellent Oral and Written Communications
e.g., Run DOE 2.1 or Trace Analyses

- **Develop behaviorally based interview questions for these areas.**

Knowledge/Skill Area #1: Problem Solving

Question: "Mary, your resume says you are a good problem solver. Tell me about an instance where you were successful in solving a tough problem on one of your projects." Tell me about the **S**ituation (e.g., customer and facility), the **T**ask (e.g., the specific problem you were facing), the **A**ctions you took (Actions are what people do—e.g., specifically the steps you took to resolve the problem), and **F**inal Results (e.g., resolved a conflict, in a timely manner, between your firm and a subcontractor that threatened to delay the project).

Note: In the above example, the items in parentheses are prompts you might use to help the candidate give you a complete answer.

Allow for silence while the candidate contemplates your questions. Remember, you spent considerable time and effort thinking about and pre-

(*Continued*)

Figure 2-3. Example Interview Form (*Concluded*)

paring behavioral interview questions, so you have a good idea of what information you are seeking. The candidate, on the other hand, likely has never been asked these questions. So, give the candidate sufficient time to recall specific instances which he or she can relate to you. You can record his or her responses to your question in the spaces below.

You should develop several questions that reflect the requirements of the job and give you a good picture of the candidate's ability to perform in the position you have open. To ensure you are protected from allegations of unfair interviewing, ensure you ask the same initial questions to every candidate. Your follow-up questions can be structured to fill in any gaps in their responses.

Situation:

Task:

Action:

Final Result:

Comments/Rating:

Acceptable:

Unacceptable:

Note: This form indicates just one example of a STAF type question. Your form should have several such questions that reflect the key points you want to discuss in your interview. It is not uncommon that your interview form for any particular position would be several pages long and have several knowledge area questions and/or skill-related questions.

You should develop several questions that reflect the requirements of the job and give you a good picture of the candidate's ability to perform in the position you have open. To ensure you are protected from allegations of unfair interviewing, ensure you ask the same initial questions to every candidate. Your follow-up questions can be structured to fill in any gaps in their responses.

7. **Conducting the Interview.** Now that you have identified the candidates you will interview and have arranged a mutually convenient place and time, you will want to continue the careful approach to the interview process that you have already started.

   There are several purposes of a job interview:

   - Help you and your organization decide if this person is a good fit for the job
   - Help the interviewee decide if the job and organization are good fits for him or her
   - Foster a positive picture of the organization to those inside and outside the organization

   Accomplishing these goals is not difficult. It's basic common sense and courtesy. In bullet form, here is a checklist of things you and your organization should do to help ensure they are achieved:

   - Ensure the interviewee is given good directions to the interview location. Provide a map if appropriate or suggest an Internet web site to obtain directions and a map.
   - Help out with flight, car and hotel arrangements.
   - Brief the receptionist that you are expecting "John Doe" and ensure he or she knows how to reach the person within your company who will take charge of the inter-

viewee first. This is a critical point in the interview process. The authors have seen too many bad starts to interviews caused by an organization dropping the ball because no one at the organization knew the interviewee was coming that day, or simply forgot. It's not a good way to start off a potential relationship.

- Follow a procedure similar to that presented in Figure 2-3. Feel free to enter this figure into your word processor to use as a template to help you conduct a good interview that meets your needs and is considerate of the interviewee's legitimate interests also. We recommend you modify it to meet your specific staffing needs.

- At the conclusion of the interview, ensure the candidate knows how to file an expense report (if not already done so while at your office), thank him or her for their interest in your organization and for coming to talk to you about the open position. Let them know about when they can expect to hear from you about your decision. Also, encourage them to call or e-mail you if they have any follow-up questions that may have arisen subsequent to the interview.

- Follow your organization's normal process to extend an offer to the top candidate. Hold off sending no-thank-you letters to the others who interviewed, in case you do not land the top candidate, and you need to move down the priority list to make another offer.

Benefits of the STAF Questioning Technique

1. It is difficult for an individual fake or color information on past experiences or details when you pin him or her down for exact information on these details. The candidate soon understands that "facts" are wanted in the interview—not hypothetical responses.

2. The best indicator of future performance is past performance. The STAF technique ensures you ask each candidate the same job-related questions that deal with actual previous actions by the candidate that will help you decide if those actions would be appropriate for the position you are seeking to fill.

3. Using the STAF technique with a written interview form (e.g., Figure 2-3 tailored for your open position). You should use this form with every candidate to help avoid allegations of unfair interviewing practices (e.g., an interviewee claiming you asked softer/easier questions to another person than you did to him or her). Or if such claims are made, you will be in a position to defend yourself and your organization that your interview process was fair and nondiscriminatory.

STAF Questioning Technique Follow-up

Often you will receive partial or vague answers to some of your behavior questions. The following are examples of follow-up questions that you can use to tie-down responses.

1. **A**ction—"Under those conditions, exactly what did you do?"
2. **F**inal Result—"So what was the outcome of your actions?"
3. "What was your role in that effort" (to tie-down the candidate's role in a group effort or to draw-out a person who is shy or is concerned that he or she will be seen as someone trying to hog the credit if he or she talks about his or her role in detail)
4. "When that happened, what did you do?"

Final Thoughts on Interviewing

Good interviewing skills are just that—skills. The more they are practiced, the better you will get at it. You should approach interviewing as an important task of project manage-

ment. Plan for it, do it, evaluate how well you did and make adjustments to do it better next time. The rewards for this effort will be new hires who will be the best people to help you succeed in managing your project.

Next Steps

With your interviews completed, you will want to meet with your HRD representative and the members of your interview team. The objectives of this meeting are to: 1) Compare notes, 2) Discuss qualifications of the candidates based on your behavioral interviews, and 3) come up with a short list of candidates whose references you will check. Checking references can take 30-60 minutes per reference check, but it is a crucial element of the hiring process. Do *not* omit it.

If possible, check three references for each person on your short list. We recommend you develop a reference check form that you can use for each reference check you make. Develop this form in cooperation with your HRD representative to ensure your questions comply with EEO and other legal requirements, and do not pose a risk of a discrimination charge against you or your firm. After you have completed your reference checks and discussed with your selection team all of the information associated with each candidate, it is time to do a final ranking, and work with your HRD to extend an offer of employment to the candidate that best meets your requirements.

If you have followed the guidance in this chapter, you can be confident that you will select qualified people for your organization.

Final Thoughts on Staffing

We began this chapter by pointing our that of all the important factors associated with a successful project, *people* heads the list. Good people make things happen, even in the face of difficult obstacles. It is for that reason that this chapter has provided considerable detail on how to staff a project for success. Good people make the project a success—that makes you a success!

Chapter 3

Fundamentals of Scheduling

The Role of the Project Manager and Scheduling

The project manager plays an important role in project scheduling. The development of a realistic schedule is crucial to the project's overall success. The project manager needs to establish checkpoints and milestones to insure the project is kept on track. Insuring that the overall project is completed on time is critical to a project manager's success The importance of completing a project "on-time" has great financial consequences. Many clients include in their contracts a "bonus" or penalty depending on the projects overall completion date.

The purpose of this chapter is to review the fundamentals of scheduling which provide the basis for today's project management software programs.

Computer tools for project management are discussed in Chapter 4.

Critical Path Method (CPM), Program Evaluation & Review Technique (PERT) and Gantt Chart

CPM, PERT and Gantt Charts are various methods used to manage project schedules. This chapter will focus mainly on the Critical Path Method of Scheduling.

The Critical Path Charts are similar to PERT Charts and are sometimes referred to as PERT/CPM.

On the other hand a Gantt chart is a matrix which lists on the vertical axis all the tasks to be performed. The horizontal axis is headed by columns indicating task duration.

Historical Background

CPM scheduling was developed in the late 1950's. It was introduced to the industry as a tool to improve planning and scheduling of construction programs. Concurrent with industrial development of CPM, the U.S. Navy introduced a similar method of scheduling called PERT. PERT is an acronym for Program Evaluation and Review Technique. The Navy developed this method to evaluate and monitor progress of the Polaris Missile Program. The major difference between CPM and PERT is that PERT is a more probabilistic approach that lends itself to activities for which there is little or no historical experience, whereas CPM uses historical information for establishing durations. Subsequent development led to a considerable amalgamation of the two methods.

It was not until 1967 that James Kelly developed the techniques of CPM as used today. He used digital computer techniques developed by Rand Corporation and applied them to a complex construction project for DuPont Corporation. This resulted in completion of a project well ahead of schedule.

Objectives of CPM

Figure 3-1 lists the objectives of CPM scheduling. As seen from the figure, CPM can be used as a logic tool for decision-making. It provides a means for planning, scheduling, **controlling and presenting alternate** courses of action. It also provides a visual means of communication to Project Management and an or-

ganized approach to implement a schedule program. CPM scheduling can be carried out manually or with a computer program.

A major problem with the CPM computer programs can be the number of activities. Very large networks became the norm during the 1960's. Size, not quality, became a dominant factor and computer scheduling methods became more important than the scheduling program itself. Theory replaced practicality and, as a result, quality of scheduling deteriorated.

It was not until the mid-1970's that a proper balance of computer method and size of networks was achieved. Experience has shown than 10,000/20,000 activity networks are costly, unmanageable and inefficient. Careful prior evaluation of criticality and networks with a maximum of 5,000 activities have proven effective.

Figure 3-1. Objectives of CPM

- Plan
- Schedule
- Control
- Communicate
- Organize
- Implement

Terms and Definitions

Figure 3-2 lists terms and definitions of typical CPM schedules. Brief definitions of each are covered with further explanations to follow.

Arrow Diagrams Vs. Precedence Drawings Vs. Time-scaled Diagrams

Figure 3-3 shows three methods of drawing CPM diagrams. Each has its pros and cons.

Arrow Diagramming, at present, seems to be the most popular method. This probably stems from the fact that it was the first

Figure 3-2. Terms and Definitions

Activities (arrows)	An item of work, with or without its duration.
Nodes (events)	Start and finish points of an activity.
Arrow Diagram	A Network showing a logical sequence of activities and events which are graphically shown as arrows and nodes.
Restraints	Limiting activities that prevent other activities from starting. They are *non-time consuming* and are referred to as "dummy" or dependent activities.
Critical Path	The longest duration chain in a Network.
Early Start (ES)	As implied this is the earliest time that work can begin on a given activity.
Late Start (LS)	The latest time that a given activity can start without affecting the overall project duration.
Early Finish (EF)	The finish achieved by starting a given activity at its Early Start and achieving the estimated duration of that activity.
Late Finish (LF)	The latest time that an activity can finish without affecting the overall Project Duration.
Float	Spare time available to activities not on the Critical Path.
Total Float	The amount of spare time available to an activity if all *preceding* activities are started as early as possible and all *following* are started as late as possible.
Free Float	The spare time available to an activity when all activities in the chain are started as early as possible.

method to be developed and computerized. It is also easier to associate with time and flow of job activities.

A major difficulty to arrow diagramming is the "dummy" activity. Learning the significance and proper usage of "dummies" requires time and experience. The arrow diagram is also cumbersome to modify.

The second method is Precedence Diagramming. As shown, the activities are on nodes. Length and direction of the arrows have no significance as they indicate only the dependency of one activity on another. This method is commonly referred to as "Activity-on Node."

This method has received wider acceptance over recent years. Its primary advantage is that it eliminates "dummy" activities. It is also easy to modify. Since there are no events in the "Activity-on Node" diagrams, it is difficult to use milestones in the network; therefore, visual aspects of precedence networks are poor. As there is no dateline, it is also very difficult to view overall status.

Both methods are acceptable, however, arrow diagrams continue to have the slight edge because of early acceptance and familiarity.

The third method, showing a time-scaled network, is just a more "visual" tool of the arrow diagram. It is not designed as a tool for detailed control, but a technique to present overall schedules to management. It gives a quick and simple picture of the schedule as it relates to time, activity interfaces and criticality.

Simple Network

Figure 3-4 illustrates a simple network of an arrow diagram. There are three activities: A, B and C. They can be defined as follows: A is the beginning activity; B follows A but cannot begin until A is complete; and C is the final activity following the completion of B. As shown, there is a logical sequence of work starting from left to right.

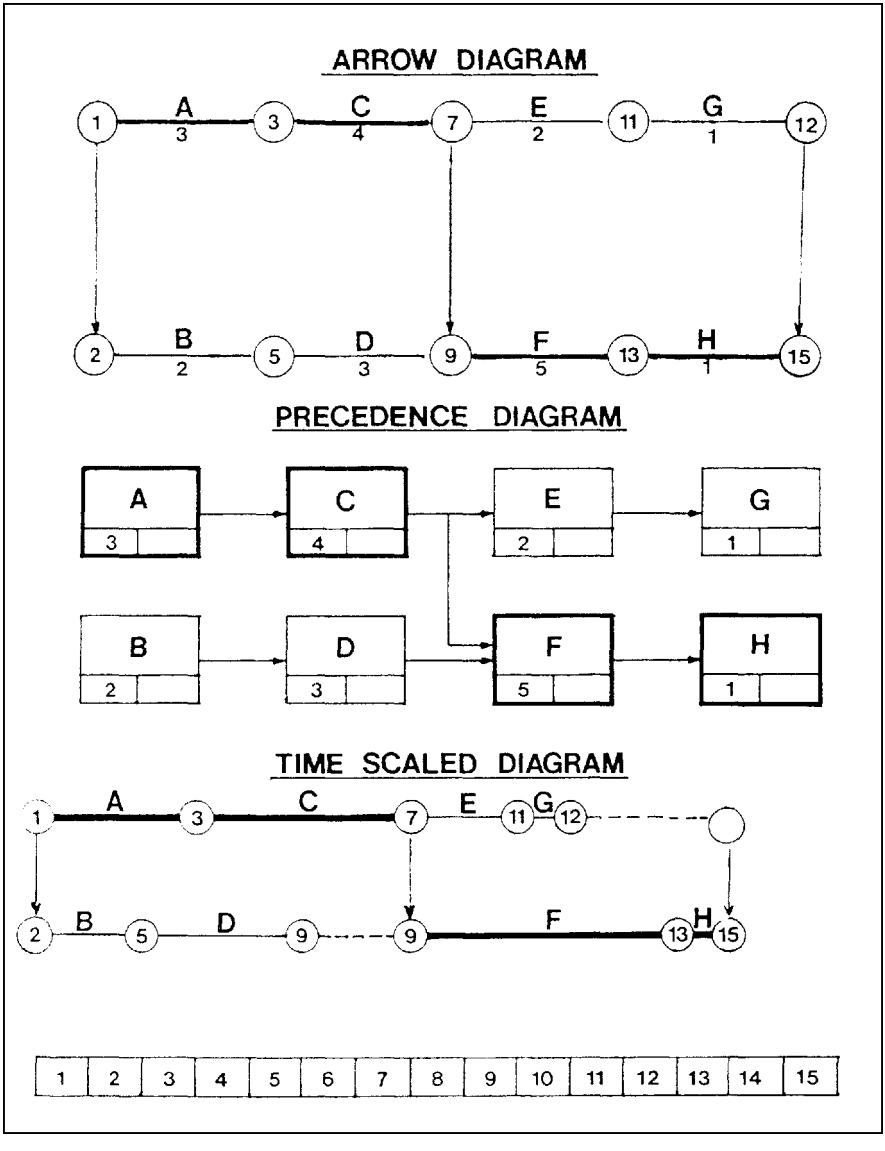


Figure 3-3. CPM Drawing Methods

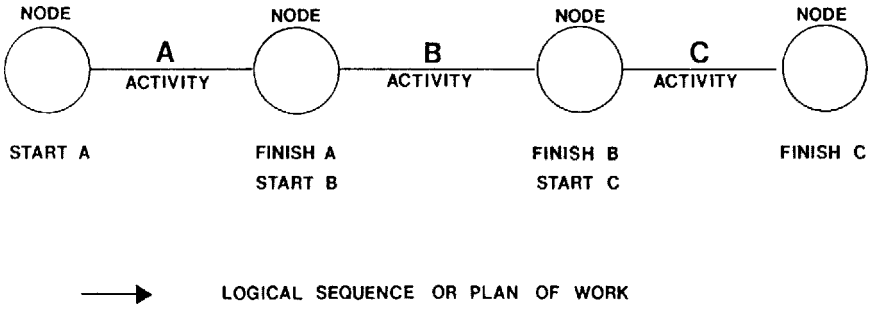


Figure 3-4. Simple Network

Problem 3-1: Network Development

In order to develop a network, the following example illustrates the steps involved. Given the data as indicated in Figure 3-5, draw an appropriate network.

Activities must follow in a logical sequence.

Analysis

First, read through the given data and note that this in a nine-activity network. Activity A is the first activity and Activity I is the last.

Figure 3-5. Network Development Problem

Given:

1) Activity B follows activity A
2) Activity A is the beginning activity
3) Activity C follows activity A
4) Activity C precedes activities E & F
5) Activity D follows activity B
6) Activity G follows activities D & E
7) Activity F precedes activity H
8) Activities G and H precede activity I
9) Activity I is the last activity

Draw the appropriate network.

Figure 3-6 shows the completed network diagram. Networks become more complex as activities are added and durations are established for each activity. Activity durations can be in days, weeks, or months; therefore, it is essential to determine from the outset the time scale. Logical sequence and durations for each activity can be determined by past experience or by work content in relation to available resources. This determination should evolve from consultation between the scheduler and appropriate construction and engineering personnel. It is important that an operating group concur with the schedule development, accept it as their schedule, and make a commitment to operate as per the plan and schedule. Work sequence can then be checked and durations assigned to each activity.

Today the **project manager** can evaluate complex schedules using a wealth of software available.

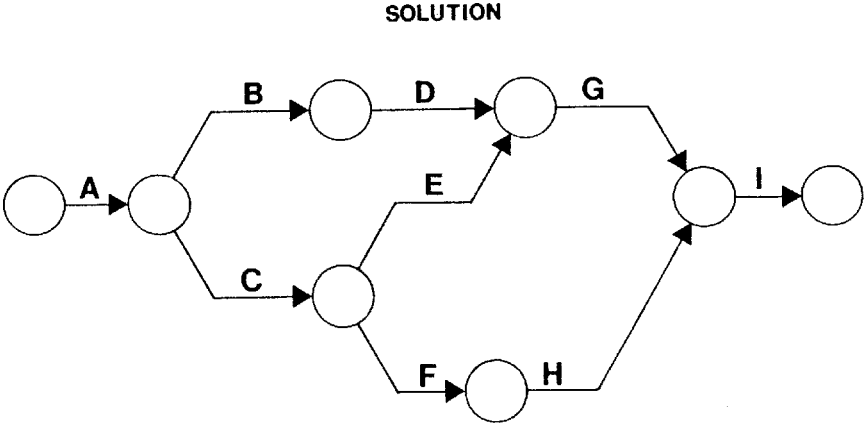


Figure 3-6. Network Development Solution

Chapter 4

Computer Tools for Project Management

Barry Benator

One of the challenges a project manager must face is how to keep track of the many elements of project management, including tasks, milestones, dependency relationships, schedules, people, costs, deliverables and progress toward interim and final goals. Until the 1980s, these tasks were often performed by hand with a calculator and a hand-drawn Gantt (or bar) chart or by a computerized project management program requiring a mainframe or minicomputer system. All of that has changed. There are now powerful computerized project management (PM) programs that can be run on personal computers costing less than $1000. The actual PM programs themselves may cost less than $100 for limited low-end products that can only handle schedules and graphics, to $500 to several thousand dollar programs that not only provide timely and accurate schedule information, but also powerful resource and cost tracking capabilities.

We introduce computer tools for project management at this stage in the book because a large part of the mission of a project management program is to assist in scheduling and keeping track of tasks and milestones. So it follows naturally after the previous chapter on the fundamentals of project scheduling. However, many good project management programs do so much more than deal with scheduling issues alone.

How Do I Know What Program to Buy?

Like any issue related to a software purchase, the most relevant question is "What do I need and what do I want it to do?" Buying a powerful program costing several thousand dollars that can handle a $100,000,000 construction project may be just what is needed if your project is that complex. On the other hand, if your project is in the $500,000-$10,000,000 range, a project management program costing around $500 might be more appropriate. For lower project budgets, a spreadsheet program with simple graphics may be your best tool. The key thing to remember is to find and use a program that fits your project, not one that is either so elementary you waste time and money performing a number of project control tasks outside the program, or so complicated that you spend more time figuring out how to use the program than letting it help you manage the project.

Some of the key issues that separate the low-end, inexpensive programs from full-powered project management programs are how well they perform in the following areas:

- Initial setup—Creating the project plan
- Tracking progress
- Reports
- Ease of use versus power and sophistication

By looking at a program with respect to these areas, you can determine if the program will meet your project management requirements.

The first step in finding the right program, as noted earlier in this chapter, is to take a long, hard look at just what your requirements are. The more clearly you have in mind what your needs are, the easier it will be to select the right software. The points that follow highlight key features you need to consider. In addition to these features, you will also want to go to the Internet and look at unbiased reviews of project management programs. In addition, talk to users of the programs you are considering to obtain first-hand, unbiased input about the programs you are considering.

Initial Setup—Creating the Project Plan

Typically, a project manager starts with an endpoint in mind—a design is completed, a building is ready for occupancy, a plant is built, etc. There is a budget, of course, but in planning a project, PMs tend to think initially in terms of a schedule of tasks and milestones. The project management programs you want to consider are ones that make planning the project relatively easy, so you actually use it, and powerful enough that it acts as a valuable tool to help you bring the project in on time and within budget.

Activities and Scheduling

Entering the Project Plan

The way you enter the project plan into the program and the ease of changing the plan will have a direct effect on how much use you get out of the program. When entering the project plan, you must define all the project activities. Most of the programs have you build your plan by listing the project activities down the left side of a Gantt or bar chart. You then fill in a form for each activity to identify its duration, the required resources and any activities that precede it.

A few programs let you create your project as a network first, actually drawing the boxes for each activity and the connecting lines that show their sequence. You may prefer one method of creating a project plan over another, but what is important is the ease with which you can create the plan and make changes to it. Some programs make it difficult to add or delete activities once the plan is created. As any experienced project manager knows, projects rarely go exactly as planned. So the first consideration is to make sure the program makes it easy to create the plan and change it. If it fails this test, you will be less likely to use it and thus take advantage of the benefits project management software has to offer.

Full Precedence/Relationship Capability

A second important feature to check for is how well the program

can represent the relationships among the activities and milestones that make up the project. When you enter the activities you also specify their sequence and precedence; that is, how the activities or milestones depend on each other and which must be done before others can begin.

As a minimum, the program must be able to contain all the project activities, and calculate and show the project's critical path. The critical path is the sequence of activities and milestones which must be completed on time if the project is to be completed on schedule. Another way of saying the same thing is any delay of any task or milestone on the critical path will delay the project.

Beyond showing the critical path, a program can be judged by how well it depicts the precedent relationships among the activities. Some programs only allow a finish-to-start relationship among activities, which means a subsequent activity can start only after a previous activity is finished.

Finish-to-start is a common relationship among activities, but you may also frequently have activities that depend on each other, but overlap to some extent. With these activities, the finish-to-start relationship does not accurately apply. So if you have program that allows only for finish-to-start relationships, you must decide either not to show the relationship as it should be or to artificially break down the activity into subactivities so they fit into the finish-to-start mode. This means you are having to adjust your work pattern to meet the program's needs rather than the other way around.

The ability to handle full precedence relationships is a key difference between programs. Determining the number and type of precedence relationships a program is capable of should be an important test of any software you consider. After all, you want the software to accommodate your project management needs, not the other way around.

Limits on Number of Activities

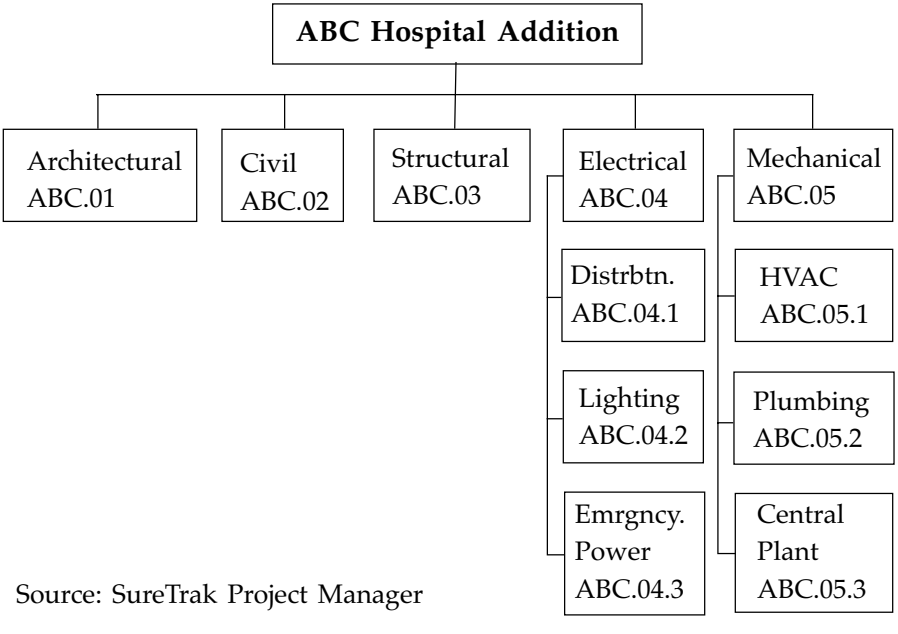
Many of the less expensive programs have a maximum number of activities that can be entered into the program. This maxi-

mum may be well below your needs. If your activities appear to come close to the maximum allowed by a program you are considering, you may want to look at a different program, one that will have the capacity to allow you to enter all of your planned activities into the program with room for additional activities, if needed.

WBS Capability

Equally important for some managers is the ability to identify activities in a work breakdown structure (WBS) format. A WBS as it applies to project management programs is the capability of assigning ID codes to each task in the project, from the highest level main tasks all the way down to the lowest level subtasks. An example of a partial work breakdown structure for a design project is shown in Figure 4-1. Note: Only the electrical and mechanical subtasks are shown for illustrative purposes, In an actual project, all relevant disciplines would be shown and in sufficient detail to allow the PM to grasp the details of the project.

Figure 4-1. Example Partial Work Breakdown Structure



Source: SureTrak Project Manager

A WBS allows the project manager to report and summarize project data at different levels of detail. For instance, a PM could ask the software program to provide all costs to date for the mechanical engineering discipline or architectural discipline and compare to budget numbers.

After defining the project activities and determining their relationships, you will want to schedule their start and finish dates and identify any other scheduling constraints individual activities may have. A distinguishing feature of some better programs is that you can assign specific start to finish dates to individual activities.

Another important issue is that some programs require that you first specify a project start date before the program will schedule the project. But, of course, you may have a project for which all you know is the deadline, the required finish date. Fortunately, some programs let you schedule the project by entering the finish date first. The program will then calculate backwards from the finish date to obtain the appropriate calendar dates for each project activity.

Schedule Display

How the schedule is displayed can also be important. For example, can the schedule be presented in various units, such as months, days and hours? And if you have a very long project, can the schedule be summarized so the entire project can be graphically represented on a single page? (While this may useful at times, the scale may be such that the print is too small to read comfortably.)

Resource Allocation

After breaking the project down into tasks and their relationships, you will need to identify available resources and allocate them to the project tasks. Surprisingly, there are several programs that do not allow for realistic resource identification and allocation, even though the ability to assign resources to a project is essential to effective project management.

Programs that allow for the assignment of resources usually make it a two-step process: (1) you first specify all project resources and their associated costs; (2) you then allocate them to the various tasks.

Assigning Resources

A key thing to look for in a program is the degree of discrimination allowed in identifying the assigning resources. Software programs vary widely with regard to resource management, and it is well worth a close look to see if the program can meet your specific needs.

The number and type of resources you can assign to a task is the first consideration. Some programs let you identify and assign only one or a few resources per task.

More powerful programs let you assign codes to each resource so you can further break down each type of resource; for example, ME1 = level 1 mechanical engineers; ME2 = level 2 mechanical engineers; etc. The program can then produce reports that are sorted based upon any given resource type or subtype. For example, you could print out a histogram, or resource allocation chart, for all level 1 engineers assigned to Subtask ABC.05.1.

Assign Partial Resources

The ability to assign partial resources to an activity is another valuable feature of some programs. You may be able to assign a percentage of a resource to a task, which is a common need in projects. If the program does not allow partial assignment of resources to a task, you will have to artificially break down the task so it matches the resources allocated to it. This may be an acceptable accommodation if the program meets your needs in other, more important ways. Still, if you have to do this, the program is forcing you to meet its requirements instead of meeting your requirements.

Many programs let you distinguish between conventional resources, such as labor and equipment, and expendable resources, such as cash. When a program lets you make this distinc-

tion, you can usually allocate the cash as an expendable resource and then produce cash-flow reports.

Resource Leveling

Resource leveling is the process of smoothing out the use of resources over time so you can meet whatever constraints you have on resource availability. Some of the better programs let you specify limits to resources, and the program will then automatically calculate the best use of the resources over time within the given limits.

Many times a project or certain activities in a project are resource-driven; that is, the availability and use of resources are of overriding importance. Using a program that does resource leveling can save a lot of time and effort when you are trying to juggle schedules to optimize the use of resources.

Assigning Costs

When you define a resource, most programs let you specify its cost per unit of time. Then, when the resource is assigned to project tasks, the total costs are calculated and kept track of by the program. Usually a program will let you assign only one rate for any given resource. To have multiple rates for a resource you would need to identify it as a different resource for each rate (e.g., Engineer 1, Engineer 2 and so on).

Another valuable feature of some programs is the ability to assign a cost to an activity and specify that the cost accrue at the beginning or end of the activity. Many programs do not give you this choice when assigning costs, and automatically prorate the cost over the duration of the activity. But sometimes this is not the way costs actually accrue. This may not be a show-stopper relative to purchasing the program but it is a factor to consider when you are evaluating different PM programs.

Tracking Progress

Showing actual progress of a project against project plan is one of the things that separates many low-end programs from

their more powerful competitors. Some low-end programs require you to change the planned schedule in order to show actual progress. This leaves no baseline plan against which you can compare actual progress.

Far better are those programs that display, usually on a Gantt chart, planned and actual progress. You enter the actual progress or percentage of completion for each activity. And the result, a graphic comparison between actual and planned progress, can be a valuable tool for managing the project. This actual vs. planned capability should also carryover to costing if that is important to you.

Reports

Reports of the project plan and project status are some of the most valuable tools a program can provide. A software program can make updating project reports quick and easy. And to the benefit of all, it is becoming the norm that programs provide both tabular and graphical reporting capabilities.

The various programs offer a full range of reporting capabilities, but there are certain reports you will want your program to produce:

- *Gantt (or bar) chart*—This favorite shows each project activity as a horizontal bar extending along the project timeline. The Gantt chart should also show milestones (key dates) and. preferably, planned activity progress versus actual progress. It is helpful if the program allows for depiction of precedence relationships among the tasks.

- *Network Diagram (PERT chart)*—the network diagram should show all project activities and their precedence relationships.

- *Activity schedule*—This report may go by various names, but it is a tabular listing of all project activities with their earliest

and latest start and finish dates. It also shows how much float, or slack time, each activity has.

- *Resource reports*—At a minimum; you will want a tabular listing of all resources and their assignment to activities. Resource histograms, vertical bar charts showing assignment of resources over time are also valuable.
- *Cost reports*—A detailed breakdown of planned and expended project costs is a minimum requirement. More powerful programs will calculate and graph out earned-value as the project progresses. An earned value graph compares project completion with costs expended. These reports will also show the estimated cost to complete the project.

Examples of computer-generated reports from Primavera Systems, Inc.'s *SureTrak Project Manager* program are presented at the end of this chapter. These are but a few of the many reports that it and others in its class can generate.

East of Use Versus Power and Sophistication

In software there often is a tradeoff between the program's ease of use and its power and sophistication. Many project management programs are extremely easy to learn and use, but are too simplistic to manage real-life projects. They might be appropriate for creating the schedule for a relatively small project (say, less than 50 activities), but are inadequate for handling the size, budget and resources of a larger project, which could comprise tasks and milestones numbering in the hundreds or more.

On the other hand, some of the more powerful programs may be so difficult to learn and to use that they are often not used at all.

Fortunately, there are a number of programs that are both easy to use and very powerful. It just takes some time and re-

search to find the best one for your project management needs. Several programs which offer the project manager a balanced combination of ease of use and power include Primavera Systems, Inc.'s *SureTrak Project Manager* and *Primavera Project Planner* and Microsoft Corporation's *Microsoft Project*.

The quality of the program's training may be one of your most important considerations. This will be true if the people who will be using the software are not themselves experienced project managers or familiar with project management techniques. In that case, you will want the program to have a good training tutorial and very clear documentation.

In Conclusion

The program features discussed in this chapter provide useful criteria for comparing programs and judging their capabilities. The most important thing is to take a hard look at your project management requirements and determine the minimum capabilities a program must have if it is to meet your needs.

Think about what you want the program to help you with most. Do your projects tend to be of a certain sort and have special requirements? For example, is account management and cost control always a primary consideration? If so, you want a program that will let you put in enough detailed cost information that you will have full cost tracking capability.

On the other hand, after a close look at the nature of your projects, you may realize they are primarily schedule intensive. For example, if most of your projects involve meeting strict deadlines (and many engineering and construction projects fall into this class), you should look first at those programs that provide excellent schedule tracking and related reports.

The power and capacity of a program might be your driving consideration. If you are the master scheduler for a large project that is made up of many other projects, you will want to look at those programs that allow unlimited tasks and speed in process-

ing, keeping in mind as well the hardware requirements.

Along this same line, some projects, especially federal government projects, have very specific reporting requirements. Even though federal projects amount in dollar volume to a large piece of the project management pie, only a few project management programs actually meet federal reporting requirements specifications. So if your projects have to meet these requirements, you need to factor this into your software requirements.

Or, again, if less experienced staff will be the primary users of the program, good training and documentation and ease of use can be a major consideration.

And finally, you will want to consider the program cost and how to justify its purchase. The best method for justifying a program's cost is to determine what your project management requirements are and to judge the value of the program on the extent to which it gives you the tools you need to better manage your projects. After a close look at your requirements you may decide that $1,000 for a program is a small price to pay for the power and sophistication it can deliver. At the same time it would be hard to justify paying a few hundred dollars for a program that lacks the capability to truly help in managing your projects.

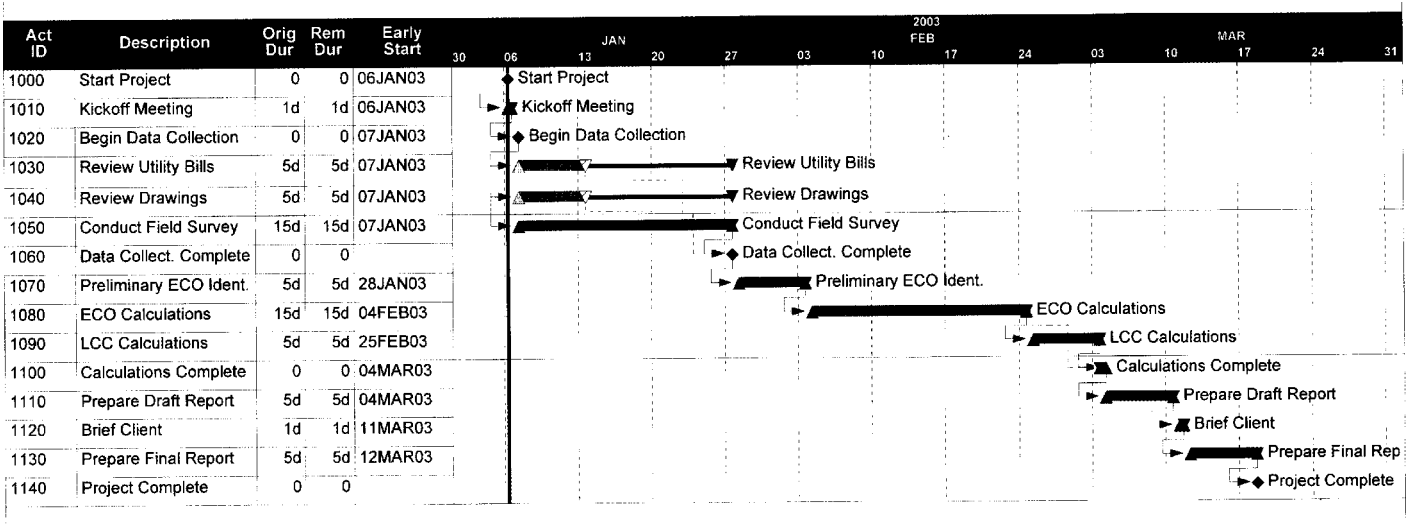
Making the effort to find the right program can yield significant dividends to the serious project manager. And with so many programs now offering full project management capability at a personal computer price, you won't have to look too far before you find the right one for you.

Figure 4-2. Example of an Activity Listing for a Basic Energy Audit Project

Act ID	Description	Original Duration	Remaining Duration	Early Start	Early Finish	Total Float	%	Resource	Budgeted Cost
1000	Start Project	0	0	06JAN03		0	0		0
1010	Kickoff Meeting	1d	1d	06JAN03	06JAN03	0	0	Engineer, ProjMgr, Sr. Engr	1,560
1020	Begin Data Collection	0	0	07JAN03		0	0		0
1030	Review Utility Bills	5d	5d	07JAN03	13JAN03	10d	0	Engineer	2,000
1040	Review Drawings	5d	5d	07JAN03	13JAN03	10d	0	Coop Stu, Engineer	3,000
1050	Conduct Field Survey	15d	15d	07JAN03	27JAN03	0	0	Coop Stu, Engineer, Sr. Engr	19,200
1060	Data Collect. Complete	0	0		27JAN03	0	0		0
1070	Preliminary ECO Ident.	5d	5d	28JAN03	03FEB03	0	0	Engineer, ProjMgr, Sr. Engr	3,900
1080	ECO Calculations	15d	15d	04FEB03	24FEB03	0	0	Coop Stu, Engr, ProjMgr, Sr. Engr	27,300
1090	LCC Calculations	5d	5d	25FEB03	03MAR03	0	0	Engineer	4,000
1100	Calculations Complete	0	0	04MAR03	03MAR03	0	0		0
1110	Prepare Draft Report	5d	5d	04MAR03	10MAR03	0	0	Engineer, ProjMgr	5,400
1120	Brief Client	1d	1d	11MAR03	11MAR03	0	0	Engineer, ProjMgr	1,080
1130	Prepare FInal Report	5d	5d	12MAR03	18MAR03	0	0	Engineer, ProjMgr, Sr. Engr	5,600
1140	Project Complete	0	0		18MAR03	0	0		0

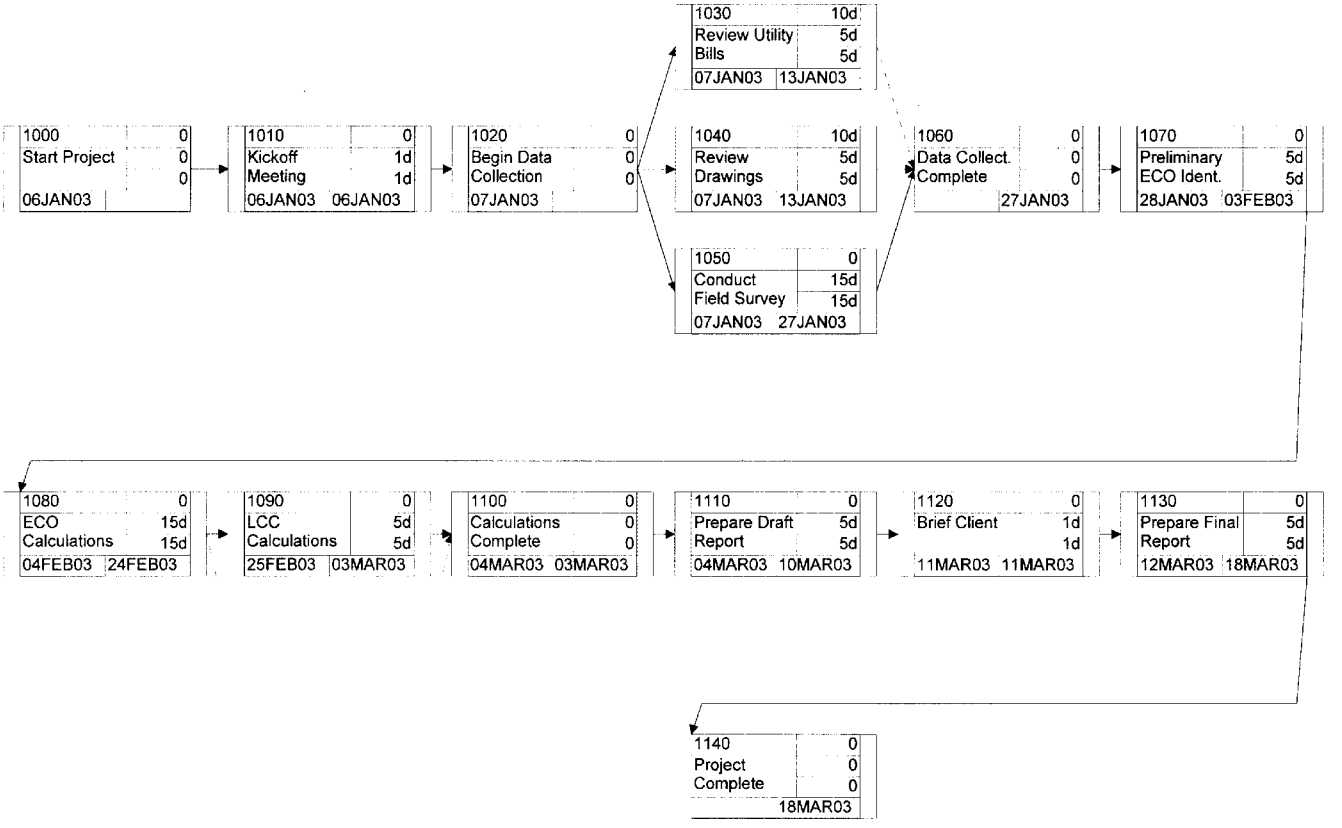
Source: *SureTrak Project Manager*

Figure 4-3. Example of a Gantt Chart Showing Dependency Relationships for a Basic Energy Audit Project



Source: SureTrak Project Manager

Figure 4-4. Example of a PERT Chart for a Basic Energy Audit Project



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Chapter 5

Technical, Schedule, Financial Management

Barry Benator

The essence of effective project management is to manage the technical, schedule and financial elements of a project to a successful conclusion, resulting in a profitable project for your firm and a satisfied customer who wants to do business with you and your company in the future. As an engineering or construction project manager, this is what you are expected to do.

This chapter provides specific guidance on how to effectively accomplish these tasks. If you follow this guidance, you will enhance your results in these areas. But it is important to understand that effective technical, schedule and financial management is not a one time event. As project manager, you must continually keep your hand on the rudder to ensure the project is headed in the right direction. Specific practices for effective technical, schedule and financial management are presented in the following sections of this chapter.

The Role of Communications

The first step in effective technical, schedule and financial management is for you, the project manager, to continually emphasize the importance of meeting the customer's and your firm's technical, schedule and financial management expectations. Say-

ing it one time is not enough. You don't want to be a broken record, but you do want to reinforce the importance of meeting technical, schedule and financial targets at every reasonable opportunity.

You can and should initiate communications about your expectations at your first project team meeting. Typically this meeting would be held after you have been designated as the project manager and one or more of your project team members have been assigned, but it can be held anytime. When I use the expression project team, I am referring to both internal and external team members (members of your firm, contractors, consultants, vendors, etc.).

At this meeting, you will want to explain very clearly your standards for the project. You might even want to hand out a paper containing your project management principles, and then review the contents of the paper with the project team. You could draw upon the principles presented in this and other chapters of the book to prepare your handout.

Effective Technical Management

Accountability at All Levels

While you as PM have overall project responsibility and accountability, in managing the technical performance of the project, it is important that you hold project team members accountable for their technical performance. How you will do this involves the skills of leadership and management, some of which you will acquire using the principles presented in this book, others you will acquire through appropriate courses and/or guidance from a friend or mentor.

This issue of accountability is crucial. Whether it is a design analysis, a CAD drawing or a construction schedule, the PM must ensure the project team members understand their responsibility and accountability for fulfilling their commitments on the technical portion of the project. It should be communicated that missing

commitment dates or not meeting quality standards is unacceptable. This does not mean you fire or replace a project team member who makes a mistake or get angry with that person, especially if he or she alerted you ahead of time that there is a problem. Rather, you want to support and coach those persons to help them meet their commitments in the future.

A good guide for you to follow in determining if a person can truly be held accountable for a specific task is to ask yourself the four questions below. If you can answer yes to all four of these questions, then it's fair for you to hold that person accountable.

- Does the person know what he or she is supposed to do?
- Does he or she know how to do it?
- Does he or she have the authority to do it?
- Does he or she receive coaching and feedback on their performance?

Codes and Standards

A significant technical management issue is compliance with appropriate codes and standards. This is, or should be, a contractual item. The technical issues here are not only ensuring your design complies with the appropriate codes and standards, but first to determine what *are* the appropriate codes and standards. Code and standard authorities may be international, national, state and local. Listed below are just a few of the code and standard authorities you may need to consider for your project.

ASHRAE—American Society of Heating, Refrigerating and Air-Conditioning Engineers

IESNA—Illuminating Engineering Society of North America

ICBO—International Conference of Building Officials

BOCA—Building Officials and Code Administrators International Inc.

SBCCI—Southern Building Code Conference International Inc.

ICC—International Code Council

NFPA—National Fire Protection Association

NCSBCS—National Conference of States on Building Codes and Standards

ASTM—American Society for Testing and Materials

ANSI—American National Standards Institute

BOMA—Building Owners and Managers Association

NAHB—National Association of Home Builders

UL—Underwriters Laboratories Inc.

HUD—Department of Housing and Urban Development

ADAAG—Americans with Disabilities Act Accessibility Guidelines

In some cases, codes and standards will conflict with each other. As PM you are responsible for sorting all this out and providing appropriate guidance to your design team so they know the standards upon which they should base their design. Work with experienced engineers, construction managers and code officials to resolve code conflicts. Be aware that even in the absence of specific codes in your contract or design documents, your firm is responsible for designing and constructing a facility using the care and skills normally exercised by qualified companies in your field.

Technical Review Meetings

It is important to hold periodic and as-needed meetings with your project technical team. This will help ensure your technical team knows what your expectations are, that appropriate communications across disciplines are occurring and that you know how well your team is producing technical results. A routine project meeting frequency of one meeting every week or two is reasonable unless events dictate a more frequent schedule.

Use these meetings to assess how the project is proceeding technically, give participants an opportunity to voice any con-

cerns, identify potential conflicts and plan work-arounds to avoid or mitigate those conflicts. You can also use these meetings to test the information you are being given for rationality and soundness.

It is very important to go into the meeting with an agenda that lets everyone know what is to be covered, who is responsible for presenting or leading that part of the meeting and the length of time each person will have to cover their particular topic. You will also want to have a *Postmeeting Action Plan* that will help everyone know what is expected to happen after the meeting. An example agenda format is presented in Figure 5-1. You can use it as a point of departure to develop your own, tailored meeting agenda. An example of a *Postmeeting Action Plan* is presented in Figure 5-2.

Figure 5-1. Example Agenda

ABC University
Project Status Meeting
February 10, 20__, 8:30a-11:30a

Participants:

Our Firm	**MEP Consultants**
Bob Project Manager	Alice Project Manager
Jane Assistant Project Manager	Phil Assistant Project Manger

I.	Current Project Status	
	A. Overall Project Status **Bob**	**20 minutes**
	B. Results of Agency Review **Jane**	**20 minutes**
	C. MEP Status **Alice**	**30 minutes**
II.	Client Concern Issues	
	A. Old Concerns **Bob**	**20 minutes**
	B. New Concerns **Jane**	**20 minutes**
III.	New Issues	**45 minutes**
	A. Our Firm **Jane**	
	B. MEP Consultants **Alice**	
IV.	Summary/Post Meeting Action Plan **Bob**	**15 minutes**
V.	Schedule Next Meeting **Bob**	**10 minutes**

The times listed in the agenda should be considered targets, not absolutes. You should manage the meeting so that relevant information is covered but time is not wasted on unnecessary tangents. All parties should have a copy of the agenda several days prior to the meeting so everyone knows what they are responsible for. Bring extra copies to the meeting for last minute meeting attendees and lost agendas.

Use the following Postmeeting Action Plan form, illustrated in Figure 5-2 and tailored to meet your specific needs, to ensure follow-up of the issues and commitments discussed in your technical review meetings.

Figure 5-2. Postmeeting Action Plan

Meeting Topic: _____

Meeting Date/Location: _____

Chairperson: _____

ACTION ITEMS

What	**Responsible Person**	**When Due**	**Comments**
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Issues Discussed/Decisions Reached:

_____ _____

_____ _____

_____ _____

_____ _____

Next Meeting Scheduled for: _____

Date/Time/Location

List of attendees attached. Recipients of this Action Plan attached.

The Postmeeting Action Plan form is best filled in real-time during the meeting. At the end of the meeting, you will want to review it with the meeting participants, make any appropriate changes and then make copies to give to each person before they leave the meeting. You might also want to follow-up with meeting minutes that expand upon this "quick look" meeting documentation form.

You can use this Postmeeting Action Plan to follow-up and manage the results expected from the project team members who attended the meeting.

Use Teammate Talent

Another means to enhance technical quality is to encourage project team members to seek out their fellow colleagues for advice and counsel on difficult technical issues. As PM you need to foster the belief that **asking for help is a strength, not a weakness**. You can underline this point by modeling the expected behavior.

Seek advice and guidance from your own team members and other PMs on difficult technical and PM issues. Consult your boss and friends. In other words, no one knows it all—neither you, your engineers, your CAD team members, your construction managers, etc. If you seek help from others on your PM issues, your team members will be more at ease in doing so themselves, and that will have the effect increasing technical performance on your project.

Sanity Checks

Use your experience as a project engineer or construction manager as a sanity check or "sixth sense" to evaluate information from your project team members, especially members with whom you have not previously worked. (I recall working with a consultant who commented midway in our project that it won't be too long for the "all-nighters to begin." When I inquired as to what he meant by that, he informed me on his previous projects the project teams always held several all-night work sessions prior to delivering the design documents to the customer. I then calibrated the

consultant that I expected him to meet his commitments in a manner that did not require anyone else on the team to work all night just because he was.).

Sometimes long days or even overnighters may be necessary due to unforeseen circumstances. Often times, however, they are the result of inadequate planning and attention to quality in the first place. By staying in touch with your project team members individually and at meetings, you can develop that sixth sense that will help you realize someone on the project team needs help or there is an impending danger to the project. What you don't want to do is ignore potential problems, hoping they will go away—they won't.

Effective Schedule Management

Communications

The first step in effective schedule management is for you, the project manager, to continually emphasize the importance of meeting the customer's and your firm's schedule. Saying it one time is not enough. You need to reinforce the importance of meeting schedule milestones at every reasonable opportunity.

One way to avoid late deliverables is to have periodic schedule review meetings. These can be combined with the technical review meetings previously discussed. At these meetings you will want to inquire about upcoming key dates and listen carefully to identify potential problems. Clues that you may have an impending problem include someone being sick or out of the office for a family crisis, a departure of a key project team member, a supplier strike, etc. Start planning work-arounds that will help mitigate the impact should any of these possibilities come to pass.

Achieving Buy-in to the Schedule

It is a fact that people demonstrate a greater ownership and commitment to a project schedule when they have had an opportunity to have an input to that schedule. As PM, you will want to

include as many project team members as possible when you are setting up the project schedule. Then have the people responsible for their particular part of the schedule sign off on their commitments so there can be no misunderstandings as to what they have committed to.

Set Early Milestone Dates

To help you manage the schedule, set up a time buffer, similar in concept to leaving sufficient space between the car ahead of you on the highway to avoid an accident if he/she stops suddenly. Try to set early milestone dates so that you will have time for review of key work products and have sufficient time to modify them before the actual deliverable dates specified in the contract. These early due dates will also allow for things that might go wrong; e.g., a faulty analysis, an illness on the part of a key team member, departure of a key team member, a crisis requiring the need to share a key team member with another project.

Use Computer-Based Scheduling

We have already discussed the benefits of computer-based scheduling (Chapter 4). Whether you use a customized spreadsheet, an in-house program or one of the commercially available programs such as Primavera Systems, Inc.'s *SureTrak Project Manager*® or *Microsoft*® *Project* or some other program, computer-based programs can help you stay on schedule. They can track your progress against plan and help you spot early on whether the project is in danger from a scheduling point of view. Once you know you have a potential schedule slippage, you are then in a position to take timely action to avoid the delay, or at the minimum, let your boss and customer know what is happening and what you are doing about it. This will show that you are on top of the situation and doing your best to minimize any slippage.

Don't Let Chronic Late Performers Slide

It is fact of project management life that while most people are committed to delivering what they promise when they prom-

ised it, sometimes you will have on your project team a person who is frequently guilty of missing committed dates. You will need to exercise judgment on how to best handle each situation, but you will want to ensure that frequent offenders are counseled and steps taken to avoid late performance in the future.

Don't be afraid to ask project team members directly if they will meet their schedule commitments. Be sensitive to problems they may have and work with them as much as possible to help them meet their commitments. However, their commitments are their commitments, and they should bring to bear all possible resources to deliver on their commitments.

Effective Financial Management

This is the Bottom Line

The most technically sound project, completed well within schedule has not fulfilled all the requirements of effective project management if it does not meet its financial targets. Even allowing for the uncertainties inherent in an early-stage R&D project or first-of-a-kind project, where costs are difficult to predict, you as PM are responsible for managing the project to a within-budget conclusion.

Project Control System

To effectively manage the financial part of your project, it is important that you become intimately familiar with the project control system used by your firm. The reports and information provided by these systems typically yield a wealth of information about the project's financial health. Sometimes these reports can be a challenge to understand, but you need to do whatever it takes to understand them so you can determine if your project is on track with respect to its budget. Once you understand how the reports are generated and what the various entries mean, it will be easy for you to use them as an effective tool to help you manage the financial element of the project.

Labor Cost Management

Labor charges can be the most significant cost element of a project, particularly with a design or energy audit project. As with the other responsibilities of project management, it is critical that you as project manager frequently reiterate to project team members the importance of controlling internal labor costs. If the project team members know that internal cost control is important to you, they are more likely to make it a priority for themselves.

Because you have prepared a budget and know what to expect in the way of project progress versus labor hours required to attain that progress, you are in an excellent position to determine if the labor costs charged to your project are reasonable compared to value received. If you determine that you have been overcharged compared to a previous commitment to deliver a product at a specified cost (or labor hours), then you should negotiate with the charger to reach a reasonable accommodation. This accommodation may involve removing some or all of the out-of-budget hours charged to your project. You'll want to be reasonable about this negotiation because there may be good reasons (e.g., unforeseeable complexities, late or incomplete input from another engineer, etc.) that the charger put more hours on the project than you anticipated. If there are, then you will want to obtain agreement from the charger that in the future he/she will talk with you prior to overcharging the project on any particular task.

Sometimes you will be hit with excess labor charges because a charger needed a place to put hours on his or her timesheet, and you may find that you have been the "lucky" person to receive them. To avoid this, you should question any hours that do not appear reasonable or that do not have good value associated with them. Do it tactfully, avoid accusations and simply inquire as to what tasks the hours were applied and what was accomplished for those hours.

Another thing to watch out for is an accounting glitch, especially when a paper timesheet is transcribed into a computer program. Sometimes through a mistaken entry, charges can end up on your project when they belong to another project. Here, as before,

you will want to carefully review the periodic project control reports you will receive (or generate yourself if that is how you work) and ensure invalid charges are removed from your project.

Once it becomes clear to all parties that you are checking project financial reports carefully and requiring invalid charges to be removed from your project, the incidences of invalid charges appearing on your project financial reports will be reduced.

Subcontractor Cost Management

Many projects use subcontractors, consultants and vendors (all referred to as subcontractors in this book). As project manager you will want to control subcontractor costs as tightly as you control other project costs.

Ways to do this include:

- Let your internal teammates know that controlling subcontractor costs is as important as controlling other costs.

- Seek multiple subcontractor quotes or use subcontractors with whom you have a good relationship and who you know will give you a quality product or service at a fair price.

- Checking into new subcontractor references is a good way to determine if the sub you are evaluating will likely be a good project team member. Experience has shown one of the best indicators of future performance is past performance. So do your homework.

- Treat your subs with fairness and respect. Negotiate services and prices that provide you and the sub with a fair balance of quality, cost and service.

- Carefully check the math and work claimed by the subcontractor. If your contract with the subcontractor requires you to reimburse your sub for equipment ordered, ask to have copies of the order form and receipt by the vendor attached to the invoice.

- Pay only on original invoices approved by the PM. Do not pay from faxes, photocopies or e-mails. This will help minimize the possibility of multiple invoices being paid for the same work.

- Do not approve a partial payment of an invoice (except retention). If a subcontractor invoices you for $10,000, but has only accomplished $7,000 of work, reject the invoice and require the subcontractor to submit a new, accurate invoice for $7,000. If you were to approve only $7,000 of the $10,000 requested, then the subcontractor's accounting department will show $3,000 as an unpaid receivable and will be calling you and/or you accounting department asking why/when the $3,000 will be paid. In their eyes, your company is not paying its bills, which isn't the case. While rejecting the invoice outright and requiring submittal of the correct invoice may seem like overkill, it will ultimately provide the smoothest and proper practice for both companies.

- Check your project control system to ensure the subcontractors invoices you approved for payment are accurately reflected in the system.

- Check your project control system to ensure that another project's subcontractor costs did not land on your project. It is very easy to key in an incorrect project number that puts incorrect charges on your project. By the same token, be a good teammate and if you do not see a subcontractor charge that you expected, inquire what happened and maybe you can save another project manager a little grief as he/she tries to sort things out.

- Be prepared to help a subcontractor get paid if its invoice gets lost in your accounts payable (A/P) system. Sometimes a correct and valid invoice may get lost in your A/P system. If this happens, be a good team partner and help shake loose

payment for the sub. It's not only the right thing to do; it's also one thing you can do that will earn loyalty and good performance from the sub.

Controlling Travel Costs

Travel costs can be a significant cost element of a project depending on the location, type and length of the project. As with the other responsibilities of project management, it is critical that you as project manager frequently reiterate to project team members the importance of controlling travel costs. If project team members know that controlling travel costs is important to you, they are more likely to make it a priority for themselves.

Here are some proven techniques for minimizing travel costs:

- Don't travel unless absolutely necessary. With almost universal access to e-mail, faxes, conference calling and internet conferencing capabilities, much business can be conducted without traveling. Use these capabilities to conduct business while saving on travel costs.

- Use the Internet to find low-cost travel options.

- Combine missions into one trip. It is not uncommon to have clients in the same locale (i.e., same city or nearby). By scheduling visits to each using the same airfare, you can save hundreds of dollars each trip and thousands of dollars on each project.

- Use advance purchase to save 25-50 % or more off full fare tickets. This requires planning (there's that word again), but it's well worth it. Our experience is that the majority of project trips can be planned 14 days or more in advance which means huge dollar savings for your project. And if you can combine a Saturday night stay-over with a 14+ day advance purchase you can save even more (at the time of this writing, a regular nonstop round-trip Atlanta-Los Angeles airfare ticket costs $2015. A 14 day advance purchase ticket

with Saturday night stay-over costs $311. This is an 85% savings off the regular, nondiscounted airfare!)

- Even if your return plans are uncertain, you can make the advance purchase with a planned return date. Then if your plans change, it often times costs a lot less to change the return date than to buy an unrestricted ticket. Airline polices regarding ticket changes are continually evolving, so ensure you provide the most up to date information to your project team members.

- Avoid upgradable restricted air fares. Although less costly than unrestricted fares, they typically cost more than non-upgradable restricted fares. An exception to this rule might be a cross-country or international flight where the benefits to the firm and the traveler are worth the extra cost.

- Airplane departure times can also make a big difference in airfares. A departure two or three hours one way or the other can significantly affect ticket prices. You may be able to make the situation a win-win between the project finances and the person traveling by compensating the traveler in some way for the inconvenience of an earlier or later flight time than ideal.

- Drive or take the train. With security procedures more stringent than ever before (resulting in increased time to get through the airport), it may make sense to drive to the site rather than fly.

Controlling Shipping Costs

An often overlooked aspect of project financial management is control of shipping costs. Too often projects incur expensive overnight shipping costs because the items to be shipped (e.g., drawings, specs, design analyses, etc.) were not ready in sufficient time to permit less expensive two-day, three-day or longer shipping periods. Over the course of a multi-month or multi-year

contract, unnecessary shipping costs can amount to thousands of dollars that come right off the bottom line.

An excellent way to capture these dollars is to negotiate overnight shipping costs with your client and then manage your project tightly enough to be able to use two or three day delivery schedules. The difference in cost between overnight shipping and the longer shipping times goes directly to the bottom line as profit.

Another way to save on shipping costs is to negotiate special shipping rates with several reputable carriers. Depending on your volume of shipments, your firm may be able to negotiate rates that are less than half of published rates. And don't think you need to be a large volume shipper to negotiate attractive shipping rates; many engineering and construction firms have already taken advantage of negotiated shipping rates. Again the result is enhanced profits.

The one thing that all of the above recommendations have in common is that they will happen by good project management. You will want to ensure your project team members understand the necessity of timely deliverables completion so lower cost shipping delivery dates can be used.

Controlling Printing Costs

Another cost of a project that can be controlled is printing. Particularly certain design projects, where one original design analysis package and set of specs can be several inches thick, and with "D" and "E" sized drawings numbering in the hundreds or thousands, printing costs can be significant. Here are proven methods to reduce such costs.

- Negotiate with local printers for lower rates than their published rates. If you can give the printer something of value, like your steady business, the printer will often provide you with lower printing costs.

- If you do the majority of your design work in your home office but have an on-site presence at your client's facility, consider e-mailing the files or shipping compact discs (CDs) containing the files to your local office and have them repro-

duce the files locally. Then you can hand deliver them and save on shipping costs.

- For drafts of prints, consider using "D" size prints if they show sufficient detail. This can be the difference of a dollar or more savings per page compared to "E" sized prints.

- If volume warrants, consider an in-house copy center. Some firms have put in place their own copy center to handle large volumes of specs and plans, reaping concomitant savings in the process. A straightforward economic analysis will help you determine if this is a good option for you.

Effective Cash Flow Management

Effective project financial management not only includes the cost control measures we have previously discussed, it also includes the very real importance of collecting the hard cash needed to run your company. An accounts receivable (A/R) entry in your firm's ledger is certainly a desirable thing; it adds to your bottom line in the accounting sense, but converting it into hard cash is the ultimate objective of any organization.

Below are effective and proven ways to enhance the cash flow of your organization.

- The best time to begin setting up your project to have a favorable cash flow arrangement is right at the beginning—in the contract. We recommend the following terms be incorporated into the contract, or at least be requested. Actual negotiations may yield something less than these, but you will almost certainly do better than if you don't seek them and leave them to chance.
  - — Start-up or mobilization payment
  - — Progress payments tied to work completed and equipment ordered
  - — Biweekly invoicing with net 15 days payment terms
  - — Provision for 1.5% per month interest for payment beyond 15 days

- Learn your customer's invoicing and payment process *and do it the way they want it done*. If necessary, meet with your customer's accounting representative to ensure you understand how to prepare your invoices in such a manner that they will flow through your customer's accounts payable (A/P) process smoothly. It is incredible how many payments are delayed and how many invoices must be resubmitted because the firm did not prepare the invoice in accordance with the customer's instructions. This means you as the PM must set up a proper invoicing procedure and ensure all invoices are prepared properly.

- Provide the required backup information (e.g., timesheets, equipment purchase proof, etc.) that will make it easy for the customer's representative to check off that you have submitted a valid invoice and authorize it for payment. One caution: do not provide more backup than required, or the customer may come to view the additional information as a new requirement.

- Ensure your invoice is submitted to the right person or office. In some cases this will be the customer's project manager. In other cases it will be to your customer's accounts payable (A/P) department or other designated department. In some cases, you may submit your invoice to the A/P office, but also submit an informal invoice to your client's PM so he or she can begin a preapproval review of it.

- Call your customer several days after you submit your invoice to ensure it did not get lost or misplaced—it happens.

- Submit your invoice as soon as possible. Every day you delay submitting your invoice is one more day you will be delayed in receiving payment. And it's one more day your firm will be paying financing charges to cover the A/R generated by your invoice.

- Get to know the A/P people who handle your invoice. Visit them on one or more trips to your client's site. Let them get to know you as a person. Thank them for their help in getting your firm paid in a timely manner. Remember them with holiday cards. Congratulate them on good news—promotion, birth, etc.

Invoicing is not a "fire and forget" evolution. Once your invoice leaves your company, it is important that you track it and insure it is in the right channel for payment in a timely manner. I am aware of a firm that had a "days receivable outstanding" period of 80 days, which was 78% longer than their targeted 45 days receivables outstanding period. This occurred because no one at the company followed up on invoices after they were sent out. As a result, invoices got lost in the customer's accounts payable process, were put in the "pay later" stack, sat in the wrong pile, etc.

One project manager instituted a simple follow-up process to track his receivables that resulted in a dramatically shortened receivables payment period of 36 days. The process included the following steps:

- Phone call several days after sending the invoice to ensure it was received and was in the proper format
- Follow-up phone calls to track it thorough the customer's A/P process
- Quick action to correct any glitches on the invoice to keep it moving through the A/P process

The most important aspect of this process is frequent vigilance and follow-up to keep the invoice moving until it is paid to your company. Don't hesitate to call upon your customer project manager for help in freeing a stuck invoice. If you have done a good job managing the project and making him or her look good, he/she will be glad to help you.

In Conclusion

This chapter has provided you with many techniques, ideas and solutions for managing the technical, schedule and financial elements of your projects. Note that these techniques, ideas and solutions are not exotic, difficult to understand concepts, but rather specific, real-world actions that you can take *right now* to manage your projects to a high quality, on-time, within budget conclusion.

We presented two meeting forms that we suggest you enter into your word processor and then modify to reflect formats that best suit your particular project management needs. We also recommend you develop a set of project management guidelines based on this chapter that you can handout to your project team members so they have in writing your project management philosophy.

Remember, project management is not a fire and forget evolution. You will always need to keep your hand on the rudder to steer it to a successful conclusion. How much effort you exert on the rudder at any one time will depend on the people on your project team and the particular issues facing the project at that time.

Chapter 6

Cost Estimating

The Role of the Project Manager and Cost Estimating

The project manager plays an important role in development of the overall estimate of the total costs of the project. In addition the project manager develops checkpoints to ensure the overall project is completed within budget. The project manager usually develops the budget in conjunction with a cost estimating department.

The purpose of this chapter is to review how to estimate a project's costs in conjunction with *other engineers, construction managers, financial staff and* a cost estimating department *if available.*

General

a) Quality of Estimate

This chapter on estimating of engineering/procurement/construction (EPC) is roughly divided into conceptual and detailed estimating. The general range in the quality of these two phases of estimating is about 40% to 10%, respectively. The measure of the quality of an estimate is usually categorized by the amount of contingency that is contained in the estimate. For example, a 10% estimate would have a 10% contingency. Due to the high development cost and the time necessary to produce a 10% quality estimate, most companies approve the funding and full execution of EPC type projects at the ± 20% estimate quality. It is possible, in the "specialist equipment" areas and building industry, to produce 10% quality estimates from preliminary design information.

The accuracy of estimates varies considerably and is largely dependent on the quality of the estimating program and experience of the estimator. Quality also can be controlled to a substantial extent, by increasing or decreasing estimating manpower and time. The relationship is not linear. Appropriate, modest investments of time and resources will, usually, provide capital cost estimates of acceptable reliability. Further improvement becomes increasingly expensive, with only modest improvements in accuracy, resulting from substantial expenditures of time and resources. A point is soon reached where estimate quality is almost completely controlled by problems of forecasting economic conditions, local project conditions and quality of project performance. No significant improvement in estimate quality can be made thereafter, except by incorporation of actual design and cost information as it develops.

b) Purpose(s) of Estimates

Owner and constructor estimates are prepared at various stages of project development. They have two major purposes:

1. To establish cost levels for economic evaluation and financial investment.
2. To provide a base for cost control as the project develops.

This second purpose of "project control" is often ignored by "professional" estimators as they perceive their only purpose is to develop a quality estimate. In such cases, the resulting estimate may be of a high quality for investment purposes, but of a low quality from a project execution/control point of view. As most conceptual estimating bases are structured on a system basis, rather than on an area basis, it requires considerable effort at an early estimating stage, to develop an estimate on an "area" basis that, in turn, maximizes the "controlability aspect."

Even though a contractor's first early estimate can be of a lesser quality than an owner's estimate, it is recommended that a contractor provide an estimate early, after a contract award. This

very quickly establishes a base for contractor cost control and should provide the contractor with a sense of commitment and responsibility for the financial basis of the project.

Due to the lack of time, it is probable that this early conceptual estimate would be a capacity-cost or curve-type estimate for direct costs with indirects on a percentage basis. Even though lacking time, the contractor should be encouraged to put as much quality (definition) into the estimate as possible, as this estimate may become the control base for the project.

The "appropriation" estimate, prepared by the owner, is on the same basis as the contractor's estimate, but statistically broken down into further detail so as to provide a checking basis of the contractor's first estimate.

The following could be the further breakdown:

- Itemized equipment list: material cost and labor man-hours
- Bulk materials: material costs and labor man-hours by category
- Off-site systems: material costs and labor man-hours
- Home office costs and engineering man-hours
- Field indirects: material costs, labor and staff man-hours
- Owner costs: capital and expenses
- Estimating allowance: risk analysis

The statistical development of man-hours provides information for overall scheduling and manpower resource evaluations.

c) Typical Estimating Categories

The following estimating methods or systems are the ones most commonly used:

1. Proration, Budget, Rough Order or Magnitude, etc.
2. Cost Capacity Curves
3. Equipment Ratio (curves)

The above methods are generally in the "Conceptual" category.

4. Quantity/Unit Cost

This last method is generally referred to as a detailed cost estimate.

Proration Estimates

This method takes the cost of a similar, previously built facility, and "prorates" the cost for the new facility, based on changes for project conditions, capacity, escalation, productivity, design differences, and time. This method is based on some historical data and a lot of statistical relationships and assumptions. It is, therefore, not very accurate and is generally around ±40%.

Cost Capacity Curves (Overall)

An historical data base is developed for similar plants where the total cost is related to capacity. This method is usually more accurate, generally around ± 30%, but does depend on the quality of the data base.

This method is also used, at a lower level of detail, for individual pieces of equipment and/or process/utility systems.

The above two conceptual estimating systems are generally used to give a quick and *early indication* of required investment level. The resulting evaluations are only used for "budget" purposes and investment possibilities. The information is not sufficiently accurate to make firm investment decisions. Sometimes investment decisions are made on this preliminary information, where economic viability is not the first priority. Projects to meet environmental standards, "stay in business" criteria, or R&D programs would fall into this category. Another purpose of these "early" estimating programs is to provide technical and economic information on investment and resource requirements to advance the technical basis and estimating quality to a higher level. Thus, many projects are funded on a partial or phased approach.

Equipment Ratio (Curves)

This method calculates the costs of "bulk" materials, such as concrete, electrical, structural, piping, etc., as a percentage of

the major equipment cost. Ratio methods can be used only with an appropriate data base. The accuracy of this method is generally ± 20%. This quality of estimate is usually the minimum requirement for a "full investment" decision of an EPC project.

This "appropriation" estimate for an EPC project should be produced after completion of conceptual design and process selection and would be an update of the conceptual estimate prepared during feasibility studies.

The following would be the design/scope basis:

- Overall process flow diagrams
- Heat and material balances
- On-site and off-site facilities and layouts (power, steam, air, electricity, water)
- Preliminary plot plans/building layouts
- Equipment list—by size and category
- Preliminary execution plan/organization/resources/schedule
- Completed survey of appropriate estimating data

This would be an equipment and bulk ratio estimate for direct labor and material costs. Indirect costs would be factored from direct costs. A further statistical breakdown would be made to develop engineering and construction man-hours for scheduling and resource evaluation.

Quantity Unit/Cost Estimates

This method is the most accurate, generally ± 10%, but it can be costly and time-consuming, as detailed takeoffs must be made of all labor and material units in the system. This method requires that engineering be sufficiently advanced so that accurate material quantity takeoffs can be produced. It also requires detailed historical data for applying unit man-hour rates and monetary costs to the estimated quantities.

This last, general category is usually referred to as a detailed

cost estimate.

This estimate can be developed only when the process design has essentially been completed. It will also require a significant amount of detailed engineering to be completed so that bulk material takeoffs can be developed for civil work, mechanical, piping, electrical, etc.

The following would be typical for an EPC project:

a) Approved process descriptions—feedstock and product slate
b) Licensor engineering (schedule A package)
c) Approved flow sheets
d) Heat and material balances
e) Approved process piping and instrumentation diagrams (PIDs) (process and utilities)
f) Approved plot plans
g) General specifications
h) Equipment specifications and data sheets
i) Completed site-soil survey and report
j) Site development and grading drawings
k) Underground piping and electrical layouts
l) Concrete foundation layouts
m) Above-ground piping layouts
n) One-line electrical drawings
o) Milestone schedule
p) Detailed project-owner conditions and requirements
q) Project-owner conditions and requirements
r) Environmental and governmental requirements
s) Equipment quotations—transportation costs
t) Bulk material takeoffs
u) Labor cost-productivity data
v) Layouts for construction temporary facilities
w) Organization charts (project, engineering, and construction)
x) Personnel schedules and manpower histograms
y) Construction equipment schedules

A detailed estimate would be quantity based with separate unit costs for material, labor, and man-hours. Construction would be based on an area breakdown rather than on the "system" basis of a conceptual estimate. This estimate could be an updated, trended version of the first conceptual estimate and subsequent updates or a completely separate exercise. In most cases, it would be a separate exercise, as the format and work breakdown structure would be different and more detailed than that of a conceptual estimate. In particular, the construction estimate would be on an area basis with takeoffs by work units and man-hour unit rates.

Apart from "trend" updates, this estimate breakdown could be sufficient to control costs to completion of the project. This estimate could be developed about 6-8 months after contract award, on an EPC reimbursable type project, as this amount of time would be required to provide an adequate completion of detailed engineering.

The most significant element of a high quality estimate is the maximizing of quantities and minimizing of factors and statistical relationships.

"Fudging" the Detailed Estimate

Many companies have a policy that requires a detailed 10% estimate before the project appropriation will be approved. These same organizations, typically manufacturing companies, also require that the project be started "yesterday." Manufacturing and plant management are able to "insist" on these conflicting objectives. These two objectives are incompatible. In most cases, the practical resolution of this management inconsistency is for the estimate to be *"fudged."* This is to say, the estimate shows a 10% contingency, "below the line," with a similar amount of money "buried above the line" in individual categories where the risk is deemed to be the greatest. Whereas this "process" meets the company financial approval policy, it, nevertheless, provides a poor basis to execute and manage the project. From a project manage-

ment viewpoint, it is poor practice. It is also quite common for such companies to execute projects on a "crisis management" basis. In most cases, this type of approach will increase the capital costs of their projects. However, this may increase the economic return as the product can reach the marketplace at an earlier time.

Project Management Estimating Responsibility

As many companies have a formal estimating section, the relationship between the estimator and project manager should be clearly defined and properly understood by all parties.

The project manager should "direct" the estimate(s) development, approve the estimate(s) prior to issue, and ensure the estimate(s) properly reflects:

a) Project objectives and their priorities
b) Design scope and design specifications
c) Maximizing of quantities and minimizing of factors (numbers of drawings and construction work units)
d) Correct evaluation of design and labor productivities
e) Current project and site conditions (access, congestion, etc.)
f) Proposed execution plan/contract strategy
g) Schedule requirements (economic versus acceleration)
h) Adequate contingency evaluation

As can be seen from the above "definition," the project manager is actively involved in the development of the estimate and is responsible for the final product.

Developing or Checking an Estimate

a) Scope Review

To ensure that the scope definition is of the required quality,

the estimator/project manager should make a detailed review of all basic design documents, their revision numbers, and dates of issue:

1) Check that all major equipment is included and is listed by equipment number.
2) Review all items shown on plot plans, flow sheets, PIDs, and equipment lists to ensure their inclusion in the estimate.
3) Equipment and system capacities, flow rates, temperatures, and pressures should be checked for deviation.
4) Check that owner costs are to be included, or shown separately.
5) Evaluate deviations in the scope, design, or estimating basis from those assumed in the earlier estimate and include these on a "puts and takes" list.
6) Specialist engineers assigned to the project should review and verify the design scope.

b) Project Conditions Review

Prior to developing the line-by-line details of the estimate, an overall evaluation should consider the following.

1) Project location considerations, i.e., site characteristics (high winds, weather, soil conditions) and local affiliate-governmental practices or regulations.
2) Schedule, i.e., start of engineering, start of construction, mechanical completion, and milestone dates.
3) Labor basis, e.g., subcontract or direct hire.
4) Economic outlook.
5) Contracting mode and execution plan.
6) Estimate is compatible with contract conditions.

c) Reviewing Significant Overall Relationships

A comparison should be made of significant relationships including:

1) Engineering man-hours per piece of equipment.
2) Construction man-hours per piece of equipment.

3) Ratio of direct field man-hours to engineering man-hours.
4) Contractor's home office and engineering cost as a percent of total cost.
5) Contractor's fee as a percent of total cost.
6) Indirect construction costs as a percent of direct labor cost.
7) Percent breakdown of engineering man-hours by prime account.
8) Percent breakdown of construction man-hours by prime account.
9) All-in engineering man-hour rate.
10) All-in field man-hour rate.
11) Escalation allowances for material and labor.
12) Productivity factors for engineering and construction.
13) Currency exchange rates (for overseas purchases).

d) Major Equipment and Material

The cost of major equipment can be established by actual quotations or from historical data. The method depends on the type of equipment involved and its relative cost. For example, quotations should be obtained for large compressors, but small mixers may be estimated from catalogues or estimating manuals.

1) Developmental (or growth) allowances for "Fast Track" projects: Estimates based on vendor quotes, catalogue prices, or initial inquiries should include an allowance for future increases in scope. Costs can rise as much as 15% from an original purchase price as a result of design changes. Verify that the estimate has included an appropriate design allowance (typically 5-10%) for future changes. Based on the general specifications and detailed equipment specifications and data sheets, evaluate as follows.
2) Vessels (towers, reactors, drums): Check unit costs; adjust for size, material, shop versus field fabrication, operating temperature-pressure, metallurgy, number of manholes and platforms, internals required, and the need for insulation-stiffening rings and lifting lugs.

3) Heat exchangers: Check the cost per square foot of useful transfer surface.
4) Heaters and furnaces: Check the cost per British thermal unit of heat absorbed. Evaluate the degree of prefabrication prior to field erection.
5) Boilers and superheaters: Check the cost per pound of steam generated.
6) Pumps: Check the cost per horsepower. Pumps of similar capacity can vary greatly in price depending on type and materials of construction. It is important to know all special service requirements and design characteristics.
7) Storage Tanks: Check the cost per barrel capacity and the cost per pound of fabricated weight. Ensure that tank foundations are adequate for duty and soil conditions.
8) Evaluate project-schedule conditions which could influence prices, e.g.:
   i. Market conditions
   ii. Purchasing preference/plant compatibility/maintenance costs
   iii. Schedule acceleration (premium costs)
   iv. Escalation/currency exchange rates
   v. Freight, duties, taxes
   vi. Size of order/quantity discount

Use a "cheapest source" program for guidance on the source for a worldwide purchasing program.

e) Bulk Materials: Quantities and Costs Evaluation

1) Concrete:
   i. Spot-check design quantities for large equipment foundations
   ii. Average cost per cubic yard installed (with rebar, formwork, excavation, and backfill)
   iii. Quantity of rebar, formwork, excavation, and backfill per cubic yard of concrete.

2) Roads and paving: Cost per square foot installed—overall areas from plant layout.
3) Underground piping and sewers:
   i. Total linear feet from drawing layout
   ii. Location and number of manholes
   iii. Cost per linear foot of installed piping, including excavation, backfill, manholes and sumps.

   On large projects, underground quantities are often underestimated.
4) Miscellaneous concrete work: Ensure sufficient requirements for cooling tower basins, API separators, pipe sleepers, culverts, and particularly road and electrical crossings.
5) Fireproofing:
   i. Check the cost per area of surface fireproofed.
   ii. Ensure adequate allowance for cutouts and rework.
6) Buildings, structures: Review individual costs for the substructure, heating, ventilation, air conditioning, plumbing, and lighting as a function of the floor area and total cost. Look at all-in square-foot costs of building.
7) Site preparation:
   i. Review grading and site preparation; check costs per cubic yard.
   ii. Check soil conditions, i.e., type, frost depth, de-watering, sheet piling, and draining requirements.
   iii. Consider possible underground obstructions.

   On large grass roots projects, earth-moving quantities are often underestimated.
8) Piling:
   i. Check the all-in cost per linear foot (including mobilization and demobilization) and the type of piles (e.g., precast, *in situ*, or timber) and the cutting of pile caps.
   ii. Check who does the layout work (the prime contractor or a subcontractor?).
9) Fencing and railroads (usually subcontracted):
   i. Total linear feet.
   ii. All-in subcontract installed costs.

10) Piping estimating methods: Following are four method's of preparing a piping estimate. The specific method would depend on detail and accuracy of the estimate.
    i. "Estimating by Length Method." This method is based on historical data and assumes an average number of fittings and flanges for a "standard" piping configuration. Costs would be on a unit length basis by pipe size and schedule. Fabrication would be separated from field installation. It is necessary to add only the cost of valves, pipe supports, testing, etc. to arrive at a total direct cost for the piping system. Care should be taken to check allowances for unusual complexity of piping arrangements (especially on-site units or revamps).
    ii. "Estimating by Weight Method." In this method, piping materials are assumed to have a value approximately proportional to their weight. Pipe is assigned a cost per pound for material and a number of man-hours per ton for fabrication and erection. Adjustments should be made for unusual materials and labor productivity for the plant location.
    iii. "Estimating by Ratio Method." This method calculates piping as a percentage of the major equipment cost. Ratio methods can be used only with an appropriate data base. This is not a very accurate method and is usually applied to conceptual estimates.
    iv. "Estimating by Unit Cost Method." This method is more accurate but is costly and time-consuming as detailed takeoffs must be made of all labor and material units in the system. This method requires that engineering be well advanced before accurate takeoffs can be produced. It also requires detailed historical data.
    v. "Piping Estimate Review." Examine the method and extent of takeoff by sampling line takeoffs, and compare actual quantities and costs with estimate. Review the basis of fabrication, impact of special materials, etc. Also check the following:

A. Total linear feet and total weight as a function of plant capacity and plant area.
B. Overall cost of pipe, fittings, valves, and flanges to total cost of piping material.
C. Separately, compute the cost per ton for material, prefabrication, and erection of both small- and large-bore piping.
D. Cost per foot of pipe tracing (steam or electrical).

11) Electrical: In estimating electrical work, a schedule of the number and size of motor drives is a basic requirement. Motor control center and power distribution items usually constitute a major part of the electrical work. Since their prices can vary considerably, budget prices should be obtained from potential suppliers. The cost of power cable should be estimated in reasonable detail. A plot plan layout is useful in assessing quantities, while material unit prices may be estimated from historical data. Minor, miscellaneous services, such as emergency lighting, fire alarms, intercoms, power outlets, and telephone systems, can be assessed approximately or represented as an allowance. Plant lighting may be estimated on an area or unit length basis. A gross estimate of electrical work based on horsepower can be inaccurate. The estimate should take into consideration local electrical codes and area classification. Climatic conditions may require a different type of cable and hardware, and therefore could affect cost.

i. Electrical estimate review. Review the motor list against the equipment list and the single-line diagram.

Also check the following:

A. Overall cost of the power supply related to the total horsepower or thousands of kilowatts.
B. Cost of the power supply per motor related to the size of the motor.
C. Lighting cost per square foot, per linear foot, etc.
D. Cost of grounding related to the area covered.

12) Instrumentation estimating methods: The following are those generally used:
    i. Factor estimating. With an adequate data base, instrumentation can be factored relative to the installed major equipment cost. Additional points for consideration are the following:
        A. Local electrical and environmental codes.
        B. Degree of computer control.
        C. Does the plant need clean, dry air? If so, an instrument air compression system may be required.
    ii. Estimating by instrument loops. Instrument costs are estimated at a cost per loop. This can be done by using previous return data to establish costs for typical loops based on instrument type and materials of construction and multiplying these by the number of estimated loops in the system. Loop configurations should be developed by the instrument engineer.
    iii. Total installed cost per unit. In this method, instruments are priced from a preliminary list by means of quotes, catalogue prices, or past data. Auxiliary material and installation costs (e.g., tubing, wiring, racks, supports, testing, etc.) are assessed for each instrument based on past experience and judgment.
    iv. Detailed estimating. This is the most accurate approach and requires a detailed instrument list. This can be priced from past data or quotes. Labor man-hours for each instrument are added. Instrument tubing and wiring should be established by detailed takeoff. Auxiliary material and labor cost can be taken as a percentage of the total instrument cost.
    v. Instrument estimate review. Examine process and instrumentation diagrams for numbers-complexity of instrumentation. Check for conflicts between owner and contractor specifications. Also review the following:
        A. Interface between scope of work for additions to existing plants.

B. Electronic-pneumatic requirements.
C. Total number of instruments related to the number of pieces of major equipment.
D. Ratio of the cost of instrument piping and instrument wiring to the basic instrument cost.
E. Average cost of piping and wiring per instrument.

13) Insulation: Review requirements for heat conservation, winterizing, cold insulation, and personnel protection for equipment and piping. Analyze the cost of pipe insulation as a factor of the total installed piping value.

14) Painting: Not normally large enough to justify a detailed estimate. Review any prorated method and values allowed.

f) Direct Construction Labor

1) Equipment installation (man-hours): A check of man-hours requirement for equipment installation may be made as follows:
   i. Man-hours; per material cost.
   ii. Man-hours per weight and type of equipment.
   iii. Man-hours per piece and type of equipment.
2) Bulk materials installation (man-hours): The following would be major items to check:
   i. Man-hours per cubic yard for excavation (machine, hand, or weighted average).
   ii. Man-hours per cubic yard for foundation concrete (including forming, pouring, reinforcing steel, and embedments). Review dewatering, sheet piping, and shoring requirements for a civil program.
   iii. Man-hours per ton of structural steel (for field fabrication and erection).
   iv. Man-hours per ton or per foot of piping by size and pipe schedule.
   v. Man-hours per valve and specialty item.
   vi. Man-hours per instrument installed (including cable,

termination and testing).

3) Productivity (man-hours): Depending on the quality of the estimating base, the preceding man-hours would normally then have to be factored for time and the location of the project. A geographic productivity system is essential for a quality estimating program. General items (handling, scaffolding, testing, rework, etc.) would be on a man-hour percentage basis for a detailed estimate and included in man-hour rates for a conceptual estimate.
4) Labor costs: Review current labor agreements and conditions, productivity factors, manpower availability, site conditions, and project conditions. Review total man-hours as well as the craft man-hour distribution:
   i. Subcontract versus direct hire; what is covered in the all-in subcontract wage rate, especially field indirects?
   ii. Average wage rate.
   iii. Inclusion of appropriate fringe benefits, taxes, and insurances.
   iv. Allowances for premium pay on overtime and shift work.

g) Construction Indirect Costs

Where possible, ensure that estimates have dimensional sketches showing layouts of temporary facilities which can then be quantified for estimating.

1) Temporary facilities: Review estimates for the following:
   i. Temporary utility lines and utilities consumed during construction.
   ii. Temporary roads and parking and laydown areas.
   iii. Fencing and security.
   iv. Temporary buildings, furnishings and equipment.
   v. Personnel transportation and equipment-receiving facilities.
   vi. Erection-operation of construction camp, if required.

   Most of these items would be estimated on a cost per foot

and square foot basis.

2) Construction tools and equipment: Discuss and check the methods used by the construction group in establishing equipment requirements. Check the following:
   i. List and scheduled duration of all major equipment.
   ii. Small tools (normally estimated as cost per labor man-hour or percent of direct-labor costs).
   iii. Availability of equipment; start and termination of rental period.
   iv. Equipment maintenance, major and minor.
   v. Equipment purchased; equipment rented and source.
   vi. Review of cranage and heavy lift requirements.
   vii. Construction equipment cost per direct-hire man-hour.
3) Construction staff: Examine the site organization chart and assignment durations of personnel; also review the following:
   i. Relocation costs, travel and living allowances, fringe benefits and burdens, and overseas allowances.
   ii. Total staff man-hours related to total labor man-hours.
   iii. Supervision cost related to the construction labor cost.
   iv. Average monthly rate for the technical staff.
4) Field office expenses: Review the estimates of field office supplies, reproduction, telephone, telex, office equipment, and consumables. These items are usually estimated as cost per labor man-hour or as a percent of direct field costs.

h) Home Office Costs

1) Percentage of project costs: This method requires considerable analysis of previous projects, but can provide a reasonable estimate of H.O. costs for a conceptual estimate. Normally, H.O. costs would be expressed as a percentage of the following bases:
   i. Total "constructed cost" (i.e., material + labor + subcontracts + field indirects). A typical range would be 10-15%.
   ii. Direct material and labor (subcontractor or direct hire). A typical range would be 18-22%.

2) Engineering man-hours based on pieces of major equipment: A typical range would be 1000-1500 man-hours/piece of equipment. Factors may be applied to reflect size, complexity, prototype, and revamp work. These man-hours will cover all engineering and design man-hours. Man-hours for services such as planning and scheduling, estimating, cost control, and procurement are derived as percentages of engineering hours.
3) Man-hours per drawing (or work item): This method requires major completion of the process design so that a detailed drawing list can be developed. It is necessary that PIDs, plot plans, and equipment lists be available from which a total number of drawings can then be estimated.
4) Reviewing home office estimate: Review the basis of establishing man-hours with the engineering group. Analyze the following:
   i. Man-hours per major piece of equipment.
   ii. Man-hours per drawing using the estimated total number of drawings.
   iii. Percentage relationship of discipline man-hours for abnormalities.
   iv. Average all-in rate for total home office technical personnel.
   v. Benefits, burdens, and overhead rates.
   vi. Fee basis on reimbursable and cost-plus contracts.
   vii. General specifications for conflict or "gold plating."
   viii. Service group estimates by organization chart, manning schedule, and statistical relationship.
   ix. New technology contingency for prototype design.

i) Contingency

The contingency or estimating allowance is usually a function of the following:

1) Design definition (process unit, off sites, revamps).
2) Estimating methods (data base and level of detail).
3) Time frame and schedule probability.

4) New technology and prototype engineering.
5) Remoteness of job site; infrastructure requirements.
6) Engineering physical progress (percentage complete).
7) Material commitment.
8) Construction physical progress (percentage complete).

Determining overall estimate reliability is made more difficult by the fact that some segments of a project may be completely defined at the time of estimate, and others only sketchily defined; some may be estimated by reliable methods and others necessarily are estimated by methods which produce less accurate results, and so forth.

To cope with this, it is necessary to separately quantify the degree of reliability of the sub-estimate for each of the major independently estimated segments or units of an estimate as a whole. This can be done with the aid of guidelines for classifying degree of definition and quality of methods/data used. These, in turn, establish appropriate estimating allowances and accuracy ranges for each of the segments.

When a project has been approved and work begun, changes begin to take place in facility definition, estimating methods, knowledge of project conditions, and forecast timespan. This entails successive re-appraisals of contingency. It should produce a continuing reduction of estimating allowances.

Estimating allowances or contingency is defined as the amount which statistical experience indicates must be added to the initial, quantifiable estimate, in order that the total estimate has an equal chance of falling above or below the actual cost. This allowance is required to cover oversights and unknowns, which on average, always results in final project costs that are higher than initial quantifiable estimates. If required, estimating allowances may be modified to produce greater or lesser overrun probabilities.

For any individual project in a series of projects, the estimated cost including estimating allowance, will fall under

or over the actual cost of the project. A well-developed estimating system, when applied to a series of projects, produces a pattern of under and overruns which approach "normal" or bell-curve distribution. Overestimate and underestimate amounts are determined by so many unrelated happenings that the results resemble those obtained by chance. Major systematic errors are eliminated in the development of an estimating system, and analysis of departures from normal distribution is one of the tools available for estimating system improvement.

The error distribution of estimates produced by a given organization at a given period in its development will have a wider or narrower spread, or range, depending on factors previously listed. A quantitative measure of this spread is "accuracy range." This is defined as the percentage range, relative to actual project costs, within which eight tenths of the estimates of a given quality will fall. Theoretically, one tenth of such estimates will be outside the range on the high side. One tenth will be outside the range on the low side. When appropriate estimating allowances have been applied, half the estimates will be over actual cost and half under, so that average deviation will be close to zero.

In practice, most companies experience an average deviation which varies 10-20% from the zero level. This means that for an 80% probability, the estimating program has a built-in bias. In general, this is mostly a plus (overrun) bias in the range of 10-15%. In simplistic terms, this means that the estimating program has a +10-15% "accuracy range," which means that more projects (10-15% more) will overrun than underrun, even with the inclusion of an appropriate contingency.

It is important therefore, that a constant analysis be carried out of the actual costs versus the estimate, so that such biases can be detected and corrected.

These elements of contingency and accuracy are often determined by a computer risk analysis program.

j) Escalation

Escalation is usually included as a separate line item or is built into the estimate details. Either method is acceptable, assuming that escalation rates and cost centroids have been developed properly. Escalation rates for material and labor costs should be separately identified. The "cost centroid" technique and application of escalation rates is illustrated with the technique found in the data section.

k) Currency Exchange Conversion

As currency conversion rates can fluctuate widely over the life of a project, it is recommended that one use the rate established at the time of appropriation and track deviations thereafter as a one-line item. Corporate and affiliate financial groups should be consulted when establishing currency conversion rates for the estimate.

Pre-estimating Survey

Figure 6-1 shows the major items to be developed and/or considered prior to developing the estimate.

Estimating Checklist

a) General

In conjunction with the Pre-Estimating Survey, a comprehensive checklist can be a significant aid in insuring that all appropriate details have been covered. The following is not a complete list, but it will significantly assist with the following major considerations:

1) Planning The Estimate
2) Cover All Items
3) Serve As A Base For Your Data Base
4) Particularly, Cover The Three P's-Political-Procurement Process Design

Figure 6-1. Pre-estimating Survey

GEOGRAPHICAL AREA
CLIMATE
SITE ACCESS
SOIL CONDITIONS
EARTHQUAKE FACTORS
SITE ELEVATION
OFFSHORE PLATFORMS
ENVIRONMENT
ATTITUDE OF COMMUNITY
POLITICAL CLIMATE
GENERAL BUSINESS CLIMATE
PRIME CONTRACTOR
JOINT VENTURE
IONIZED LABOR
QUALIFIED LABOR POOL
RECRUITING AND TRAINING
LABOR PRODUCTIVITY
LABOR CONTRACTS
LABOR COST

OVERTIME
PRE-FABRICATE ASSEMBLIES
SPECIFICATIONS
LOCAL CODES
PROCUREMENT
ORIGIN OF MATERIALS & EQUIPMENT
EXPORT PACKING
CONSTRUCTION FACILITIES
TEMPORARY FACILITIES
HOUSING
LOGISTICS
COMMUNICATIONS
WAREHOUSING
GUARD SERVICE
SITE FABRICATION FAC.
CONSTRUCTION EQUIPMENT
MEDICAL FACILITIES
FOOD & CATERING
SANITARY FACILITIES

RECREATION FAC.
SCHOOL
PERMANENT COMMUNITY
SCHEDULE
INFLATION
ESCALATION
CURRENCIES
FINANCING
OVERSEAS PREMIUM
COST OF LIVING
COST OF TRAVELING
TAXES
INSURANCE
LEGAL ASSISTANCE
GOVERNMENT AGENCIES
LETTERS OF CREDIT AND BONDS

LANGUAGE PROBLEMS
LOCAL CULTURES

RETRO-FIT/REVAMP

- HAZARDS-WORK LIMITATIONS
  - —— MEN
  - —— EQUIPMENT
- SECURITY—CLEARANCE—PERMITS
- HEALTH FACTORS
- CONTRACT TRAINING
- STANDBY ALLOWANCE

b) **Political Considerations**

These considerations can be broken down as follows:

1) Local, political and social environment
2) Regulatory, permitting requirements
3) Business environment
4) Tax structure; expense vs. capital costs allocation
5) Overseas—nationalistic/logistics/infrastructure

c) Procurement Program Considerations

A careful review of the procurement program is essential, as the equipment/material costs can be more than 50% of the total cost. The following are typical considerations:

1) Quality Vendors List/Information/Experience of Suppliers
2) Domestic Vs. Worldwide Purchasing Plan
3) Import Duties, Taxes, Delivery Charges (company exception)
4) Currency Considerations and Exchange Rates
5) Vendor Servicemen Requirements
6) Plant Compatibility of Existing Vs. New
7) Ease of Maintenance/Operating Costs
8) Spare Parts Requirements
9) Inspection and Expediting Requirements
10) "Critical" Purchasing Plan (Schedule Priority)

d) Detailed Checklist for Estimating

1. *Climate*
   - Arctic
   - Humidity
   - Temperate
   - Temperature
   - Prevailing Winds
   - Winterization
   - Storms
   - Winters
   - Snow Accumulation

- Rain
- Lost Days Due to Weather
- Shelters Required
- Special Method of Construction Necessary
- Indoor/Outdoor Equipment

2) *Earthquake Factors*

3) *Access*
   - Distance
   - Roads/Water/Air/Railroads
   - Conditions of Roads
   - Clearance of Roads (Tunnels)
   - Capacity of Roads & Bridges
   - Ice Conditions

4) *Offshore Facilities*
   - Water Depth
   - Wind Forces
   - Wave Forces
   - Sea Floor Conditioning
   - Soil Conditions

5) *The Environment*
   - The Attitude of the Community
   - Present & Future Zoning
   - Other Industry in the Area
   - Environmental Restrictions
   - Environmental Impact Study
   - Required Permits—Local—State—Federal—Others
   - Legal Counseling
   - Delays in Obtaining Permits & Associated Costs in Terms of Escalation
   - Requirements for Pollution Control for Noise, Air, Water, Disposal of Waste, and Their Cost
   - Consideration for Alternate Site

6) *The Political Aspect*
   - What is the political climate of the proposed site and the prospect for future stability?
   - Is the governing authority encouraging investment; is it favorable to business; what is the tax structure?
   - For an overseas project, to what degree are governments involved?
   - For an overseas project, what are the terms of payment and are delayed payments probable?

7) *Procurement*
   - What is the source of information about vendors
   - Where are the vendors located
   - How will equipment and material be transported
   - Are there a minimum of three bidders available
   - What is vendor reliability and experience
   - What will be the origin of material and equipment
   - For overseas, what are the import restrictions
   - What is the import duty
   - Is equipment available on reasonable delivery schedules
   - What will be the terms and conditions
   - Any discounts for large purchases
   - Will purchase orders be firm, cost plus, or with specified escalation
   - What are the warranties
   - What service can a supplier provide during construction and operation, and at what cost
   - Provisions for inspection and expediting
   - Export packing requirements
   - Spare parts and their costs
   - In what currency will the purchases be made
   - What is the exchange rate
   - What will be the payment schedule
   - Marshaling yards requirements
   - Loading and unloading requirements

- Lightering Demurrage costs
- Higher costs due to congested harbors
- Will trading companies be used

8) *The Process*
   - What is the plant capacity
   - What are the products
   - What are the by-products
   - Flow sheets available
   - Utility flow sheets
   - The plant layout
   - Plant location
   - Material specs—exotic-standard
   - Mechanical specs: Pressures-temperatures-flows-corrosion

9) *The Process*
   - Local code requirements
   - State code requirements
   - National code requirements
   - Client/engineer's specifications
   - Architectural requirements
   - Metric/English measurements
   - Pollution control

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Chapter 7

Leadership Fundamentals

Barry Benator

So far, we have talked about several important functions of project management. We have discussed how to staff the project team, the fundamentals of project scheduling, the use of computer tools to assist in managing the project and how to successfully manage the technical, schedule and financial elements of a project.

All of these functions are performed by people. Good people, well led, always find a way to make things happen—to overcome the many challenges inherent in any engineering or construction project. The project manager's ability to lead his or her people effectively can have a significant impact on the success of a project.

In this chapter we delve into the *people* aspects of project management, and learn how to lead people in order to arrive at a successful project. For many technical professionals, this is the most challenging aspect of project management. Most technical professionals go into engineering or construction because they enjoy designing things, building things and solving problems. However, as these same people grow in their organization and seek project management responsibilities (or have these responsibilities thrust upon them), an increasing amount of their work will involve leading others to accomplish the many project functions. You may be one of those people.

Leadership can be an uncomfortable topic for some people, especially technical project managers who may have extensive

experience in being a *doer*, but precious little in being a person who is responsible for leading others to get the job done. This chapter will equip you with the fundamentals for being an effective leader in project management.

Are Leaders Born or Made?

You sometimes hear people say "He [or she] is a natural born leader." That is true of some people—just as we hear of natural born athletes, there are also some people who just have a gift that encourages people to follow them.

Leadership skills, like athletic skills, in our population seem to follow a Normal Curve distribution. (See Figure 7-1). There are a relatively few natural born leaders, just as there are relatively few natural born athletes. But here's the good news—just as there are a lot of good athletes who, while not born gifted with athletic skills, work hard and become good athletes, the same is true with leaders.

Almost anyone can become a good leader with hard work, coaching and practice. This chapter will help you unlock the good

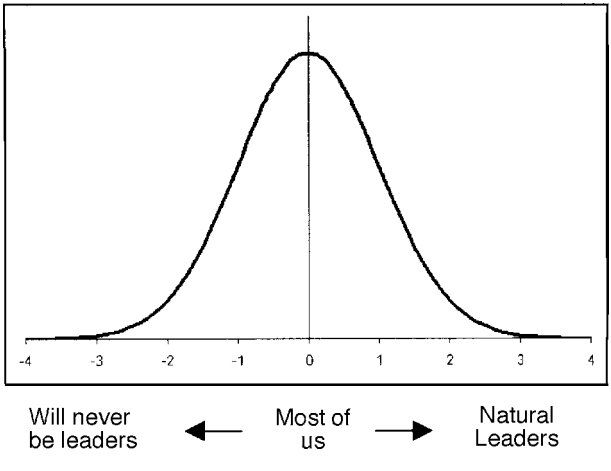


Figure 7-1. Normal Curve

leader within you to succeed as a project manager and leader.

Remember, like any other job function, leadership proficiency can be learned. And just as almost anyone can improve a skill with practice, so can leadership skills can be learned and improved upon with practice.

Making Sense of All Those Leadership Theories

One of the challenges facing leaders today is that there are numerous so-called "correct" leadership theories. A few of the more well-known theories include:

Situational Leadership®
Participative Leadership
Autocratic Leadership
Theory X
Theory Y
One Minute Manager
Many, many more

And these are but a few of the many leadership theories that you may have heard about.

In light of the large number of such leadership theories, it's no mystery why many leaders are confused as they try to make sense of these often conflicting leadership concepts and apply them in the real-world arena of the workplace.

Our position on business leadership theories and models is:

A theory or model is worthless
unless it can be applied in the real world

We believe for you as a project manager, this is the real test of a useful business theory or model—can it be used to help you be a better leader? This emphasis on practical leadership tools will run throughout this chapter.

Outstanding Leader Model

The model we will present in this chapter is based on a scientifically valid blind research study (McBer and Company, 1983) that identified the characteristics and competencies of outstanding leaders. The expression "scientifically valid" means that the research, which was based on interviews with more than 100 leaders, is valid for most of the population of leaders. This validity is important because it separates this model from the many "sound good, but don't work" leadership theories of the week or flavors of the month. It means that you can improve your performance as a leader by effectively doing what the outstanding leaders do to be successful.

Heads-up: Unlike Newton's laws, Ohm's law or other time-tested laws of physics, people are difficult to predict with 100% accuracy. However, this model will help you *increase your leadership batting average.* And that will help you be more effective as a leader of your project team.

Leadership Definition

We are going to be talking about leadership in this chapter, so let's go ahead and define what we mean by leadership. You will see other definitions during your work career, but we'll use this as our definition. It will serve us now, and serve you well in your career as a project manager.

Leadership—The process of influencing individuals or groups to accomplish an organizational goal or mission.

Key points:

- Leadership is a ***process***—it is not a one-time, fire and forget evolution. To be an effective leader, you must continually exercise good leadership skills. You don't need to be perfect, but you should always strive to apply sound leadership principles to your leadership efforts.

- It involves ***influencing*** individuals or groups. Good leaders are effective influencers of others because they know leaders can't do everything.

- Good leadership is designed to *accomplish an organizational goal or mission*. For you, that means leading your project team and managing your project to a high quality, on time and within budget conclusion with a customer who is happy with that conclusion.

Definition of Leadership Competency

We will be talking about *leadership competencies* in this chapter, so it would be a good idea to make sure we understand how the word competency is used in this chapter.

Definition of *Competency*:

A *competency* is any knowledge, skill, behavior, attitude, or trait that can be shown to distinguish reliably between effective and less effective job performance.

In other words, a competency is what superior performers do more often, in more situations, and for better results, than average performers.

Outstanding Leader Competency Model

The outstanding leader competency research identified a set of skills, behaviors or indicators that the outstanding leaders performed or demonstrated that made them outstanding. The researchers then grouped them into the 11 competencies as shown in Figure 7-2.

Figure 7-2. Outstanding Leader Competencies

- **Sense of Responsibility**
- **Positive Expectations**
- **Informed Judgment**
- **Conceptualization**
- **Use of Multiple Influence Strategies**
- **Leader Influence**
- **Conscientious Use of Discipline**
- **Effective Communication**
- **Planning**
- **Initiative**
- **Monitoring for Results**

Details of each of these competencies are discussed in this chapter. The skills, behaviors or indicators associated with each competency are presented with the competency. To get the most benefit of these competencies, you should read and think about each behavior or indicator listed under the competency. Think about the projects and teams with which you have been associated and the leaders of those projects. Contemplate how you would apply the competency and its associated skills/behaviors/indicators in situations you typically encounter in the workplace.

Note: Outstanding Does *Not* Mean Perfect. The outstanding leaders identified in the research were terrific leaders, but they were not perfect. Even the outstanding leaders made mistakes. So, as you apply these competencies, don't expect perfection. You will, however, become a more effective leader as you apply and hone these competencies in your role as project manager.

The Outstanding Leader Competencies:

Sense of Responsibility

There were 11 competencies identified in the research. The researchers noted that no competency was considered more important than another; however, listing Sense of Responsibility first really hits the target about leadership—if the leader is not responsible, nothing else matters, because little else will happen, except perhaps by accident.

- *Takes responsibility for own and team's performance, including failures or problems.*

The outstanding leader has an almost palpable sense of responsibility toward his or her people and toward his or her project. This leader is continually asking "How can we do things better?" When things go wrong, he/she asks "What could I have done to prevent this?" The outstanding leader does hold other people accountable for their roles in the project, but he or she does not automatically blame others when problems arise.

- *Takes responsibility for team's reputation or image.*

The outstanding leader seeks to build team morale and spirit by striving for a strong positive team image. He or she plays up positives; plays down negatives.

For example, if a person on the team or the entire team receives a compliment from a client or other person in the company,

the outstanding leader (PM) would congratulate the person/team publicly and note his or her (i.e., the PM's) appreciation for their good performance. If it is a big enough success, the leader might inform a higher level leader and ask that person to congratulate and praise the persons/team who were responsible for the good performance. This has the effect of showing others what good performance looks like, and instilling in everyone a sense of pride and an enhanced motivation to perform well.

If something goes wrong, the leader focuses on resolving any immediate problems first. Then, taking steps to avoid embarrassing anyone, he/she puts in place processes that will help avoid similar occurrences in the future. This follow-up could include additional training, ensuring the leader's instructions and standards are understood and instituting procedures or other actions that will help minimize the possibility that the same mistake will happen again.

- *Takes responsibility for the safety and well-being of team members in job-related activities.*

The outstanding leader is concerned about and looks after team members' health and safety. This can include furnishing safety equipment for the job, sometimes above and beyond OSHA requirements, as well as other appropriate means to protect his or her project team members. It might include contracting for additional security to accompany people to their car after dark or paying for a taxi home after working late at night or on the weekend. As a result of the leader's sincere interest in the work safety of his or her members, he or she attains a higher level of support and loyalty from his/her team members than would otherwise be the case. Wouldn't you feel a stronger sense of loyalty and commitment to a leader or firm that looked after your safety above and beyond the minimum?

- *Takes actions to support the member's responsibilities toward his/her family.*

The outstanding leader understands team members have a life outside of work. While the outstanding leader holds people accountable for their work performance, he or she is supportive when a team member has family needs. Examples include:

- Time off for personal crises

- Phone calls to check on a sick family member

- Shifting work load temporarily to meet a temporary crisis

- Thank you note to spouse or family thanking them for their support of an associate during a period of long and/or hectic work hours. An alternative form of this appreciation might be a special effort at a company function such as a picnic to praise the work of the associate to the spouse, child or other family member of the associate.

You may think that some of these actions are coddling of employees and that some will take advantage of you. Of course there will always be a few employees who will try to take advantage of your good will. But the research shows that a large majority of employees truly appreciate this kind of support by their leaders and tend to give that discretionary effort above and beyond the minimum necessary to hold their job. Think about your own reaction if your boss showed you the kind of respect and support we're talking about here. Wouldn't that motivate you to give extra effort in your job?

As for the employees who do try to take advantage of your efforts to implement this competency behavior, deal with them on a case by case basis. You don't need to buy-into any anyone's efforts to take advantage of your efforts to support your team. But you also don't want to spoil it for the good people by not implementing this competency behavior.

The bottom line is this competency pays BIG DIVIDENDS in morale and commitment to the project and project leader.

Positive Expectations about Their People

The outstanding leader starts out with a positive mindset about his or her people. His or her positive expectations are based on respect for people's dignity and self worth. The expectation is that when people are treated well they will do well. It's not an unrealistic pollyanna view of their people, but rather a positive bias that is sensed by the team members and which tends to instill a sense of wanting to live up to the expectations of the leader. The following are ways in which outstanding leaders display positive expectations toward their people.

- *Has a strong conviction that subordinates are valuable resources.*

Good leaders listen to their people. They provide feedback to people on their input. The outstanding leader understands that he or she does not know it all. One outstanding leader put it this way "I try hard, but I'm not God. I don't have all the answers. Sure, I make all the major decisions, but I take full advantage of the experience and ingenuity sitting out there."

And when people are treated as intelligent adults with something to contribute, it builds their self-confidence, morale and project commitment.

- *Acknowledges a person's strengths as well as shortcomings (balanced perspective—avoids halo or dirtbag labels about people).*

No one is all good or all bad. When a person has performed poorly, it's easy to condemn him or her overall. Similarly, one good performance might produce the "halo effect"—the idea that the person can do no wrong.

The outstanding leader takes a balanced approach to assessing people. He or she doesn't hold well-intentioned mistakes against persons (unless they are excessive). Similarly, the outstanding leader recognizes that the "star" performer may have gaps in his or her skills and seeks to help fill those gaps through training, coaching, etc.

- *Directly expresses to people the belief that they can and will succeed.*

When a leader is positive about his/her people—"Betty, I know you'll do a great job on this project"—it has the effect of elevating the person's performance to meet the leader's expectations. The person is inclined to not let the leader down. Just think about your own reaction to someone you respect who expresses confidence in you. Don't you want to live up to that person's expectations?

Informed Judgment

Even the best managed and led projects encounter bumps along the road to success. Sometimes, it can be very stressful for everyone, especially the leader. Some leaders react inappropriately to setbacks by "tripping out on overload" and begin screaming, pointing fingers and denigrating the people he or she thinks caused the problem(s). Even worse, the leader may take out his/her frustrations on anyone nearby. The outstanding leader on the other hand tends to keep a cool head, press for the facts, strive for objectivity and seeks to reach sound conclusions.

- *Forms opinions and makes decisions on information and the identification of available facts.*

The outstanding leader doesn't rush to judgment. He or she is not a "screamer" and stays calm when others are crisising. This ability to stay calm in stressful circumstances, when chaos and confusion are swirling all around, promotes confidence in the leader by his or her people and others around him/her. This results in everyone being able to focus their energies on finding the best solutions rather than responding to the leader's rantings or finger-pointing.

- *Makes decisions or draws conclusions using data and information from own and others' experiences.*

While taking responsibility for his or her actions, the outstanding leader knows he or she doesn't know everything, and does not hesitate to obtain input from others. The leader encourages input from team members to help make better decisions. In seeking this input, the outstanding leader may have to work hard to build trust because some team members may have previously worked for a screamer, and thus may be reluctant to give the leader their input for fear of ridicule.

Over time, as you apply the principles in this chapter, you will earn trust from your teammates that will allow you to overcome any reluctance people may have to give you their frank input.

Conceptualization

This is what I call the "connect the dots" competency. It allows the leader to take different cues and organize them into wholes (concepts). It allows the leader to see patterns and sort relevant information from irrelevant information. The indicators or behaviors associated with this competency are listed below.

- *Identifies multiple causes for an event, situation, or behavior (e.g., a late deliverable).*

This indicator or behavior says that if something happens on the project, the outstanding leader will seek more than just the simple or seemingly obvious reason(s). An example might be a person on your project team who seems to miss deadlines more than you find acceptable. Instead of assuming that this person does not appreciate the importance of deadlines or doesn't care whether he or she meets them at all, the outstanding leader will dig into the "whys" of the unacceptable behavior. Reasons might include a combination of the following:

— Person is overloaded with work
— Leader has not explained the importance of meeting deadlines
— Person has not been properly trained

— Person is incompetent
— Person may be receiving late input from others

Whatever the reasons, the outstanding leader will utilize this behavior or indicator to get to the bottom of the situation.

- *Interprets meaning of nonverbal cues—(a facial expression, a walk, a slouch).*

The outstanding leader looks behind words for true meanings and understandings. For example, the leader may ask a project team member, do you understand the instructions?" The team member may answer "Yes." But the way she answered yes; i.e., with a pause, furrowed brow, uncertain expression, suggests the real answer is "I'm not sure."

Because you know about this competency and spot the disconnect between the employee's words and his or her body language, you might say something like "It doesn't look like you're sure. Would you like me to explain it again or show you what to do?" This can offer the employee an opportunity to ask for clarification without feeling like you will think he or she is slow.

- *Identifies trends in events or patterns of behavior.*

This skill requires the ability to identify trends and patterns; i.e., when things are improving or when things are going the other way. The outstanding leader asks why, and begins to reinforce the good, and identifying changes to fix the bad. An example of this skill might be the results of your efforts to reduce shipping costs. You notice that your team has successfully implemented a program to complete tasks earlier than before and thus be able to take advantage of lower 2- and 3-day shipping rates. The outstanding leader's appropriate response would be to thank the team for their efforts in reducing shipping costs and perhaps even taking them to lunch or find some other ways of rewarding their positive contributions to the project.

Another example of this outstanding leader behavior is when the leader notices when something is not part of a trend or pattern. For example, a normally cheerful person appears troubled. The outstanding leader would spot this, inquire as to what is going on with that person and take appropriate action.

- *Identifies commonalities or patterns between old and new situations.*

The outstanding leader is a good learner. He or she is able to learn from the past and apply lessons learned from previous events to new, but similar situations. In other words, the outstanding leader avoids reinventing the wheel.

- *Identifies key differences among situations or between opposing viewpoints.*

At the same time, the outstanding leader recognizes key differences among situations that may, on the surface, appear to be the same. An example might be an increase in days receivables outstanding (increased accounts receivables collection period). The last time this occurred was because the accounting department was sending incorrectly formatted invoices to the client. Instead of assuming this is the case again, the outstanding leader would investigate what is happening in order to identify the actual reason(s) for the delay in payment. He or she might then find that the customer has assigned a new accounts payable person for your company and she has not received training on how to handle your invoices. Appropriate action can then be taken in concert with the customer's PM to correct the situation.

- *Grasps and communicates ideas or situations through the use of metaphors and analogies when appropriate.*

"If we don't fix this problem, the customer is going to walk." (In other words, we will lose the customer if we don't fix the

problem.) Unless physically handicapped, the customer can probably walk now, but to emphasize that the customer will walk away "from us," this would be an example of how the outstanding leader might utilize this competency behavior.

In the South, a common metaphor for letting a person know that his or her reasoning does not ring true with the listener is when the listener says "That dog won't hunt." In other words, "I don't buy your argument."

Use of Multiple Influence Strategies

Recall that in our definition of leadership, *influencing* was the operative word. The outstanding leader uses a number of strategies to influence those on his or her project team as well as others within and outside the organization.

- *Establishes credibility as a leader by displaying own expertise and professionalism—(competence).*

The outstanding leader does not need to be the best at a particular skill set (e.g., best engineer, best electrician, best mechanic), but he or she does need to be perceived as a competent practitioner of the skill by his or her staff. This allows leader to be accepted as a teacher or critic by his or her project team members.

It is important to understand that the longer one functions as a project manager, the less technical expertise he or she is expected to have. So don't worry if your technical skills are not what they used to be—your job now is to manage projects and lead people, not be lead engineer or lead mechanic.

- *Leads by example. Influences by consciously modeling expected behavior.*

The outstanding leader understands that if others are to perform up to standards, the leader must model those standards and expectations. In other words, the outstanding leader must walk the talk. Everything the leader does is observed by his or her

people. Even when the leader thinks no one is watching, people are looking to him/her for guidance on how to act.

If you preach attention to detail or meeting commitments, and yet you are loose on details or frequently miss your commitments, you can't expect to inspire others to perform up to your stated standards. They may do just the minimum to avoid disciplinary action, because they see you do not walk your talk.

- *Influences by appeal to higher purpose—(customer, team, company, family).*

"John, it's important that you be respectful of our customers or we may lose them. That would hurt career opportunities for not only you but the entire team." This is another influence strategy that the outstanding leader can use to influence his or her people. It brings in others in the lives of his/her people, and provides additional motivations for his or her people to perform well.

- *Structures situation or environment to influence people's attitude or behavior—(more or less formal, as appropriate).*

You may take over a low-performing team with a "don't give a hoot" attitude. As a result, you may decide that a formal, structured environment may be appropriate. You set standards, hold people accountable for their performance and take quick action when standards are not met. It is likely that under these conditions, you will not win "Most Popular Manager" accolades, but you will in fact be sowing the seeds for a successful turnaround. In turn, you will build pride and positive morale as people realize they are improving and becoming a high performing team. Then, after they start performing well, you may choose to relax the environment to reward them for their improving performance. (We recommend you read *The Situational Leader* or attend a workshop on *Situational Leadership*® for additional information on this skill.)

Another thing you might do to structure an environment is to

move out from behind your desk to talk to someone. You will appear less intimidating and perhaps encourage the person with whom you are speaking to be more at ease during the conversation.

- *Builds and maintains relationships—(customer, boss, other leaders, etc.) for the purpose of accomplishing organizational goals.*

You can't succeed alone. No one can. The outstanding leader builds supportive, trusting relationships up, down and across the chain of command. He or she helps others achieve their goals and as a result, when they need help, others are glad to help.

An example of how you might implement this indicator is supporting another project manager who comes to you to borrow a piece of equipment or use one of your best people for a task. While it will require some adjustments on your part, you find a way to help your colleague. Then when you need help (and you will eventually), he or she will likely do most anything to help you because you were there to help when he/she needed it.

Leader Influence

Similar to the previous competency, this one involves the leader invoking his or her stature as project manager to influence others in a very personal way. It can be considered "close-in" influence.

- *Leader visits shops or work areas, or otherwise makes self available or visible with the express purpose of showing interest, concern, or appreciation (MBWA).*

The outstanding leader does not stay closeted in his/her office. Exactly the opposite, the outstanding leader gets out and about to say hello to those in his or her group or team, thank them for their work, ask about their family, etc. They practice MBWA: "Management by Walking Around." If they catch someone doing a good job, they compliment them right then.

This walking around time is also a great opportunity to ask about family members of the people on your team or about other coworkers. You might inquire about a sick child that you are aware of, or how a spouse is doing in a new job. The key thing is the outstanding leader is interested in his or her people beyond the workplace and shows his/her interest using this competency behavior.

- *Leader uses symbols to increase morale, loyalty, or a sense of belonging to the project or team.*

This will vary with the individual team. Examples might include a team golf shirt with company or team logo, baseball-type cap with logo, coffee cup with person's name on it, etc.

Another way to effect this indicator is a classy welcome-aboard plan for new hires. Just think, how would you view a company or leader who, when you reported for work on your first day on the job, had your desk already set up, with basic office supplies, a phone ready to go and a switchboard operator who knows your name and extension. Add to that a balloon tied to the chair welcoming you to the firm, and you have the makings of a very excited employee who starts off with a very positive feeling about you and your firm.

- *Leader publicly recognizes superior individual or group performance.*

One of the most powerful ways a leader can influence his or her people is to recognize and praise good work by his people. Even improvement over previously unacceptable performance can be praiseworthy. Praise is a powerful motivator and the outstanding leader is generous with it, WHEN IT IS EARNED. Praise when not earned diminishes the value of it for everyone and ceases to be a motivator.

How might this be actually performed in the workplace? There are many ways—first of all a simple thank you for a good result or even a good effort. Stopping by a person's desk to let

them know you heard from the client that they had solved a problem for the customer and you appreciate it. This kind of praise gets around the workplace within microseconds, and has the effect of motivating not only the person who performed the good deed in the first place, but also his or her teammates who now know they will be recognized for their good work.

Public attaboys/attagirls/attateams, promotion ceremonies, award ceremonies, employee of the week/month, etc. are all ways to recognize excellent performance. You have probably seen others. The point is *don't let good performance go unrecognized*, even if it is simply a sincere thank you in the hall. Of course, you will want to keep a record of the good work by your people so you can reward them at performance appraisal time.

You can increase the power of your praise when, for special recognition occasions, you have your boss or a senior level leader present the letter from the customer (or whatever other document might be involved). Most leaders are glad to do this and it can be an additional motivator for the individual receiving the recognition as well as others on the project team who see it rendered.

- *Communicates standards and expectations through consistent reinforcement of project and company standards (e.g., mission statement, core values.) These standards are reinforced in words, at gatherings, at promotions, meetings, etc.*

The idea behind this behavior is to use appropriate opportunities to restate and reinforce the company's and your project values and standards. For example, if someone is recognized because they received a letter of praise from a customer, in the ceremony presenting that letter, the leader could discuss how this employee not only distinguished him or herself, but also reflected the core value of strong customer service to your firm's customers. You could also note how this above and beyond performance will help us receive additional work from that customer and good recommendations from that customer as we try to attain additional work. This reinforces in everyone's mind the importance of the customer in our operations.

Conscientious Use of Discipline

One of the more difficult things for a leader to do is hold people accountable for results. Almost no one wants to be the "bad guy." We all would rather pat someone on the back for a good job rather than discipline someone. But it's an inescapable truth that one facet of a leader's job is to hold people accountable for results and to enforce company standards.

This competency deals with the fact that the outstanding leader will use discipline where warranted. But as the title of the competency implies, it is *discipline governed by conscience*. It is not wild raving tantrums or subtle psychological torture or attacks on a person's dignity (e.g., "John, you're worthless." or "Mary, why can't you do anything right?"). Rather it is the outstanding leader's attempt to help a person who is not performing well to rise up and meet or exceed accepted company and your project standards. It is also the leader's intent to let others on the project team know that continued substandard performance will not be tolerated. It does not take long for resentment to form against the leader if project team members see an employee frequently falling short of performance standards and suffering no consequences. They naturally feel "Why should I break my neck covering for Jane's poor performance when my leader knows what is happening and won't take appropriate action to correct the matter?"

The power of a project manager to exercise disciplinary power varies with each organization. In many organizations, the project manager has no direct line control over his or her project team members. In this situation, any discipline involved will likely need to involve the individual in question's direct supervisor. But regardless of the organizational relationship between leader and the employee, the leader cannot escape the responsibility of ensuring his or her people perform their jobs up to standards. *Hoping* won't make a discipline problem go away; the leader needs to take appropriate action. Below are the behaviors associated with outstanding leaders with respect to this competency.

- *Enforces company and project standards.*

The outstanding leader does not let standards be violated with impunity. These standards could be related to the way the customer is treated, the quality of his or her engineering calculations, the ability to meet project schedules, and so on. If standards are missed, however, the outstanding leader does not come down hard on the employee the first time or possibly even after several times. Rather, he or she will coach and counsel the employee to help that person succeed in their job. Often times the failure of an employee to meet standards is not the fault of the employee. Rather it is a result of a failure of leadership to ensure the employee is properly trained and led to success.

- *Despite a concern for the individual's future, the outstanding leader will exercise disciplinary power when harm to project or team appears likely.*

While concerned about the individual, the outstanding leader will not let one person harm the whole team or adversely impact the customer or firm. If necessary, the outstanding leader will remove the person from the team or project. This is a judgment call and should not be taken without your boss being on board and your human resources representative being consulted. Many organizations have what is called a "progressive discipline policy" that governs discipline matters. This typically includes verbal warnings, written warnings, a final warning (in which the employee is specifically told that if his or her performance fails to meet standards within a specified period of time, he or she will be terminated from the organization) and ultimately, dismissal from the company.

Effective Communication

It is impossible to lead people if they do not understand you. Poor communication between the leader and his or her people can lead to lack of understanding of the mission, values, standards

and expectations of the leader and the organization. Take a moment to think back to the times when things did not go as well as you or someone else thought they should. How many of these instances can be traced to miscommunications? This is why this competency appears on the list of outstanding leader competencies.

Listed below are the behaviors and skills associated with this competency. Chapter 8 provides additional information about effective communication skills. You can use it to help you improve your communication skills on the job and elsewhere.

- *Explains why, shares information, communicates the purpose of decisions.*

Research shows that people will give greater effort and commitment when they understand the "why" of a decision. Whenever possible, the outstanding leader will bring his or her people on board with the "why" to gain greater commitment and support.

- *Takes steps to ensure that people absorb what is communicated to them—(non-verbal cues, repeat-backs, observation).*

The outstanding leader will use more than a simple "Do you understand what I said?" to check for understanding. He or she will look for understanding in the person's eyes, asking for repeat-backs, monitoring their performance, etc. to ensure the communication has been effective.

- *Tailors communications to people's level of understanding—(college educated, high school education, etc.).*

The outstanding leader will tailor words, vocabulary and phrasing to the education and training level of the people with whom he or she is communicating. Some people are auditory learners; some are visual learners, etc. The outstanding leader knows how his or her people learn best and communicates in a way that works best for each of them.

Myers-Briggs Type Indicator® (MBTI®)—
An Effective Communication Tool:

One of the most effective tools for facilitating communication and understanding between people is the Myers-Briggs Type Indicator (MBTI). Although not a part of the McBer and Company research, the MBTI is a validated, research-based instrument that has proven to be highly successful in helping individuals and teams communicate more effectively with each other. We recommend you look into this powerful tool for your team and your firm. Information can be found on the Internet or you can contact the author for additional information.

Planning

One of the most boring things for many people to do is plan. Very few managers jump out of bed each day and say "Hot dog! I am so excited—I am going to be planning most of the day!" Did you? You may smile at this thought, but planning is one of the most important functions a leader can do. While it may not be as fun and exciting as analyzing a building's energy usage, designing a mechanical system or receiving and installing a piece of equipment at a construction site, the outstanding leaders do it well. The skills associated with this competency are presented below.

- *Plans beyond the demands of an immediate situation or problem.*

The outstanding leader hates crises and looks ahead, way ahead, to put plans and systems into place to avoid them. It's tough to eliminate crises, but you can reduce them and manage them more effectively with sound planning.

- *Sets priorities*.

The outstanding leader understands that not everything can be a top priority. He or she uses his or her skills and those of his/her people to set priorities, so that the right level of effort and intensity is focused where it needs to be. Another way of saying the same thing is *first things first*. In other words, the outstanding leader first determines the right things to do, and then sets about doing those things right. Everything can't be number one priority.

- *Identifies obstacles to progress and plans work-arounds.*

Because the outstanding leader tries to stay ahead of the crisis curve, he/she identifies potential obstacles to mission accomplishment well before they become crises. For example, the outstanding leader looks ahead to potential obstacles to mission accomplishment, such as vacation schedules of key people, scheduled equipment shutdowns for maintenance, bad weather, etc. The latter can affect a tight project schedule by reducing the workdays available to the project. In Florida, for instance, a planned 3-5 day "hurricane" work stoppage may be appropriate. In the North, appropriate snow days might need to be factored into the schedule.

- *Matches people to jobs to get the best performance.*

Outstanding leaders seek to staff their teams, projects, or departments with the right people. They know the strengths and weaknesses of their people and assign them tasks that allow them to accomplish the mission. They also assign tasks that stretch the capabilities of their people so they can grow and help themselves and the organization.

Another way of thinking of this skill is "Put the square pegs into square holes and the round pegs into round holes." Some people are better at some skills than others. That's why we have mechanical engineers, electrical engineers, civil engineers, electricians, construction managers etc. Some people are better at details than others. Some people work better with the customer than others. The outstanding project manager will seek to staff his or her project with people that meet project needs and assign these people to tasks best suited for their capabilities and interests.

- *Identifies, and lines up in advance, resources (programs, people, funds) needed to achieve an objective.*

Continually looking ahead, outstanding leaders actively seek out the resources they need to accomplish their assigned

mission(s). It could be a top programmer, a top engineer, the right technology, etc. If resources are not available within the organization, the outstanding leader will look outside to meet his or her resource needs. Whatever route the PM takes, he or she identifies needed resources early and then takes steps to obtain them.

- *Develops an action plan to reach an objective.*

The outstanding leader does not rely on "seat-of-the-pants" planning. He/she puts together appropriate plans with tasks, people, resources, timeframes, etc. to ensure the job gets done on-time and in a quality manner. In doing so, he/she consults with the people who will have to carry out these plans to obtain their input and commitment to accomplishing the plan. In addition, he/she does not keep these plans secret—barring competitive or other concerns, they are published so all who need to know are informed about them.

Initiative

The outstanding leader is proactive. He or she doesn't wait to be overtaken by events—he or she *makes* the events.

- *Introduces new ideas or new procedures to the team.*

The research found that the outstanding leader is not bound by "we've always done it this way" type of thinking. He or she seeks new and better ways of accomplishing the mission and encourages others to do the same. He or she is quick to recognize those who contribute to the team with good ideas and concepts.

This indicator might be demonstrated by the outstanding leader soliciting ideas from his or her team on how to best solve a problem, improve productivity, meet a schedule, deal with a difficult customer, etc. It's an understanding by the leader that he or she doesn't know it all, and values the input from his or her team or people outside the team.

- *Shares good ideas or better ways to proceed with other teams.*

The outstanding leader is a team player among his/her colleagues. He/she shares good ideas and procedures with his/her fellow PMs and leader teammates. This, in turn, increases the level of trust and teamwork between his unit and other units, results in other PMs sharing their good ideas and raising the level of performance for all teams in the organization and benefiting the organization as a whole.

- *Acts quickly or immediately to resolve problems.*

The outstanding leader does not let problems drag on. He/she aggressively attacks problems to fix them before they turn into crises.

Too many leaders let problems persist and "try to ignore them away." Unfortunately, most problems do not lend themselves to being ignored away. Yet these same leaders will complain about the problems without taking appropriate corrective action. The outstanding leader takes timely action to correct problems and then moves on. As a result, the leader can focus his or her attention on other important issues rather than continually being dragged back to the same problems over and over again.

- *Persists in overcoming obstacles.*

No good leader is a quitter. The outstanding leader is persistent in pursuing his or her goals! He/she will not be stopped by obstacles in his/her path, and will go around them, over them or through them to accomplish his/her goals. In addition, the outstanding leader instills this persistence in project team members, so they learn to overcome obstacles in their work.

Monitoring for Results

Project managers are responsible for results. Outstanding leaders use the following means to determine if they have achieved the results they are seeking, and to identify actions necessary to attain the desired results.

- *Gets out of the office, actively observes work progress, seeks and collects performance information.*

This indictor is as much an art as a behavior. The outstanding leader does not stay closeted in his/her office or glued to the phone or computer. He or she gets out and about, observes work performance, talks to people (without spying on them) and gathers data and information on performance.

- *Evaluates performance.*

With the data from the previous indicator, the leader evaluates performance. Did we meet goals? Why or why not? How does customer feel about our performance? What can we do better next time?

It's a continual assessment of "how are we doing now, and what can we do better?" An analogy might be setting a course in a ship and then monitoring the compass to ensure we are on the right course. Appropriate rudder is applied to ensure the ship is traveling in the right direction.

- *Sees the information provided by own staff, customer, business partners and other feedback as meaningful and useful. Acts on that information to improve performance.*

The outstanding leader values feedback that will help improve his project and/or improve his people. Even if the feedback involves a criticism of the leader, he or she is not defensive, nor does he or she "kill" messenger. The leader expresses appreciation for that feedback and takes steps to implement the parts of the feedback that will improve the project.

Summary

We have presented the results of the Outstanding Leader Competency research and have tailored it to the challenges you face or will face as an engineering or construction project manager. It is important to understand that the information presented

in this chapter is not based on the latest touchy-feely fad of the week or flavor of the month. The information provided is based on sound research about what outstanding leaders do that make them so effective. The message is that if you do these things you will be a more effective leader.

Case Study

To help you put into practice the principles and competencies we have presented in this chapter, a case study reflecting an actual real-world work situation is presented in the pages that follow. In the left column is the story pretty much as it played out in real life (with names changed, etc.). On the right side of the case study are horizontal lines indicating where you should write in the competency that was demonstrated (or in a few situations, poorly demonstrated).

The best way to benefit from this case study is to read the case study through once or twice to get a feel for what is going on. Then, using the information in this chapter (open book, because life is open book), go ahead and write on the lines the competency(ies) you believe are demonstrated in the text to the left of the lines. Do this throughout the entire case study. To get you started, we have filled in the competencies for the lines corresponding to the second paragraph, beginning "Betty met with her new boss…"

When you have competed the exercise, you can look at the Answer Key following the case study where a set of answers (competencies) are presented. These competencies are based on the actual competencies the leader (Betty) exhibited, the author's experience, and input from others who have reviewed the case study. Likely, your responses will be similar to ours, but do not be overly concerned if you have some different ones. You may see something we didn't. After you have reviewed the answer key, go back over your answers and this chapter. See if you can clarify in your mind how Betty accomplished what she did and how she utilized the outstanding leader competencies to be successful.

LEADERSHIP COMPETENCIES
CASE STUDY
(Refer to organization chart on last page as you read)

The Story	*Competencies Exhibited*
Betty Johnson had been leading a group of five engineers in *Engineering Excellence, Inc.*, an engineering consulting firm. Recently she was asked to take on a new assignment as Manager of Corporate Administration for the company. In this position, Betty would be responsible for the corporate headquarters administrative staff, the headquarters phone system, the technical support of more than 250 computers in the company, and all legal and contractual matters for the company.	
Betty met with her new boss, Bill Dallas, to discuss her new duties. Bill had a reputation for being a good manager and Betty's meeting with him indicated he would be very supportive in helping her succeed. He told her that she had her work cut out for herself—it seemed to him that he was receiving complaints about all her functional areas every hour-on-the-hour and sometimes more often. She knew this was going to be a challenge.	Effective Communications. (By Bill), Positive Expectations _____ Informed Judgment _____ Conceptualization___
After discussing her various duties with Bill, she realized she had a tiger by the tail. Where to begin first? Betty asked Bill which should be her highest priority. Bill said, smiling, "they're ALL high priority, but your highest priority has	_____

to be straightening out the dismal performance of the corporate administrative assistant (AA) group. Let me know what I can do to help you."

After completing her welcome-aboard meeting with Bill, she set out to learn more about the AA group. This group was comprised of seven administrative assistants (AAs) whose primary duties were word processing for headquarters staff. The group was led by an Administrative Supervisor. Betty talked to a number of (internal) customers of the group and learned that there was almost universal disdain for the group in the company. The AAs, who were the primary word processing resource for headquarters staff, frequently missed deadlines, delivered sloppy work product to their internal customers, and feedback from both clients and internal customers indicated the receptionists were sometimes rude on the phone. Betty took her Administrative Supervisor out to lunch to get her input on the situation.

The Administrative Supervisor, Lisa Wilson, was not encouraging. She called the AA group "the administrative staff from hell." (This troubled Betty because she tended to think highly of people, but she held her tongue so as not to intimidate Lisa or put a damper on her willingness to communicate.) Lisa then recounted a number of problems she faced in trying to get them to perform—she had counseled them, met with them, tried to show them what to do, etc. Nothing seemed to work. "Oh boy," Betty thought, "this is

going to be rough." While Betty was unsure of her plan as of now, she did know she wanted to try to set a more positive tone in the group,and asked Lisa to stop calling her people"the administrative staff from Hell." Betty said, "I think they're better than that, and I want us to think of them in a positive manner."

After gathering all this information, Betty spent some time sorting through the data. She also drew upon her own experiences with the AA group. Betty believed that the group was comprised of basically good people who, for whatever reason, were not performing. She decided the next step was to meet with the group and get the issues on the table to get their side of the issues before formulating a plan of corrective action. Betty had Lisa set up a meeting with the AAs to discuss goals, standards and performance expectations.

In the meeting with the group, Betty said she was pleased to be associated with the group. She told the members that as a former customer of the group, she knew they were good people, capable of good work. She also told them that their reputation in the company was not good (and she saw several of the AAs nod in agreement). She asked them what they saw as the reasons for that. She was not prepared for what she heard.

Almost simultaneously they started complaining about the workload, the unreasonable demands being placed on

them, how nobody appreciated their work, how demanding their customers are, etc.—a real pity party. After letting them vent, Betty sized-up the situation and decided the way to handle this was to obtain more information from them and develop a plan of action as to where to go from there. When things quieted down in the room, she asked for specifics. Each AA had a story to tell and Betty listened intently. She asked questions to ensure she understood what was being told to her. During the discussion, a picture started to form in Betty's mind as to what this was about.

Betty realized these AAs weren't being asked to do an unreasonable amount of work. Their workload was typically a steady level, with short periods of intense activity and other periods of lighter activity. The plain fact was these people felt sorry for themselves, and were blaming their customers and others for their failure to perform. And, unfortunately, Lisa didn't seem to grasp this. (Betty decided she would talk with Lisa later about the plan to improve performance, but right now Betty believed it was important to state clearly what her expectations were for the group and get them calibrated as to the standards they would be expected to meet.)

After everyone had their say, Betty said she understood how everyone felt, but that "having talked with a number of *our customers*, and having listened to the group today, we need to do a better job of serving our customers. This group is not

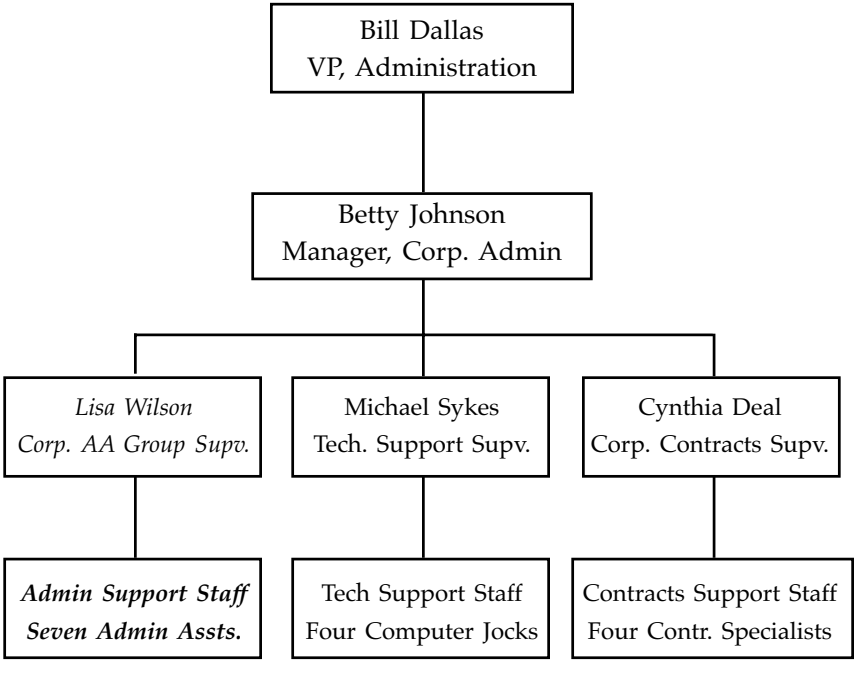
overworked; we're under-performing. And we can do better—**you** can do better. I have worked with each of you before, and have seen the good work you can do, so I know you have the ability to do it. Now we just need to develop a plan to turn our performance around and become consistently strong performers. I'll work with Lisa and she'll work with you to develop a plan and some milestones, so we can measure our performance along the way. It will take hard work by all of us, but I have confidence that this group can become the best admin group among all the companies in Atlanta." The meeting ended shortly thereafter.

After a very difficult three-month period of training, providing people feedback on their performance and holding people accountable for standards, this group set a new standard of performance. Assignments were completed on-time, quality was higher and improving, there was a strong sense of customer service focus, and morale had never been higher. The true measure of their achievement occurred when three of their most vocal critics told Betty after a particularly difficult assignment, "this was the best performance of the admin group I have seen at our company in more than two years."

Throughout the come-back process, Betty and Lisa met frequently with the AA staff and gave them feedback on how they were performing. When the group was consistently performing up to high standards, Betty and Lisa wrote memos to each star performer (with copy

to his/her personnel file) commending each on his/her excellent performance and quoting what the managers had said. The group developed a strong sense of pride and continued its top performance with minimal supervision from Lisa.

Case Study
Organization Chart



LEADERSHIP COMPETENCIES
CASE STUDY—ANSWER KEY
(Refer to organization chart on last page as you read)

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After discussing her various duties with Bill, she realized she had a tiger by the tail. Where to begin first? Betty asked Bill which should be her highest priority. Bill said, smiling, "they're ALL high priority, but your highest priority has to be straightening out the dismal performance of the corporate administra-	Informed Judgment, Conceptualization Planning (Setting Priorities)

tive assistant (AA) group. Let me know what I can do to help you."

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Initiative, Informed Judgment
Informed Judgment
Effective Communic.
Informed Judgment
Initiative, Informed Judgment Influence Strategy

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Non-positive Expectations (By Lisa)
Pos. Expect. (Betty)
Effective Communica.
Conceptualization

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Effective Communica.

Positive Expectations

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Informed Judgment

Positive Expectations

Effective Communica.

Informed Judgment

Planning

Influence Strategy,

Effective Communica.

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Effective Communica.

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Effective Communica.

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Effective Communica.
Conceptualization,
Informed Judgment
Planning
Effective Communica.
Informed Judgment
Conceptualization

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Conceptualization
Conceptualization (by Betty, not by Lisa)
Effective Communica.
Planning to meet stds.

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Effective Communica.
Effective Communica.

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Positive Expectations
Planning
Effective Communica.
Monitoring for Results
Positive Expectations

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Monitoring for Results
Conceptualization (trend is up in quality, customer service and morale)

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Monitoring for Results
Effective Comms
Leader Influence (Recognition)

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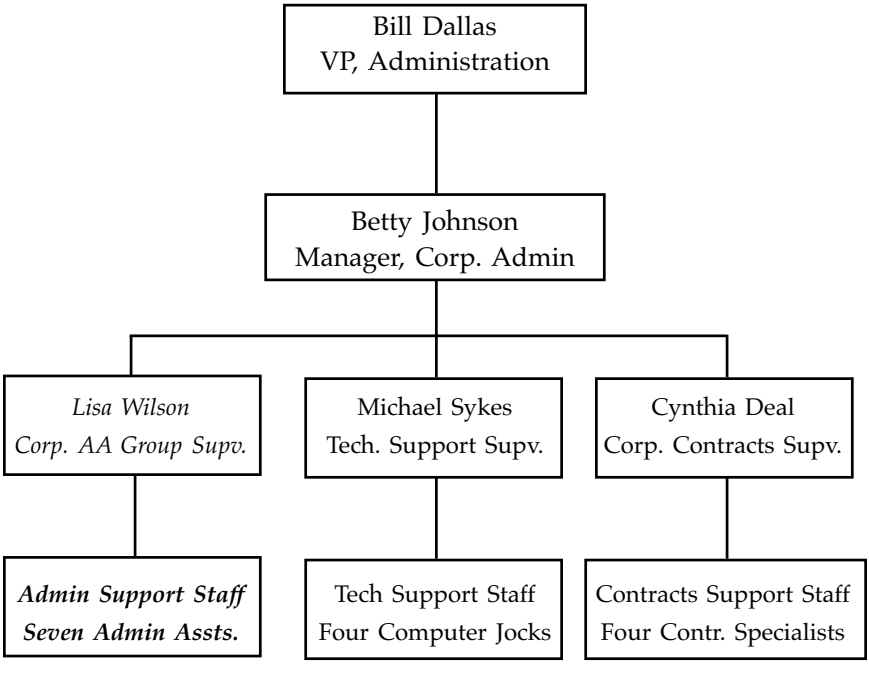
Case Study
Organization Chart



Chapter 8

Effective Communications

Barry Benator

***Communication**: the imparting or interchange of thoughts, opinions, or information by speech, writing, or signs* (Webster's College Dictionary, 3rd Edition)

"I am so frustrated. I can't get John to do anything I ask."

"Betty is moving in slow motion again. I am going to tell her to speed it up or else."

Background

As supervisors and managers we take pride in our ability to solve problems. Give us a problem to solve and we are on it, now. However, in our zeal to solve problems, we may not listen to a person or group well enough to understand what the problem really is. This can result in our trying to solve the wrong problem and/or gaining a reputation as someone who doesn't listen to people.

One of the most critical skills possessed by good leaders is their *ability to effectively communicate*. Effective communication is not simply talking clearly; it is, in many cases, and often more importantly, **listening effectively**. By effective listening, we are not referring to someone speaking and someone else simply hearing the words. Rather, effective communication often requires that the listener understand the *emotional content* of the speaker's words as well as the words themselves.

This is easier said than done. Throughout life we are told to speak clearly, say what we mean, use proper English. Rarely are we taught how to listen effectively. We are taught to listen and understand words in their literal sense, but not to listen for the emotional context in which they are spoken. We tend to listen to prepare a reply, instead of understanding what the speaker is trying to tell us. Yet, it is through understanding the emotional content of the words and what they mean to the speaker that will allow you to unlock the effective communicator within you.

Active/Empathic Listening

To be an effective communicator, it is important to understand how things appear *to the speaker*. We need to understand the person who is speaking and what he or she is really trying to convey. Often simply listening to the speaker's words alone will not do the trick.

Think about the times you have tried to convey your thoughts or feelings to someone, and in spite of your best efforts, they didn't get it. You may have ended up frustrated or angry with the listener because of it. Or perhaps you were listening to someone and they told you that you "just don't understand." It could have been a peer, a direct report or perhaps a spouse, child or friend.

The listening skill that will help you be an effective listener is called *active listening* or *empathic listening*. In this type of listen-

ing, the objective is to seek understanding of the speaker's words and feelings, so that you genuinely understand how that person sees things. As put by Stephen Covey in *Seven Habits of Highly Effective People*, **seek to understand first, then to be understood**.

In active or empathic listening, you listen with your ears, your eyes, and your heart. Your objective is to understand how the other person views a situation. By understanding the other person's point of view, you see the world as they see it and you understand how they feel. As a result, you are in a better position to respond to that person in ways that make sense to him or her, not in ways that make sense to you. That's one of the big challenges in empathic listening—you need to work at it in order to really understand the other person's point of view.

The good news is that research has shown you will have a better chance of gaining trust and achieving more effective communications if you do try to understand the situation from the other person's world than if you focus on your own frame of reference or own needs.

It Takes Courage

Empathic or active listening is so powerful because you focus on the needs of the other person, not your own. And if you do this in a genuine way, you will unlock the potential to establish true effective communications. So how do you do that? Can you learn how to be an effective listener? The answer is an unqualified yes, if you are willing to apply a few proven principles of effective listening and work at it—*really work at it*. Make no mistake, developing good listening skills takes commitment and practice. It also takes courage. By being an empathic listener and understanding the other person's point of view, you run the risk of agreeing with him or her. But so what? Maybe their idea or way of proceeding is better than yours. If not, at least now you know how they see things and can seek solutions that best meet everyone's needs.

Active/Empathic Listening Skills

It's time to take this discussion out of the what and why and start focusing on the *how*. How do we listen effectively? How can we apply the principles of active listening? For one thing, the very word *active* implies that you are working at listening, not simply along for the ride.

Stop What You're Doing

When you want to engage in effective listening, to really understand what is going on with the other person and what is being communicated and felt by the other person, stop what you're doing and give him or her your full attention. Don't take phone calls. Don't type on the keyboard or connect to the Internet (these can be seen in person and heard over the phone, and convey the message "you're really not that important to me").

By stopping what you are doing and giving full attention to the person, you are sending a powerful message that he or she is the most important person in the world to you at that moment. That alone helps set a positive communicating environment that fosters trust and openness, and conveys that you truly want to understand what is going on with that person.

Look At the Person

Give the person face time in the literal sense as well as the figurative sense. Make eye contact. Show concern and interest in what the person is telling you.

Listen

Listen to the person's words, tone, feelings. Focus on the message, not on whether the person is well-spoken or has an accent different from yours. In today's multicultural environment, you will see and hear an increasing number of people who speak differently than you. You may have to work at it. Don't think how you are going to respond or solve the problem. Just listen—seek to understand.

Get Comfortable with Silence

The person may be telling you about a very private matter (e.g., a harassment situation, death of a family member, or other personal situation) and may need time to marshal his or her thoughts and words. Usually the pause or silence only lasts a few seconds or minutes, but it can seem like a lot longer. Don't rush the person. Avoid the temptation to fill in the blanks or complete the person's thought.

Don't be Judgmental

You may be shocked at what you hear. You may disagree or agree with what you hear. But reserve judgment while you are listening. Remember, you are seeking to *understand first*. This is about the person speaking and you listening, not your own values or your own set of do's and don'ts.

Be Encouraging

Let the person know you are listening by comments like "Yes," "I see…" or "Uh-huh" at appropriate times. Non-verbal encouragement such as a nod or smile is also encouraging behavior on your part. This does not imply that you agree with the person, but rather an acknowledgment that you are interested in what the person is telling you and making it easy for him or her to continue talking.

Restating in Your Own Words

To let the person know you have indeed heard and understood what he or she is saying, restate the other's basic ideas in your own words. "It sounds like you are upset because…" "If I understand your position, you believe…" or "In other words, you think we should take this approach because…." Pause to let the speaker react. If you got it right, the person may say "yes and…." Or if you are incorrect, the person can correct you right then so you do know what he or she meant. Either way, you have listened effectively in the sense that the person knows you want to understand and you have correctly captured the person's content. This

allows the person to develop trust in you and more readily accept your comments when you do offer guidance or support.

Restate, yes, but don't start telling your own story about how you dealt with a similar situation. ("Yeah, I remember when I was faced with the same challenge…") Active listening is about listening to the other person, not about you and your autobiography. You may draw upon your own experience later on after you fully understand the other person's situation, but not while you are seeking to understand the person's own situation.

Observing and Reflecting Feelings

The emotions and feelings behind the words are often more important than what is actually said. Look beyond the mere words the speaker uses to understand what the person is feeling. Listen with your eyes and heart. Show you understand the person's emotional status by reflecting your understanding of the person's feelings. "You sound pretty upset, John." Or "How are you today, Betty?" Betty answers, barely audibly, with her head down, "Oh, I'm okay." You sense all is not right with Betty, so you might say, "Gee, Betty, you don't sound like you're okay." Betty, sensing a genuine interest by you, might reply "Well, actually, everything is not all right. Last night I learned…." Sometimes, you may not have a clue as to what the other person feels. So, you might try, "How did that make you feel, Bill." And then listen.

When the person believes you are genuinely interested in him or her and develops trust in you based on that belief, you are in a good position to understand what is going on with the person and possibly help them. That help might be in the form of providing options for them to consider, referral to a professional counselor or other type of assistance. Often, just talking it out with an empathic listener will help them see the best solution options for them (and frequently, your organization).

When Can You Respond or Seek to Be Understood?

The effective/empathic listener can respond or seek to be understood after you have applied the skills in this chapter to

truly understand the other person. If you have succeeded in listening to and understanding the other person, then you will be in the best position to offer your input and have it considered.

Make no mistake—empathic listening does take time, but not nearly as much time as it takes to backup and correct misunderstandings that could have been avoided if you had listened actively and empathetically in the first place. The payoff for your patience and skill in using active/empathic listening is a deeper understanding of the other person and the ability to fashion solutions that meet the person's needs, the organization's needs and your needs.

Okay, you've listened well.
Now you can solve the problem!!

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Chapter 9

Economic Decision Making

The Project Manager and Economic Decision Making

A thorough understanding of how to make decisions based on the "return on Investment" is essential. The project manager needs to guide the design team in optimizing the performance of buildings and plants over their life. The "lowest" cost facility usually will result in the highest operating costs which may result in a facility that has the highest life cycle costs.

Life Cycle Costing

When a plant manager is assigned the role of energy manager, the first question to be asked is: "What is the economic basis for equipment purchases?"

Some companies use a simple payback method of two years or less to justify equipment purchases. Others require a life cycle cost analysis with no fuel price inflation considered. Still other companies allow for a complete life cycle cost analysis, including the impact for the fuel price inflation and the energy tax credit (if available).

Using the Payback Period Method

The payback period is the time required to recover the capital investment out of the earnings or savings. This method ignores all savings beyond the payback years, thus penalizing projects that have long life potentials for those that offer high savings for a relatively short period.

The payback period criterion is used when funds are limited and it is important to know how fast dollars will come back. The payback period is simply computed as:

$$\text{Payback period} = \frac{\text{initial investment}}{\text{annual after tax savings}} \tag{9-1}$$

The project manager who must justify energy equipment expenditures based on a payback period of one year or less has little chance for long-range success. Some companies have set higher payback periods for energy utilization methods. These longer payback periods are justified on the basis that:

- Fuel pricing may increase at a higher rate than the general inflation rate.

- The "risk analysis" for not implementing energy utilization measures may mean loss of production and losing a competitive edge.

Using Life Cycle Costing

Life cycle costing is an analysis of the total cost of a system, device, building, machine, etc., over its anticipated useful life. The name is new but the subject has, in the past, gone by such names as "engineering economic analysis" or "total owning and operating cost summaries."

Life cycle costing has brought about a new emphasis on the comprehensive identification of all costs associated with a system. The most commonly included costs are initial in place cost, operating costs, maintenance costs, and interest on the investment. Two factors enter into appraising the life of the system: namely, the expected physical life and the period of obsolescence. The lesser factor is governing time period. The effect of interest can then be calculated by using one of several formulas which take into account the time value of money.

When comparing alternative solutions to a particular problem, the system showing the lowest life cycle cost will usually be the first choice (performance requirements are assessed as equal in value).

Life cycle costing is a tool in value engineering. Other items, such as installation time, pollution effects, aesthetic considerations, delivery time, and owner preferences will temper the rule of always choosing the system with the lowest life cycle cost. Good overall judgment is still required.

The life cycle cost analysis still contains judgment factors pertaining to interest rates, useful life, and inflation rates. Even with the judgment element, life cycle costing is the most important tool in value engineering, since the results are quantified in terms of dollars.

As the price for energy changes, and as governmental incentives are initiated, processes or alternatives which were not economically feasible will be considered. This chapter will concentrate on the principles of the life cycle cost analysis as they apply to energy conservation decision making.

The Time Value of Money

Most energy saving proposals require the investment of capital to accomplish them. By investing today in energy conservation, yearly operating dollars over the life of the investment will be saved. A dollar in hand today is more valuable than one to be

received at some time in the future. For this reason, a *time value* must be placed on all cash flows into and out of the company.

Money transactions are thought of as a cash flow to or from a company. Investment decisions also take into account alternate investment opportunities and the minimum return on the investment. In order to compute the rate of return on an investment, it is necessary to find the interest rate which equates payments outcoming and incoming, present and future. The method used to find the rate of return is referred to as *discounted cash flow.*

Investment Decision-making

To make investment decisions, the energy manager must follow one simple principle: Relate annual cash flows and lump sum deposits to the same time base. The six factors used for investment decision making simply convert cash from one time base to another; since each company has various financial objectives, these factors can be used to solve *any* investment problem.

Single Payment Compound Amount—F/P

The F/P factor is used to determine the future amount F that a present sum P will accumulate at i percent interest, in n years. If P (present worth) is known, and F (future worth) is to be determined, then Equation 9-2 is used.

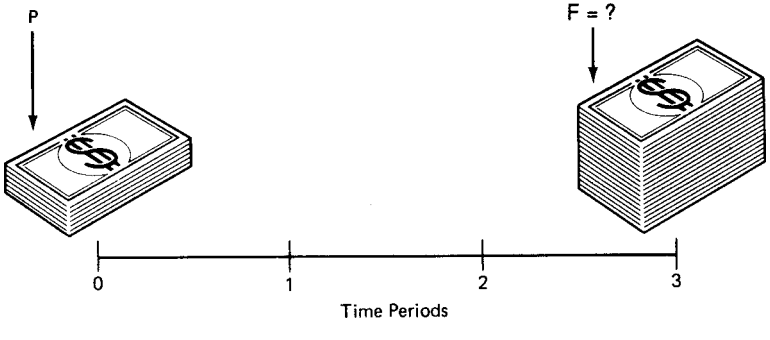

Figure 9-1. Single payment compound amount (F/P).

$$F = P \times (1 + i)^n \tag{9-2}$$

$$F/P = (1 + i)^n \tag{9-3}$$

The F/P can be computed by an interest formula, but usually its value is found by using the interest tables. Interest tables for interest rates of 10 to 50 percent are found in this chapter (Tables 9-1 through 9-8). In predicting future costs, there are many unknowns. For the accuracy of most calculations, interest rates are assumed to be compounded annually unless otherwise specified. Linear interpolation is commonly used to find values not listed in the interest tables.

Tables 9-9 through 9-12 can be used to determine the effect of fuel escalation on the life cycle cost analysis.

Single Payment Present Worth—P/F

The P/F factor is used to determine the present worth, P, that a future amount, F, will be at interest of i-percent, in n years. If F is known, and P is to be determined, then Equation 9-4 is used.

$$P = \mathrm{F} \times 1/(1 + i)^n \tag{9-4}$$

$$\mathrm{P/F} = \frac{1}{(1 + \mathrm{i})^{\mathrm{n}}} \tag{9-5}$$

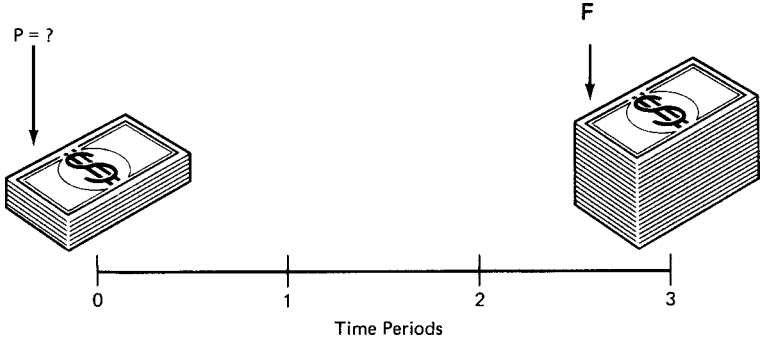

Figure 9-2. Single payment present worth (P/F).

Table 9-1. 10% Interest factors.

Period n	Single-payment compound-amount F/P Future value of \$1 $(1+i)^n$	Single-payment present-worth P/F Present value of \$1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.100	0.9091	1.000	1.00000	1.10000	0.909
2	1.210	0.8264	2.100	0.47619	0.57619	1.736
3	1.331	0.7513	3.310	0.30211	0.40211	2.487
4	1.464	0.6830	4.641	0.21547	0.31147	3.170
5	1.611	0.6209	6.105	0.16380	0.26380	3.791
6	1.772	0.5645	7.716	0.12961	0.22961	4.355
7	1.949	0.5132	9.487	0.10541	0.20541	4.868
8	2.144	0.4665	11.436	0.08744	0.18744	5.335
9	2.358	0.4241	13.579	0.07364	0.17364	5.759
10	2.594	0.3855	15.937	0.06275	0.16275	6.144
11	2.853	0.3505	18.531	0.05396	0.15396	6.495
12	3.138	0.3186	21.384	0.04676	0.14676	6.814
13	3.452	0.2897	24.523	0.04078	0.14078	7.103
14	3.797	0.2633	27.975	0.03575	0.13575	7.367
15	4.177	0.2394	31.772	0.03147	0.13147	7.606
16	4.595	0.2176	35.950	0.02782	0.12782	7.824
17	5.054	0.1978	40.545	0.02466	0.12466	8.022
18	5.560	0.1799	45.599	0.02193	0.12193	8.201
19	6.116	0.1635	51.159	0.01955	0.11955	8.365
20	6.727	0.1486	57.275	0.01746	0.11746	8.514
21	7.400	0.1351	64.002	0.01562	0.11562	8.649
22	8.140	0.1228	71.403	0.01401	0.11401	8.772
23	8.954	0.1117	79.543	0.01257	0.11257	8.883
24	9.850	0.1015	88.497	0.01130	0.11130	8.985
25	10.835	0.0923	98.347	0.01017	0.11017	9.077
26	11.918	0.0839	109.182	0.00916	0.10916	9.161
27	13.110	0.0763	121.100	0.00826	0.10826	9.237
28	14.421	0.0693	134.210	0.00745	0.10745	9.307
29	15.863	0.0630	148.631	0.00673	0.10673	9.370
30	17.449	0.0673	164.494	0.00608	0.10608	9.427
35	28.102	0.0356	271.024	0.00369	0.10369	9.644
40	45.259	0.0221	442.593	0.00226	0.10226	9.779
45	72.890	0.0137	718.905	0.00139	0.10139	9.863
50	117.391	0.0085	1163.909	0.00086	0.10086	9.915
55	189.059	0.0053	1880.591	0.00053	0.10053	9.947
60	304.482	0.0033	3034.816	0.00033	0.10033	9.967
65	490.371	0.0020	4893.707	0.00020	0.10020	9.980
70	789.747	0.0013	7887.470	0.00013	0.10013	9.987
75	1271.895	0.0008	12708.954	0.00008	0.10008	9.992
80	2048.400	0.0005	20474.002	0.00005	0.10005	9.995
85	3298.969	0.0003	32979.690	0.00003	0.10003	9.997
90	5313.023	0.0002	53120.226	0.00002	0.10002	9.998
95	8556.676	0.0001	85556.760	0.00001	0.10001	9.999

Table 9-2. 12% Interest factors.

Period n	Single-payment compound-amount F/P Future value of \$1 $(1+i)^n$	Single-payment present-worth P/F Present value of \$1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.120	0.8929	1.000	1.00000	1.12000	0.893
2	1.254	0.7972	2.120	0.47170	0.59170	1.690
3	1.405	0.7118	3.374	0.29635	0.41635	2.402
4	1.574	0.6355	4.779	0.20923	0.32923	3.037
5	1.762	0.5674	6.353	0.15741	0.27741	3.605
6	1.974	0.5066	8.115	0.12323	0.24323	4.111
7	2.211	0.4523	10.089	0.09912	0.21912	4.564
8	2.476	0.4039	12.300	0.08130	0.20130	4.968
9	2.773	0.3606	14.776	0.06768	0.18768	5.328
10	3.106	0.3220	17.549	0.05698	0.17698	5.650
11	3.479	0.2875	20.655	0.04842	0.16842	5.938
12	3.896	0.2567	24.133	0.04144	0.16144	6.194
13	4.363	0.2292	28.029	0.03568	0.15568	6.424
14	4.887	0.2046	32.393	0.03087	0.15087	6.628
15	5.474	0.1827	37.280	0.02682	0.14682	6.811
16	6.130	0.1631	42.753	0.02339	0.14339	6.974
17	6.866	0.1456	48.884	0.02046	0.14046	7.120
18	7.690	0.1300	55.750	0.01794	0.13794	7.250
19	8.613	0.1161	63.440	0.01576	0.13576	7.366
20	9.646	0.1037	72.052	0.01388	0.13388	7.469
21	10.804	0.0926	81.699	0.01224	0.13224	7.562
22	12.100	0.0826	92.503	0.01081	0.13081	7.645
23	13.552	0.0738	104.603	0.00956	0.12956	7.718
24	15.179	0.0659	118.155	0.00846	0.12846	7.784
25	17.000	0.0588	133.334	0.00750	0.12750	7.843
26	19.040	0.0525	150.334	0.00665	0.12665	7.896
27	21.325	0.0469	169.374	0.00590	0.12590	7.943
28	23.884	0.0419	190.699	0.00524	0.12524	7.984
29	26.750	0.0374	214.583	0.00466	0.12466	8.022
30	29.960	0.0334	241.333	0.00414	0.12414	8.055
35	52.800	0.0189	431.663	0.00232	0.12232	8.176
40	93.051	0.0107	767.091	0.00130	0.12130	8.244
45	163.988	0.0061	1358.230	0.00074	0.12074	8.283
50	289.002	0.0035	2400.018	0.00042	0.12042	8.304
55	509.321	0.0020	4236.005	0.00024	0.12024	8.317
60	897.597	0.0011	7471.641	0.00013	0.12013	8.324
65	1581.872	0.0006	13173.937	0.00008	0.12008	8.328
70	2787.800	0.0004	23223.332	0.00004	0.12004	8.330
75	4913.056	0.0002	40933.799	0.00002	0.12002	8.332
80	8658.483	0.0001	72145.692	0.00001	0.12001	8.332

Table 9-3. 15% Interest factors.

Period n	Single-payment compound-amount F/P Future value of \$1 $(1+i)^n$	Single-payment present-worth P/F Present value of \$1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.150	0.8696	1.000	1.00000	1.15000	0.870
2	1.322	0.7561	2.150	0.46512	0.61512	1.626
3	1.521	0.6575	3.472	0.28798	0.43798	2.283
4	1.749	0.5718	4.993	0.20027	0.35027	2.855
5	2.011	0.4972	6.742	0.14832	0.29832	3.352
6	2.313	0.4323	8.754	0.11424	0.26424	3.784
7	2.660	0.3759	11.067	0.09036	0.24036	4.160
8	3.059	0.3269	13.727	0.07285	0.22285	4.487
9	3.518	0.2843	16.786	0.05957	0.20957	4.772
10	4.046	0.2472	20.304	0.04925	0.19925	5.019
11	4.652	0.2149	24.349	0.04107	0.19107	5.234
12	5.350	0.1869	29.002	0.03448	0.18448	5.421
13	6.153	0.1625	34.352	0.02911	0.17911	5.583
14	7.076	0.1413	40.505	0.02469	0.17469	5.724
15	8.137	0.1229	47.580	0.02102	0.17102	5.847
16	9.358	0.1069	55.717	0.01795	0.16795	5.954
17	10.761	0.0929	65.075	0.01537	0.16537	6.047
18	12.375	0.0808	75.836	0.01319	0.16319	6.128
19	14.232	0.0703	88.212	0.01134	0.16134	6.198
20	16.367	0.0611	102.444	0.00976	0.15976	6.259
21	18.822	0.0531	118.810	0.00842	0.15842	6.312
22	21.645	0.0462	137.632	0.00727	0.15727	6.359
23	24.891	0.0402	159.276	0.00628	0.15628	6.399
24	28.625	0.0349	194.168	0.00543	0.15543	6.434
25	32.919	0.0304	212.793	0.00470	0.15470	6.464
26	37.857	0.0264	245.712	0.00407	0.15407	6.491
27	43.535	0.0230	283.569	0.00353	0.15353	6.514
28	50.066	0.0200	327.104	0.00306	0.15306	6.534
29	57.575	0.0174	377.170	0.00265	0.15265	6.551
30	66.212	0.0151	434.745	0.00230	0.15230	6.566
35	133.176	0.0075	881.170	0.00113	0.15113	6.617
40	267.864	0.0037	1779.090	0.00056	0.15056	6.642
45	538.769	0.0019	3585.128	0.00028	0.15028	6.654
50	1083.657	0.0009	7217.716	0.00014	0.15014	6.661
55	2179.622	0.0005	14524.148	0.00007	0.15007	6.664
60	4383.999	0.0002	29219.992	0.00003	0.15003	6.665
65	8817.787	0.0001	58778.583	0.00002	0.15002	6.666

Table 9-4. 20% Interest factors.

Period n	Single-payment compound-amount F/P	Single-payment present-worth P/F	Uniform series compound-amount F/A	Sinking-fund payment A/F	Capital recovery A/P	Uniform-series present-worth P/A
	Future value of \$1 $(1+i)^n$	Present value of \$1 $\frac{1}{(1+i)^n}$	Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.200	0.8333	1.000	1.00000	1.20000	0.833
2	1.440	0.6944	2.200	0.45455	0.65455	1.528
3	1.728	0.5787	3.640	0.27473	0.47473	2.106
4	2.074	0.4823	5.368	0.18629	0.38629	2.589
5	2.488	0.4019	7.442	0.13438	0.33438	2.991
6	2.986	0.3349	9.930	0.10071	0.30071	3.326
7	3.583	0.2791	12.916	0.07742	0.27742	3.605
8	4.300	0.2326	16.499	0.06061	0.26061	3.837
9	5.160	0.1938	20.799	0.04808	0.24808	4.031
10	6.192	0.1615	25.959	0.03852	0.23852	4.192
11	7.430	0.1346	32.150	0.03110	0.23110	4.327
12	8.916	0.1122	39.581	0.02526	0.22526	4.439
13	10.699	0.0935	48.497	0.02062	0.22062	4.533
14	12.839	0.0779	59.196	0.01689	0.21689	4.611
15	15.407	0.0649	72.035	0.01388	0.21388	4.675
16	18.488	0.0541	87.442	0.01144	0.21144	4.730
17	22.186	0.0451	105.931	0.00944	0.20944	4.775
18	26.623	0.0376	128.117	0.00781	0.20781	4.812
19	31.948	0.0313	154.740	0.00646	0.20646	4.843
20	38.338	0.0261	186.688	0.00536	0.20536	4.870
21	46.005	0.0217	225.026	0.00444	0.20444	4.891
22	55.206	0.0181	271.031	0.00369	0.20369	4.909
23	66.247	0.0151	326.237	0.00307	0.20307	4.925
24	79.497	0.0126	392.484	0.00255	0.20255	4.937
25	95.396	0.0105	471.981	0.00212	0.20212	4.948
26	114.475	0.0087	567.377	0.00176	0.20176	4.956
27	137.371	0.0073	681.853	0.00147	0.20147	4.964
28	164.845	0.0061	819.223	0.00122	0.20122	4.970
29	197.814	0.0051	984.068	0.00102	0.20102	4.975
30	237.376	0.0042	1181.882	0.00085	0.20085	4.979
35	590.668	0.0017	2948.341	0.00034	0.20034	4.992
40	1469.772	0.0007	7343.858	0.00014	0.20014	4.997
45	3657.262	0.0003	18281.310	0.00005	0.20005	4.999
50	9100.438	0.0001	45497.191	0.00002	0.20002	4.999

Table 9-5. 25% Interest factors.

Period n	Single-payment compound-amount F/P Future value of \$1 $(1+i)^n$	Single-payment present-worth P/F Present value of \$1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.250	0.8000	1.000	1.00000	1.25000	0.800
2	1.562	0.6400	2.250	0.44444	0.69444	1.440
3	1.953	0.5120	3.812	0.26230	0.51230	1.952
4	2.441	0.4096	5.766	0.17344	0.42344	2.362
5	3.052	0.3277	8.207	0.12185	0.37185	2.689
6	3.815	0.2621	11.259	0.08882	0.33882	2.951
7	4.768	0.2097	15.073	0.06634	0.31634	3.161
8	5.960	0.1678	19.842	0.05040	0.30040	3.329
9	7.451	0.1342	25.802	0.03876	0.28876	3.463
10	9.313	0.1074	33.253	0.03007	0.28007	3.571
11	11.642	0.0859	42.566	0.02349	0.27349	3.656
12	14.552	0.0687	54.208	0.01845	0.26845	3.725
13	18.190	0.0550	68.760	0.01454	0.26454	3.780
14	22.737	0.0440	86.949	0.01150	0.26150	3.824
15	28.422	0.0352	109.687	0.00912	0.25912	3.859
16	35.527	0.0281	138.109	0.00724	0.25724	3.887
17	44.409	0.0225	173.636	0.00576	0.25576	3.910
18	55.511	0.0180	218.045	0.00459	0.25459	3.928
19	69.389	0.0144	273.556	0.00366	0.25366	3.942
20	86.736	0.0115	342.945	0.00292	0.25292	3.954
21	108.420	0.0092	429.681	0.00233	0.25233	3.963
22	135.525	0.0074	538.101	0.00186	0.25186	3.970
23	169.407	0.0059	673.626	0.00148	0.25148	3.976
24	211.758	0.0047	843.033	0.00119	0.25119	3.981
25	264.698	0.0038	1054.791	0.00095	0.25095	3.985
26	330.872	0.0030	1319.489	0.00076	0.25076	3.988
27	413.590	0.0024	1650.361	0.00061	0.25061	3.990
28	516.988	0.0019	2063.952	0.00048	0.25048	3.992
29	646.235	0.0015	2580.939	0.00039	0.25039	3.994
30	807.794	0.0012	3227.174	0.00031	0.25031	3.995
35	2465.190	0.0004	9856.761	0.00010	0.25010	3.998
40	7523.164	0.0001	30088.655	0.00003	0.25003	3.999

Table 9-6. 30% Interest factors.

Period n	Single-payment compound-amount F/P Future value of \$1 $(1+i)^n$	Single-payment present-worth P/F Present value of \$1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.300	0.7692	1.000	1.00000	1.30000	0.769
2	1.690	0.5917	2.300	0.43478	0.73478	1.361
3	2.197	0.4552	3.990	0.25063	0.55063	1.816
4	2.856	0.3501	6.187	0.16163	0.46163	2.166
5	3.713	0.2693	9.043	0.11058	0.41058	2.436
6	4.827	0.2072	12.756	0.07839	0.37839	2.643
7	6.275	0.1594	17.583	0.05687	0.35687	2.802
8	8.157	0.1226	23.858	0.04192	0.34192	2.925
9	10.604	0.0943	32.015	0.03124	0.33124	3.019
10	13.786	0.0725	42.619	0.02346	0.32346	3.092
11	17.922	0.0558	56.405	0.01773	0.31773	3.147
12	23.298	0.0429	74.327	0.01345	0.31345	3.190
13	30.288	0.0330	97.625	0.01024	0.31024	3.223
14	39.374	0.0254	127.913	0.00782	0.30782	3.249
15	51.186	0.0195	167.286	0.00598	0.30598	3.268
16	66.542	0.0150	218.472	0.00458	0.30458	3.283
17	86.504	0.0116	285.014	0.00351	0.30351	3.295
18	112.455	0.0089	371.518	0.00269	0.30269	3.304
19	146.192	0.0068	483.973	0.00207	0.30207	3.311
20	190.050	0.0053	630.165	0.00159	0.30159	3.316
21	247.065	0.0040	820.215	0.00122	0.30122	3.320
22	321.194	0.0031	1067.280	0.00094	0.30094	3.323
23	417.539	0.0024	1388.464	0.00072	0.30072	3.325
24	542.801	0.0018	1806.003	0.00055	0.30055	3.327
25	705.641	0.0014	2348.803	0.00043	0.30043	3.329
26	917.333	0.0011	3054.444	0.00033	0.30033	3.330
27	1192.533	0.0008	3971.778	0.00025	0.30025	3.331
28	1550.293	0.0006	5164.311	0.00019	0.30019	3.331
29	2015.381	0.0005	6714.604	0.00015	0.30015	3.332
30	2619.996	0.0004	8729.985	0.00011	0.30011	3.332
35	9727.8060	0.0001	32422.868	0.00003	0.30003	3.333

Table 9-7. 40% Interest factors.

Period n	Single-payment compound-amount F/P Future value of \$1 $(1+i)^n$	Single-payment present-worth P/F Present value of \$1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is \$1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of \$1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of \$1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.400	0.7143	1.000	1.00000	1.40000	0.714
2	1.960	0.5102	2.400	0.41667	0.81667	1.224
3	2.744	0.3644	4.360	0.22936	0.62936	1.589
4	3.842	0.2603	7.104	0.14077	0.54077	1.849
5	5.378	0.1859	10.946	0.09136	0.49136	2.035
6	7.530	0.1328	16.324	0.06126	0.46126	2.168
7	10.541	0.0949	23.853	0.04192	0.44192	2.263
8	14.758	0.0678	34.395	0.02907	0.42907	2.331
9	20.661	0.0484	49.153	0.02034	0.42034	2.379
10	28.925	0.0346	69.814	0.01432	0.41432	2.414
11	40.496	0.0247	98.739	0.01013	0.41013	2.438
12	56.694	0.0176	139.235	0.00718	0.40718	2.456
13	79.371	0.0126	195.929	0.00510	0.40510	2.469
14	111.120	0.0090	275.300	0.00363	0.40363	2.478
15	155.568	0.0064	386.420	0.00259	0.40259	2.484
16	217.795	0.0046	541.988	0.00185	0.40185	2.489
17	304.913	0.0033	759.784	0.00132	0.40132	2.492
18	426.879	0.0023	1064.697	0.00094	0.40094	2.494
19	597.630	0.0017	1491.576	0.00067	0.40067	2.496
20	836.683	0.0012	2089.206	0.00048	0.40048	2.497
21	1171.356	0.0009	2925.889	0.00034	0.40034	2.498
22	1639.898	0.0006	4097.245	0.00024	0.40024	2.498
23	2295.857	0.0004	5737.142	0.00017	0.40017	2.499
24	3214.200	0.0003	8032.999	0.00012	0.40012	2.499
25	4499.880	0.0002	11247.199	0.00009	0.40009	2.499
26	6299.831	0.0002	15747.079	0.00006	0.40006	2.500
27	8819.764	0.0001	22046.910	0.00005	0.40005	2.500

Table 9-8. 50% Interest factors.

Period n	Single-payment compound-amount F/P Future value of $1 $(1+i)^n$	Single-payment present-worth P/F Present value of $1 $\frac{1}{(1+i)^n}$	Uniform series compound-amount F/A Future value of uniform series of $1 $\frac{(1+i)^n \pm 1}{i}$	Sinking-fund payment A/F Uniform series whose future value is $1 $\frac{i}{(1+i)^n \pm 1}$	Capital recovery A/P Uniform series with present value of $1 $\frac{i(1+i)^n}{(1+i)^n \pm 1}$	Uniform-series present-worth P/A Present value of uniform series of $1 $\frac{(1+i)^n \pm 1}{i(1+i)^n}$
1	1.500	0.6667	1.000	1.00000	1.50000	0.667
2	2.250	0.4444	2.500	0.40000	0.90000	1.111
3	3.375	0.2963	4.750	0.21053	0.71053	1.407
4	5.062	0.1975	8.125	0.12308	0.62308	1.605
5	7.594	0.1317	13.188	0.07583	0.57583	1.737
6	11.391	0.0878	20.781	0.04812	0.54812	1.824
7	17.086	0.0585	32.172	0.03108	0.53108	1.883
8	25.629	0.0390	49.258	0.02030	0.52030	1.922
9	38.443	0.0260	74.887	0.01335	0.51335	1.948
10	57.665	0.0173	113.330	0.00882	0.50882	1.965
11	86.498	0.0116	170.995	0.00585	0.50585	1.977
12	129.746	0.0077	257.493	0.00388	0.50388	1.985
13	194.620	0.0051	387.239	0.00258	0.50258	1.990
14	291.929	0.0034	581.859	0.00172	0.50172	1.993
15	437.894	0.0023	873.788	0.00114	0.50114	1.995
16	656.841	0.0015	1311.682	0.00076	0.50076	1.997
17	985.261	0.0010	1968.523	0.00051	0.50051	1.998
18	1477.892	0.0007	2953.784	0.00034	0.50034	1.999
19	2216.838	0.0005	4431.676	0.00023	0.50023	1.999
20	3325.257	0.0003	6648.513	0.00015	0.50015	1.999
21	4987.885	0.0002	9973.770	0.00010	0.50010	2.000
22	7481.828	0.0001	14961.655	0.00007	0.50007	2.000

Table 9-9. Five-year escalation table.

Present Worth of a Series of Escalating Payments Compounded Annually
Discount-Escalation Factors for n = 5 Years

Discount Rate	Annual Escalation Rate					
	0.10	0.12	0.14	0.16	0.18	0.20
0.10	5.000000	5.279234	5.572605	5.880105	6.202627	6.540569
0.11	4.866862	5.136200	5.420152	5.717603	6.029313	6.355882
0.12	4.738562	5.000000	5.274242	5.561868	5.863289	6.179066
0.13	4.615647	4.869164	5.133876	5.412404	5.704137	6.009541
0.14	4.497670	4.742953	5.000000	5.269208	5.551563	5.847029
0.15	4.384494	4.622149	4.871228	5.131703	5.404955	5.691165
0.16	4.275647	4.505953	4.747390	5.000000	5.264441	5.541511
0.17	4.171042	4.394428	4.628438	4.873699	5.129353	5.397964
0.18	4.070432	4.287089	4.513947	4.751566	5.000000	5.259749
0.19	3.973684	4.183921	4.403996	4.634350	4.875619	5.126925
0.20	3.880510	4.084577	4.298207	4.521178	4.755725	5.000000
0.21	3.790801	3.989001	4.196400	4.413341	4.640260	4.877689
0.22	3.704368	3.896891	4.098287	4.308947	4.529298	4.759649
0.23	3.621094	3.808179	4.003835	4.208479	4.422339	4.645864
0.24	3.540773	3.722628	3.912807	4.111612	4.319417	4.536517
0.25	3.463301	3.640161	3.825008	4.018249	4.220158	4.431144
0.26	3.388553	3.560586	3.740376	3.928286	4.124553	4.329514
0.27	3.316408	3.483803	3.658706	3.841442	4.032275	4.231583
0.28	3.246718	3.409649	3.579870	3.757639	3.943295	4.137057
0.29	3.179393	3.338051	3.503722	3.676771	3.857370	4.045902
0.30	3.114338	3.268861	3.430201	3.598653	3.774459	3.957921
0.31	3.051452	3.201978	3.359143	3.523171	3.694328	3.872901
0.32	2.990618	3.137327	3.290436	3.450224	3.616936	3.790808
0.33	2.939764	3.074780	3.224015	3.379722	3.542100	3.711472
0.34	2.874812	3.014281	3.159770	3.311524	3.469775	3.634758

Table 9-10. Ten-year escalation table.

Present Worth of a Series of Escalating Payments Compounded Annually
Discount-Escalation Factors for n = 10 Years

Discount Rate	Annual Escalation Rate					
	0.10	0.12	0.14	0.16	0.18	0.20
0.10	10.000000	11.056250	12.234870	13.548650	15.013550	16.646080
0.11	9.518405	10.508020	11.613440	12.844310	14.215140	15.741560
0.12	9.068870	10.000000	11.036530	12.190470	13.474590	14.903510
0.13	8.650280	9.526666	10.498990	11.582430	12.786980	14.125780
0.14	8.259741	9.084209	10.000000	11.017130	12.147890	13.403480
0.15	7.895187	8.672058	9.534301	10.490510	11.552670	12.731900
0.16	7.554141	8.286779	9.099380	10.000000	10.998720	12.106600
0.17	7.234974	7.926784	8.693151	9.542653	10.481740	11.524400
0.18	6.935890	7.589595	8.312960	9.113885	10.000000	10.980620
0.19	6.655455	7.273785	7.957330	8.713262	9.549790	10.472990
0.20	6.392080	6.977461	7.624072	8.338518	9.128122	10.000000
0.21	6.144593	6.699373	7.311519	7.987156	8.733109	9.557141
0.22	5.911755	6.437922	7.017915	7.657542	8.363208	9.141752
0.23	5.692557	6.192047	6.742093	7.348193	8.015993	8.752133
0.24	5.485921	5.960481	6.482632	7.057347	7.690163	8.387045
0.25	5.290990	5.742294	6.238276	6.783767	7.383800	8.044173
0.26	5.106956	5.536463	6.008083	6.526298	7.095769	7.721807
0.27	4.933045	5.342146	5.790929	6.283557	6.824442	7.418647
0.28	4.768518	5.158489	5.585917	6.054608	6.568835	7.133100
0.29	4.612762	4.984826	5.392166	5.838531	6.327682	6.864109
0.30	4.465205	4.820429	5.209000	5.634354	6.100129	6.610435
0.31	4.325286	4.664669	5.035615	5.441257	5.885058	6.370867
0.32	4.192478	4.517015	4.871346	5.258512	5.681746	6.144601
0.33	4.066339	4.376884	4.715648	5.085461	5.489304	5.930659
0.34	3.946452	4.243845	4.567942	4.921409	5.307107	5.728189

Table 9-11. Fifteen-year escalation table.

Present Worth of a Series of Escalating Payments Compounded Annually
Discount-Escalation Factors for n = 15 years

Discount Rate	Annual Escalation Rate					
	0.10	0.12	0.14	0.16	0.18	0.20
0.10	15.000000	17.377880	20.199780	23.549540	27.529640	32.259620
0.11	13.964150	16.126230	18.690120	21.727370	25.328490	29.601330
0.12	13.026090	15.000000	17.332040	20.090360	23.355070	27.221890
0.13	12.177030	13.981710	16.105770	18.616160	21.581750	25.087260
0.14	11.406510	13.057790	15.000000	17.287320	19.985530	23.169060
0.15	10.706220	12.220570	13.998120	16.086500	18.545150	21.442230
0.16	10.068030	11.459170	13.088900	15.000000	17.244580	19.884420
0.17	9.485654	10.766180	12.262790	14.015480	16.066830	18.477610
0.18	8.953083	10.133630	11.510270	13.118840	15.000000	17.203010
0.19	8.465335	9.555676	10.824310	12.303300	14.030830	16.047480
0.20	8.017635	9.026333	10.197550	11.560150	13.148090	15.000000
0.21	7.606115	8.540965	9.623969	10.881130	12.343120	14.046400
0.22	7.227109	8.094845	9.097863	10.259820	11.608480	13.176250
0.23	6.877548	7.684317	8.614813	9.690559	10.936240	12.381480
0.24	6.554501	7.305762	8.170423	9.167798	10.320590	11.655310
0.25	6.255518	6.956243	7.760848	8.687104	9.755424	10.990130
0.26	5.978393	6.632936	7.382943	8.244519	9.236152	10.379760
0.27	5.721101	6.333429	7.033547	7.836080	8.757889	9.819020
0.28	5.481814	6.055485	6.710042	7.458700	8.316982	9.302823
0.29	5.258970	5.797236	6.410005	7.109541	7.909701	8.827153
0.30	5.051153	5.556882	6.131433	6.785917	7.533113	8.388091
0.31	4.857052	5.332839	5.872303	6.485500	7.184156	7.982019
0.32	4.675478	5.123753	5.630905	6.206250	6.860492	7.606122
0.33	4.505413	4.928297	5.405771	5.946343	6.559743	7.257569
0.34	4.345926	4.745399	5.195502	5.704048	6.280019	6.933897

Table 9-12. Twenty-year escalation table.

Present Worth of a Series of Escalating Payments Compounded Annually
Discount-Escalation Factors for n = 20 Years

Discount Rate	Annual Escalation Rate					
	0.10	0.12	0.14	0.16	0.18	0.20
0.10	20.000000	24.295450	29.722090	36.592170	45.308970	56.383330
0.11	18.213210	22.002090	26.776150	32.799710	40.417480	50.067940
0.12	16.642370	20.000000	24.210030	29.505400	36.181240	44.614710
0.13	15.259850	18.243100	21.964990	26.634490	32.502270	39.891400
0.14	14.038630	16.694830	20.000000	24.127100	29.298170	35.789680
0.15	12.957040	15.329770	18.271200	21.929940	26.498510	32.218060
0.16	11.995640	14.121040	16.746150	20.000000	24.047720	29.098950
0.17	11.138940	13.048560	15.397670	18.300390	21.894660	26.369210
0.18	10.373120	12.093400	14.201180	16.795710	20.000000	23.970940
0.19	9.686791	11.240870	13.137510	15.463070	18.326720	21.860120
0.20	9.069737	10.477430	12.188860	14.279470	16.844020	20.000000
0.21	8.513605	9.792256	11.340570	13.224610	15.527270	18.353210
0.22	8.010912	9.175267	10.579620	12.282120	14.355520	16.890730
0.23	7.555427	8.618459	9.895583	11.438060	13.309280	15.589300
0.24	7.141531	8.114476	9.278916	10.679810	12.373300	14.429370
0.25	6.764528	7.657278	8.721467	9.997057	11.533310	13.392180
0.26	6.420316	7.241402	8.216490	9.380883	10.778020	12.462340
0.27	6.105252	6.862203	7.757722	8.823063	10.096710	11.626890
0.28	5.816151	6.515563	7.339966	8.316995	9.480940	10.874120
0.29	5.550301	6.198027	6.958601	7.856833	8.922847	10.194520
0.30	5.305312	5.906440	6.609778	7.437339	8.416060	9.579437
0.31	5.079039	5.638064	6.289875	7.054007	7.954518	9.021190
0.32	4.869585	5.390575	5.995840	6.702967	7.533406	8.513612
0.33	4.675331	5.161809	5.725066	6.380829	7.148198	8.050965
0.34	4.494838	4.949990	5.475180	6.084525	6.795200	7.628322

Uniform Series Compound Amount—F/A

The F/A factor is used to determine the amount F that an equal annual payment *A* will accumulate to in *n* years at *i* percent interest. If *A* (uniform annual payment) is known, and *F* (the future worth of these payments) is required, then Equation 9-6 is used.

$$F = A \times \frac{(1+i)^n \pm 1}{i} \tag{9-6}$$

$$F/A = \frac{(1+i)^n \pm 1}{i} \tag{9-7}$$

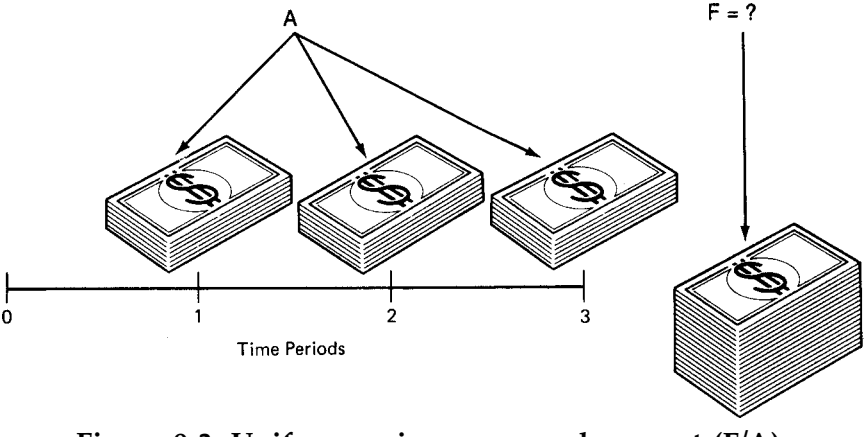

Figure 9-3. Uniform series compound amount (F/A).

Uniform Series Present Worth—(P/A)

The P/A factor is used to determine the present amount *P* that can be paid by equal payments of *A* (uniform annual payment) at *i* percent interest, for *n* years. If *A* is known, and *P* is required, then Equation 9-8 is used.

$$P = A \times \frac{(1+i)^n \pm 1}{i(1+i)^n} \tag{9-8}$$

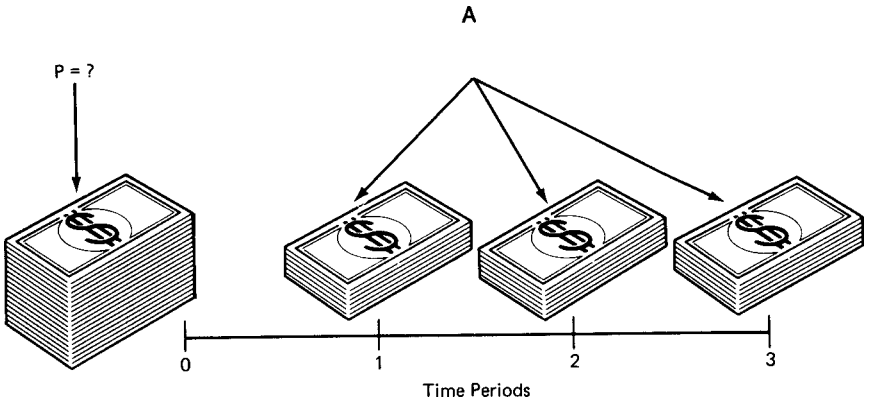

Figure 9-4. Uniform series present worth (P/A).

$$P/A = \frac{(1+i)^n \pm 1}{i(1+i)^n} \tag{9-9}$$

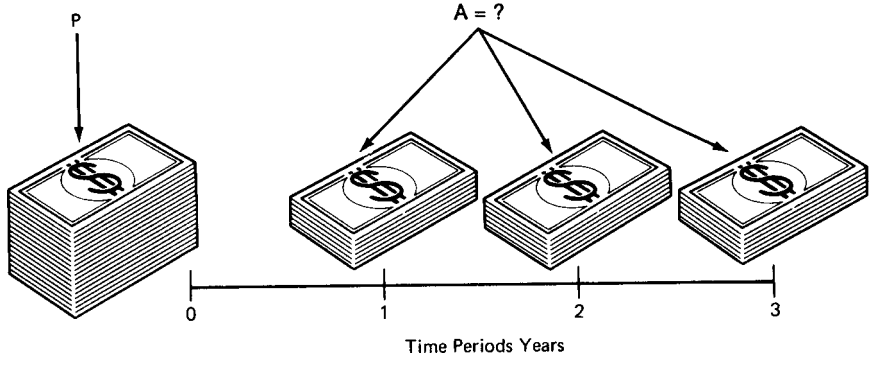

Figure 9-5. Capital recovery (A/P).

Capital Recovery—A/P

The A/P factor is used to determine an annual payment *A* required to pay off a present amount *P* at *i* percent interest, for *n* years. If the present sum of money, *P*, spent today is known, and the uniform payment *A* needed to pay back *P* over a stated period of time is required, then Equation 9-10 is used.

$$A = P \times \frac{i(1+i)^n}{(1+i)^n \pm 1} \tag{9-10}$$

$$A/P = \frac{i(1+i)^n}{(1+i)^n \pm 1} \tag{9-11}$$

Sinking Fund Payment—A/F

The A/F factor is used to determine the equal annual amount R that must be invested for n years at i percent interest in order to accumulate a specified future amount. If F (the future worth of a series of annual payments) is known, and A (value of those annual payments) is required, then Equation 9-12 is used.

$$A = F \times \frac{i}{(1+i)^n \pm 1} \tag{9-12}$$

$$A/F = \frac{i}{(1+i)^n \pm 1} \tag{9-13}$$

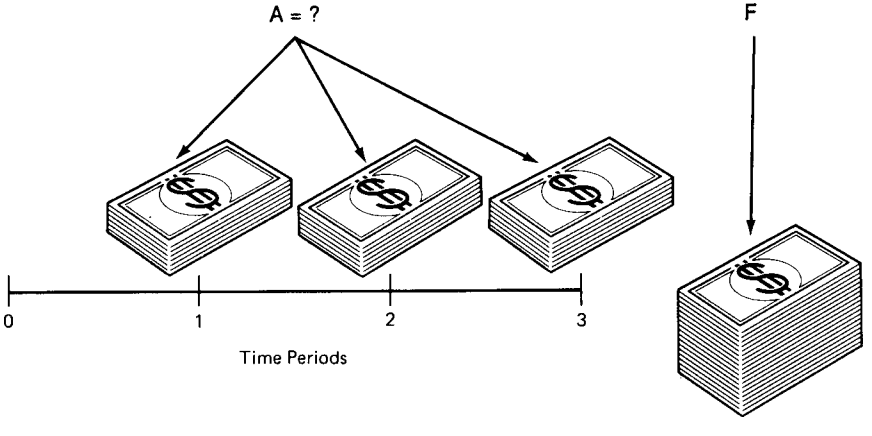

Figure l9-6. Sinking fund payment (A/F).

Gradient Present Worth—GPW

The GPW factor is used to determine the present amount P that can be paid by annual amounts A' which escalate at e percent,

at i percent interest, for n years. If A' is known, and P is required, then Equation 9-14 is used. The GPW factor is a relatively new term which has gained in importance due to the impact of inflation.

$$P = A' \times (\text{GPW})i_n \tag{9-14}$$

$$P/A' = GPW = \frac{\frac{1+e}{1+i}\left[1 \pm \left(\frac{1+e}{1+i}\right)^n\right]}{1 \pm \frac{1+e}{1+i}} \tag{9-15}$$

The three most commonly used methods in life cycle costing are the annual cost, present worth and rate-of-return analysis.

In the present worth method a minimum rate of return (i) is stipulated. All future expenditures are converted to present values using the interest factors. The alternative with lowest effective first cost is the most desirable.

A similar procedure is implemented in the annual cost method. The difference is that the first cost is converted to an annual expenditure. The alternative with lowest effective annual cost is the most desirable.

In the rate-of-return method, a trial-and-error procedure is usually required. Interpolation from the interest tables can determine what rate of return (i) will give an interest factor which will

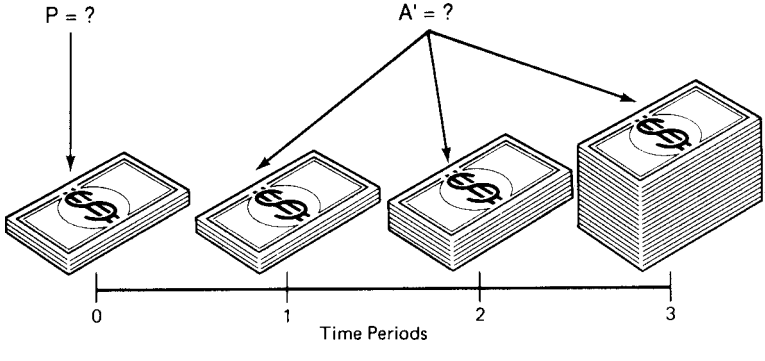

Figure 9-7. Gradient present worth.

make the overall cash flow balance. The rate-of-return analysis gives a good indication of the overall ranking of independent alternates.

The effect of escalation in fuel costs can influence greatly the final decision. When an annual cost grows at a steady rate it may be treated as a gradient and the gradient present worth factor can be used.

Special thanks are given to Rudolph R. Yanuck and Dr. Robert Brown for the use of their specially designed interest and escalation tables used in this text.

When life cycle costing is used to compare several alternatives the differences between costs are important. For example, if one alternate forces additional maintenance or an operating expense to occur, then these factors as well as energy costs need to be included. Remember, what was previously spent for the item to be replaced is irrelevant. The only factor to be considered is whether the new cost can be justified based on projected savings over its useful life.

The Job Simulation Experience

Throughout the text you will experience job situations and problems. Each simulation experience is denoted by SIM. The answer will be given below the problem. Cover the answers, then you can "play the game."

SIM 9-1

An evaluation needs to be made to replace all 40-watt fluorescent lamps with a new lamp that saves 12 percent or 4.8 watts and gives the same output. The cost of each lamp is $2.80.

Assuming a rate of return before taxes of 25 percent is required, can the immediate replacement be justified? Hours of operation are 5800 and the lamp life is two years. Electricity costs 7.0¢/kWh.

ANSWER

$$A = 5800\ \text{h/yr} \times 4.8\ \text{watts/lamp} \times \$0.07/\text{kWh} \times 1\ \text{kWh}/1000\ \text{wh} = \$1.94\ \text{savings/yr/lamp}$$

$$A/P = 1.94/2.80 = .69$$

From Table 9-5 a rate of return of 25 percent is obtained. When analyzing energy conservation measures, never look at what was previously spent or the life remaining. Just determine if the new expenditure will pay for itself.

SIM 9-2

An electrical energy audit indicates electrical motor consumption is 4×10^6 kWh per year. By upgrading the motor spares with high efficiency motors a 10% savings can be realized. The additional cost for these motors is estimated at $80,000. Assuming an 8¢ per kWh energy charge and 20-year life, is the expenditure justified based on a minimum rate of return of 20% before taxes? Solve the problem using the present worth, annual cost, and rate-of-return methods.

Analysis

	Present Worth Method	
	Alternate 1 *Present Method*	*Alternate 2* *Use High Efficiency Motor Spares*
(1) First Cost (P)	—	$80,000
(2) Annual Cost *(A)*	$4 \times 10^6 \times .08$ = $320,000	.9 × $320,000 = $288,000
P/A (Table 9-4)	4.87	4.87
(3) *A* × 4.87 = Present Worth	$1,558,400	$1,402,560
(1)+(3)	$1,558,400	$1,482,560
		Choose Alternate with Lowest Present Worth

Annual Cost Method

	Alternate 1	*Alternate 2*
(1) First Cost (P)	—	$80,000
(2) Annual Cost (*A*)	$320,000	$288,000
A/P (Table 9-4)	.2	.2
(3) P × .2	—	$16,000
Annual Cost (2)+(3)	$320,000	$304,000  Choose Alternate with Lowest Annual Cost

Rate of Return Method

$$P = (\$320{,}000 - \$288{,}000)$$

$$P/A = \frac{80{,}000}{32{,}000} = 2.5$$

What value of i will make P/A = 2.5? i = 40% (Table 9-7).

SIM 9-3

Show the effect of 10 percent escalation on the rate of return analysis given the

Energy equipment investment	= $20,000
After-tax savings	= $2,600
Equipment life (n)	= 15 years

ANSWER

Without escalation:

$$\frac{A}{P} = \frac{2{,}600}{20{,}000} = 0.13$$

From Table 9-1, the rate of return is 10 percent. With 10 percent escalation assumed:

$$\frac{P}{A} = \frac{20{,}000}{2{,}600} = 7.69$$

From Table 9-11, the rate of return is 21 percent.

Thus we see that taking into account a modest escalation rate can dramatically affect the justification of the project.

Making Decisions for Alternate Investments

There are several methods for determining which energy conservation alternative is the most economical. Probably the most familiar and trusted method is the annual cost method.

When evaluating replacement of processes or equipment *do not* consider what was previously spent. The decision will be based on whether the new process or equipment proves to save substantially enough in operating costs to justify the expenditure.

Equation 9-16 is used to convert the lump sum investment P into the annual cost. In the case where the asset has a value after the end of its useful life, the annual cost becomes:

$$AC = (P - L) * \mathrm{A/P} + iL \tag{9-16}$$

where

AC is the annual cost

L is the net sum of money that can be realized for a piece of equipment, over and above its removal cost, when it is returned at the end of the service life. *L* is referred to as the salvage value.

As a practical point, the salvage value is usually small and can be neglected, considering the accuracy of future costs. The annual cost technique can be implemented by using the following format:

	Alternate 1	Alternate 2
1. First cost (P)		
2. Estimated life (n)		
3. Estimated salvage value at end of life *(L)*		
4. Annual disbursements, including energy costs & maintenance (E)		
5. Minimum acceptable return *before* taxes (i)		
6. A/P n, i		
7. $(P - L) * A/P$		
8. Li		
9. $AC = (P - L) * A/P + Li + E$		

Choose alternate with lowest annual cost

The alternative with the lowest annual cost is the desired choice.

SIM 9-4

A new water line must be constructed from an existing pumping station to a reservoir. Estimates of construction and pumping costs for each pipe size have been made.

The annual cost is based on a 16-year life and a desired return on investment before taxes of 10 percent. Which is the most economical pipe size for pumping 4,000 hours/year?

Pipe Size	Estimated Construction Costs	Cost/Hour for Pumping
8"	$80,000	$4.00
10"	$100,000	$3.00
12"	$160,000	$1.50

ANSWER

	8" Pipe	10" Pipe	12" Pipe
P	\$80,000	\$100,000	\$160,000
n	16	16	16
E	16,000	12,000	6,000
i	10%	10%	10%
A/P = 0.127	—	—	—
$(P - L)$ A/P	10,160	12,700	20,320
Li	———	———	———
AC	\$26,160	\$24,700 (*Choice*)	\$26,320

Depreciation, Taxes, and The Tax Credit

Depreciation

Depreciation affects the "accounting procedure" for determining profits and losses and the income tax of a company. In other words, for tax purposes the expenditure for an asset such as a pump or motor cannot be fully expensed in its first year. The original investment must be charged off for tax purposes over the useful life of the asset. A company usually wishes to expense an item as quickly as possible.

The Internal Revenue Service allows several methods for determining the annual depreciation rate.

Straight-line Depreciation. The simplest method is referred to as a straight-line depreciation and is defined as:

$$D = \frac{P \pm L}{n} \tag{9-17}$$

where

D is the annual depreciation rate

L is the value of equipment at the end of its useful life, commonly referred to as salvage value

n is the life of the equipment, which is determined by Internal Revenue Service guidelines
P is the initial expenditure.

Sum-of-Years Digits

Another method is referred to as the sum-of-years digits. In this method the depreciation rate is determined by finding the sum of digits using the following formula,

$$N = n\,\frac{(n+1)}{2} \tag{9-18}$$

where n is the life of equipment.

Each year's depreciation rate is determined as follows:

First year $$D = \frac{n}{N}\,(P \pm L) \tag{9-19}$$

Second year $$D = \frac{n \pm 1}{N}\,(P \pm L) \tag{9-20}$$

n year $$D = \frac{1}{N}\,(P \pm L) \tag{9-21}$$

Declining-Balance Depreciation

The declining-balance method allows for larger depreciation charges in the early years which is sometimes referred to as fast write-off.

The rate is calculated by taking a constant percentage of the declining undepreciated balance. The most common method used to calculate the declining balance is to predetermine the depreciation rate. In the double declining-balance depreciation method, a rate equal to 200 percent of the straight-line depreciation rate is used.

Under other circumstances the rate is limited to 1-1/2 or 1/4 times as great as straight-line depreciation. In this method the

salvage value or undepreciated book value is established once the depreciation rate is pre-established.

To calculate the undepreciated book value, Equation 9-22 used.

$$D = 1 \pm \left(\frac{L}{P}\right)^{1/N} \tag{9-22}$$

where

D is the annual depreciation rate
L is the salvage value
P is the first cost.

Comparing Depreciation Methods

Depending on the depreciation method used, the charges would vary.

SIM 9-5

Compare the depreciation charges for a $5000 computer with a 3-year life, for the following methods: Straight Line Depreciation, Sum of Years Digits and Double Declining Balance.

Answer

Method	*Year 1*	*Year 2*	*Year 3*
Straight Line	$1,666	$1,666	$1,666
Sum of Years	$2,400	$1,600	$1,000
Double Declining Balance	$3,300	$1,700	0

Tax Considerations

Consult the accounting department for the latest Internal Revenue Rules for depreciation and tax credits.

Tax-deductible expenses such as maintenance, energy, operating costs, insurance, and property taxes reduce the income subject to taxes.

For the after-tax life cycle analysis and payback analysis the actual incurred and annual savings is given as follows.

$$AS = (1 - I)\ E + ID \tag{9-23}$$

where

- AS is the yearly annual after-tax savings (excluding effect of tax credit)
- E is the yearly annual energy savings (difference between original expenses and expenses after modification)
- D is the annual depreciation rate
- I is the income tax bracket.

Equation 9-23 takes into account that the yearly annual energy savings are partially offset by additional taxes which must be paid due to reduced operating expenses. On the other hand, the depreciation allowance reduces taxes directly.

After-tax Analysis

To compute a rate of return which accounts for taxes, depreciation, escalation, and tax credits, a cash-flow analysis is usually required. This method analyzes all transactions including first and operating costs. To determine the after-tax rate of return a trial-and-error or computer analysis is required.

All money is converted to the present assuming an interest rate. The summation of all present dollars should equal zero when the correct interest rate is selected, as illustrated in Figure 9-8.

This analysis can be made assuming a fuel escalation rate by using the gradient present worth interest of the present worth factor.

SIM 9-6

Develop a set of curves that indicate the capital that can be invested to give a rate of return of 15 percent after taxes for each $1,000 saved for the following conditions:

Year	1 Investment	2 Tax Credit	3 After-tax Savings (AS)	4 Single Payment Present Worth Factor	(2 + 3) × 4 Present Worth
0	$-P$				$-P$
1		$+TC$	AS	P/F_1	$+P_1$
2			AS	P/F_2	P_2
3			AS	P/F_3	P_3
4			AS	P/F_4	P_4
Total					$\sum P$

$$AS = (1 - I)\ E + ID$$

Trial-and-Error Solution:
Correct i when $\sum P = 0$

Figure 9-8. Cash flow rate of return analysis.

1. The effect of escalation is not considered.
2. A 5 percent fuel escalation is considered.
3. A 10 percent fuel escalation is considered.
4. A 14 percent fuel escalation is considered.
5. A 20 percent fuel escalation is considered.

Calculate for 5-, 10-, 15-, 20-year life.

Assume straight-line depreciation over useful life, 34 percent income tax bracket, and no tax credit.

ANSWER $AS = (1 - I)E + ID$

$I = 0.34, \qquad E = \$1{,}000$

$$AS = 660 + \frac{0.34P}{N}$$

Thus, the after-tax savings (AS) are comprised of two components. The first component is a uniform series of \$660 escalating at e percent/year. The second component is a uniform series of $0.34P/N$.

Each component is treated individually and converted to present day values using the GPW factor and the P/A factor, respectively. The sum of these two present worth factors must equal P. In the case of no escalation, the formula is:

$$P = 660 * P/A + \frac{0.34P}{N} \quad P/A$$

In the case of escalation:

$$P = 660\ GPW + \frac{0.34P}{N} * P/A$$

Since there is only one unknown, the formulas can be readily solved. The results are indicated in the following chart.

	$N = 5$ \$$P$	$N = 10$ \$$P$	$N = 15$ \$$P$	$N =20$ \$$P$
$e = 0$	2,869	4,000	4,459	4,648
$e = 10\%$	3,753	6,292	8,165	9,618
$e = 14\%$	4,170	7,598	10,676	13,567
$e = 20\%$	4,871	10,146	16,353	23,918

Figure 9-9 illustrates the effects of escalation. This figure can be used as a quick way to determine after-tax economics of energy utilization expenditures.

SIM 9-6

It is desired to have an after-tax savings of 15 percent. Comment on the investment that can be justified if it is assumed that the fuel rate escalation should not be considered and the annual energy savings is $2,000 with an equipment economic life of 15 years.

Comment on the above, assuming a 14 percent fuel escalation.

ANSWER

From Figure 9-9, for each $1,000 energy savings, an investment of $4,400 is justified or $8,800 for a $2,000 savings when no fuel increase is accounted for.

With a 14 percent fuel escalation rate an investment of $10,600 is justified for each $1,000 energy savings, thus $21,200 can be justified for $2,000 savings. Thus, a much higher expenditure is economically justifiable and will yield the same after-tax rate of return of 15 percent when a fuel escalation of 14 percent is considered.

Impact of Fuel Inflation on Life Cycle Costing

As illustrated by problem 9-5 a modest estimate of fuel inflation has a major impact on improving the rate of return on investment of the project. The problem facing the project manager is how to forecast what the future of energy costs will be. All too often no fuel inflation is considered because of the difficulty of projecting the future.

Summary of Life Cycle Costing

Always draw a cash flow diagram on a time basis scale. Show cash flow ins as positive and cash flow outs as negative.

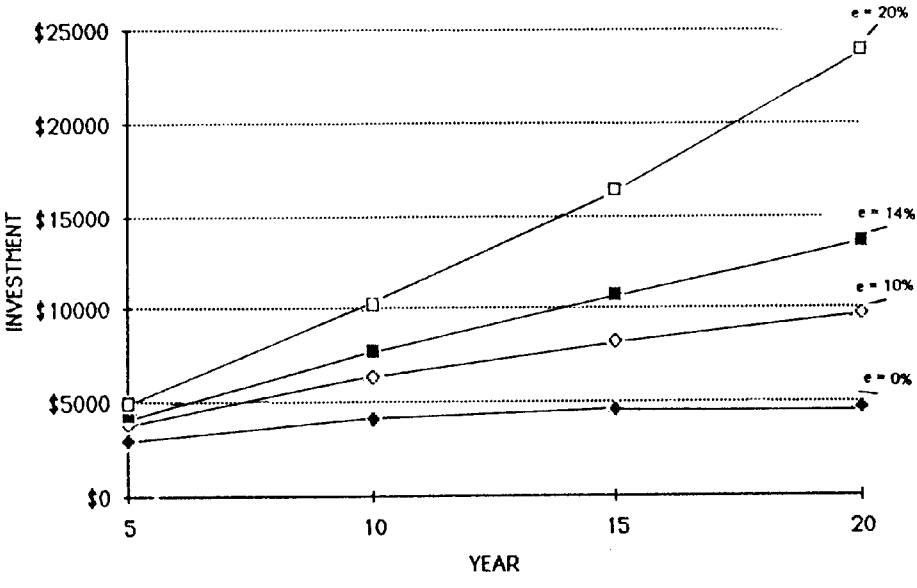

Figure 9-9. Effects of escalation on investment requirements.
Note: Maximum investment in order to attain a 15% after-tax rate of return on investment for annual savings of $1,000.

In determining which interest formula to use, the following procedure may be helpful. First, put the symbols in two rows, one above the other as below:

$$\frac{\text{PAF (unknown)}}{\text{PAF (known)}}$$

The top represents the unknown values, and the bottom line represents the known. From information you have and desire, simply circle one of each line, and you have the correct factor.

For example, if you want to determine the annual saving "A" required when the cost of the energy device "P" is known, circle P on the bottom and *A* on the top. The factor A/P or capital recovery is required for this example. Table 9-11 summarizes the cash analysis for interest formulas.

Table 9-11. Cash Analysis for Interest Formulas.

GIVEN	*FIND*	*USE*
P	F	F/P
F	P	P/F
A	F	F/A
F	A	A/F
P	A	A/P
A	P	P/A

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Chapter 10

Contract Planning Essentials

It is essential that the administration and management of contracts results in reducing risks, maximizing cost savings, minimizing claims, and improving economic return. These results can only be achieved through effectively managing contract risks: developing fair contract documents, engaging in effective negotiating practices, and employing outstanding communication skills.

The process of reaching a contract requires a specific sequence of steps. In taking these steps, the project manager must make a series of choices between priorities for project objectives, degrees of risk to be assumed by the contracting parties, control over project activities, and the cost of achieving selected goals. This process must first be fully understood by the project manager, then be tempered by experience, and finally be expanded into the ability to reach a contract through the exercise of negotiating and communicating skills.

An excellent, simple-to-use reference on contracts is *ASHRAE Member's Survival Guide*—Contracts available from www.ashrae.org.

What is a Contract?

A contract is a mutual business agreement recognized by law under which one party undertakes to do work (or provide a service) for another party for a "consideration."

Owner contracting arrangements would cover:

- Contract Conditions Commercial Terms & Pricing Arrangements
- Scope of Work (Technical)
- Project Execution Plan

Why Have a Contract?

A written contract provides the document by which the risks, obligations, and relationships of all parties are clearly established, and ensures the performance of these elements in a disciplined manner. In the owner situation, the contract is the means by which the contractor can be controlled and ensures that the work and end product satisfy the owner's requirements.

Parties to the Contract

Most projects are executed under a three-party contractual relationship:

- The owner, who establishes the form of contract and the general conditions.
- The engineer, who can have the following three roles:
  - — Designer—carrying out the detailed engineering work, and purchasing equipment and material on the owner's behalf
  - — Arbitrator—acting as the owner's agent in administering the contract and deciding, impartially, on certain rights of the parties under the contract
  - — Project manager-handling design, procurement, and construction or construction management/services.
- The contractor

The normal contractual relationship among these three parties on a single project is for the owner to have one contract with the engineer for design, procurement, and other services, and a separate contract with the contractor for the construction work. No contractual relationship exists between the engineer and the contractor. This is usually referred to as a "divided or split responsibility" arrangement. In an alternative arrangement, called "single responsibility," a general contractor is awarded total responsibility for the engineering, procurement, and construction.

The project manager must carefully decide on a specific contracting arrangement, as outlined in the section below on Contract Strategy, and in Chapter 6, Planning.

Contract Responsibility

The project manager is essentially responsible for the contract strategy, which is developed as part of the project strategy. However, the proposed division of work, contracting arrangements, forms of contract, and bidders' lists should be developed in conjunction with the company's contracts department.

This combined responsibility of the project manager and the contracts department in the contracting process can lead to inefficiencies, delays, and disagreements and can negatively impact the project cost and schedule when there are organizational conflicts. Close coordination and effective communications must exist between all groups to ensure complete agreement and commitment to the proposed contracting program. This is particularly important in all submissions to contract committees and/or senior management.

The project manager must obtain agreement from the company's contracting department and insurance department before committing to contractual language regarding liability, indemnity, or insurance.

Contract Strategy

As covered in the project strategy, the following would be major considerations when developing a contract strategy for the project:

- When and how will the work be divided up?

- How will the division of work affect client/project team/main contractor/vendor/subcontractor interfaces? (This division enables the project coordination procedures to be properly prepared.)

- What type of contract should be used? Segment the project into discrete work packages to facilitate management, and subject the work packages to available resources. Consider the contract philosophy, the type of contract best suited to the project, contract interfaces, bid evaluation techniques, and bid documentation. This enables the contract strategy to be produced in liaison with the contracts department.

- What roles are licensers and consultants expected to play? This allows arrangements to be made for prequalifying suitable contractors, issuing invitations to bid, evaluating bids, and making award recommendations.

- Are there potential conflicts of interest with other owner projects in contractors' offices, in vendors' workshops, or within fabrication yards? Such conflicts can have an impact on the bidder's list.

- What is the availability of skilled labor? What is the industrial relations climate local to fabrication yards and local to the construction site? Lack of labor can delete a contractor from the bidder's list.

- What is the quality and availability of personnel to develop, evaluate, and administer the required type of contract/contract conditions?

Contracting Arrangements

Engineering and construction contracts can be drawn in a great variety of forms, depending on the contract strategy and the financial resources of the contractor. The most successful contracts have at least one element in common: thoughtful and thorough preparation before the contract is let.

Contractual arrangements in construction are becoming increasingly more involved, which leads to the potential for significant added costs. Project complexity, and the changing and increasingly costly legal and insurance environments, are major reasons for considering whether better contractual arrangements are possible. Contracts, of course, must be made early in the life of a project. To do this while simultaneously providing for the risks of uncertainties and gaining improved performance and innovation presents major challenges for owners and contractors alike.

Forms of Contract

There are three principle types of contracts: reimbursable, measured (unit price), and lump sum. The following forms of contract are typical of these types:

- Cost Reimbursable (Time & Material)
- Cost Reimbursable with Percentage Fee
- Cost Reimbursable with Fixed Fee
- Cost Reimbursable Plus Cost/Schedule Bonus-Penalties
- Measured Unit Price (Mostly Construction)
- Guaranteed Maximum Price
- Lump Sum/Fixed Price

The objectives of cost, time, quality, risks, and liabilities must be analyzed and prioritized, since trade-offs will probably be necessary in deciding the type of contract to be used.

Reimbursable Cost Contracts

These require little design definition, but need to be constructed in a way that allows expenditures to be properly controlled. The major advantage of a reimbursable cost contract is time, since a contract can be established during the early stages of a project. This type of contract does present a disadvantage to an owner, however, since poor contractor performance can result in increased costs, and the final costs are the owner's responsibility. Additionally, the final/total investment level is not known until the work is well advanced.

Reimbursable cost contracts can contain lump sum elements, e.g. the contractor's overhead charges and profit, which is usually preferable to a percentage basis for calculating these costs. Reimbursements may be applied to salaries, wages, insurance and pension contributions, office rentals, communication cost, etc. Alternatively, reimbursement can be applied to all-inclusive hourly or daily rates for time spent by engineers on the basis that all office support costs are built into these rates. This form of contract is generally known as a fixed fee/reimbursable cost contract and can be used for both engineering and other office services as well as for construction work.

Such arrangements give the owner greater control over the contractor's engineering work, but the effect of reducing the lump sum content of the contractor's remuneration is to reduce its financial incentive to complete the work economically and speedily. It also reduces the ability to compare/evaluate competitive bids, since the comparison that can be made between contractor bids involves only a small percentage of the project cost. It is possible that the "best" contractor may not quote the lowest prices.

- Requirements
  a. A competent and trustworthy contractor

b. Close quality supervision and direction by the owner
c. Detailed definition of work and payment terms covered by lump sums and by "all-inclusive" rates

- Advantages
  a. Flexibility in dealing with changes (which is very important when the job is not well defined), particularly if new technology development is proceeding concurrently with the design
  b. An early start can be made
  c. Useful where site problems such as delays and disruptions may be encountered
  d. Owner can exercise control on all aspects of the work

- Disadvantages
  a. Final cost is unknown
  b. Difficulties in evaluating proposals-strict comparison of the amount tendered may not result in selection of the "best" contractor or in the lowest cost of the project
  c. Contractor has little incentive for early completion or cost economy
  d. Contractor can assign its "second division" personnel to the job and may make excessive use of agency personnel and/or use the job as a training vehicle for new personnel
  e. Owner carries most of the risks and faces the difficult decisions

Target Contracts (Cost and Schedule)

Target contracts are intended to provide a strong financial incentive for the contractor to complete the work at minimum cost and time. In the usual arrangement, the contractor starts work on a reimbursable cost basis. When sufficient design is complete, the contractor produces a definitive estimate and project schedule for owner review, mutual negotiation, and agreement. After agreement is reached, these become targets. At the end of the job, the

contractor's reimbursable costs are compared with the target and any savings or overrun is shared between the owner and the contractor on a pre-arranged basis. Similarly, the contractor qualifies for additional payment if it completes the work ahead of the agreed-upon schedule. The main appeal this form of contract has to the contractor is that it does not involve competitive bidding for the target cost and schedule provisions.

- Requirements
  a. A competent and trustworthy contractor
  b. Quality supervision by owner (both technical and financial)

- Advantages
  a. Flexibility in controlling the work
  b. Almost immediate start on the work, even without a scope definition
  c. Encourages economic and speedy completion (up to a point)

- Disadvantages
  a. Final cost initially unknown
  b. No opportunity for competitive bidding for the "targets"
  c. Difficulty in agreeing on an effective target
  d. Variations are difficult and costly once the target has been established—contractors tend to inflate the cost of all variations so as to increase profit potential with "easy" targets
  e. If the contractor fails to achieve the targets, it may attempt to prove that this was due to interference by the owner, or to factors outside the contractor's control; hence, effective control and reporting is essential

Measured (Unit Price) Contracts

These require sufficient design definition or experience in

order to estimate the unit/quantities for the work. Contractors then bid fixed prices for each unit of work. The advantage is that the time and cost risk is shared: the owner will be responsible for the total quantities, and the contractors will have the risk of the fixed unit price. A quantity increase greater than 10% can lead to increases in the unit prices.

- Requirements
  a. An adequate breakdown and definition of the measured units of work
  b. A good quantity surveying/reporting system
  c. Adequate drawings and/or substantial experience for developing the Bill of Quantities
  d. Financial/payment terms that are properly tied to the measured work and partial completion of the work
  e. Owner-supplied drawings and materials must arrive on time
  f. Quantity-sensitivity analysis of unit prices to evaluate total bid price for potential quantity variations

- Advantages
  a. Good design definition is not essential—"typical" drawings can be used for the bidding process
  b. Very suitable for competitive bidding and relatively easy contractor selection, subject to sensitivity evaluation
  c. Bidding is speedy and inexpensive and an early start is possible
  d. Flexibility—depending on the contract conditions, the scope and quantity of work can be varied

- Disadvantages
  a. Final cost is not known at the outset since the Bills of Quantities have been estimated on incomplete engineering
  b. Additional site staff are needed to measure, control, and report on the cost and status of the work

Lump Sum/Fixed Price Contracts

In this type of contract, the contractor is generally free to employ whatever methods and resources it chooses in order to complete the work. The contractor carries total responsibility for proper performance of the work although approval of design, drawings, and the placement of purchase orders and subcontracts can be monitored by the owner to ensure compliance with the specification. The work to be performed must be closely defined. Since the contractor will not carry out any work not contained in the specification without requiring additional payment, a fully developed specification is vitally important. The work has to be performed within a specified period of time, and status/progress can be monitored by the owner to ensure that completion meets the contractual requirements.

The lump sum/fixed price contract presents a low financial risk to the owner, and the required investment level can be established at an early date. This type of contract allows a higher return to the contractor for superior performance. A good design definition is essential, although this may be time-consuming. Further, the bidding time can be twice as long as that for a reimbursable contract bid. For contractors, the cost of bids and the high financial risk are factors in determining the lump sum approach.

- Requirements
  a. Good definition and stable project conditions are essential
  b. Effective competition is essential
  c. Several months are needed for bidding and appraisal
  d. Minimal scope changes

- Advantages
  a. Low financial risk to owner, maximum financial risk is on the contractor
  b. Cost (and project viability) is known before commitment is made
  c. Minimum owner supervision-mostly quality assurance and schedule monitoring

d. Contractor will usually assign its best personnel to the work
e. Maximum financial motivation of contractor-maximum incentive for the contractor to achieve early completion at superior performance levels
f. Contractor has to solve its own problems-and quickly
g. Contractor selection (by competitive bidding) is fairly easy, apart from deliberate low price

Disadvantages

a. Variations are difficult and costly—the contractor, having quoted keenly when bidding, will try to make as much as possible on extras
b. An early start is not possible because of the time taken for bidding and for developing a good design basis
c. The contractor will tend to choose the cheapest and quickest solutions, making technical monitoring and strict quality control by the owner essential; schedule monitoring is also advisable
d. The contractor has a short-term interest in completing the job and may cause long-term damage to local relationships, e.g. by setting poor precedents/union agreements
e. Bidding is expensive for the contractor, so the bid invitation list will be short; technical appraisal of bids by the owner may require considerable effort
f. Contractors will usually include allowances for contingencies in the bid price and they might be high.
g. Bidding time can be twice that required for other types of contracts

Conditions of the Contract

While the same risks/liabilities can be established for most forms of contract, the price for those risks/liabilities can vary significantly, depending on contracting skills and the business environment/market place.

Typical Forms of Contract Used in the United Kingdom and the United States

- United Kingdom
  a. Institute of Civil Engineers—ICE—mainly for civil and construction-only contracts
  b. Federation Internationale des Ingenieurs-Conseils—FIDIC—primarily for offshore and overseas work
  c. Institute of Mechanical Engineers—IMech E—primarily for design and erection of mechanical plant

- United States
  a. American Institute of Architects (AIA) mainly for engineering work and project/construction management; the A/E usually functions as the owner's "agent" on a fee/reimbursable basis
  b. The Associated General Contractors of America (AGC) mainly for construction work and construction management; the contractor usually functions as an "independent contractor" on a lump sum/fixed price basis
  c. The EJCDC forms of contract documents (issued jointly by the NSPE, ACEC, ASCE, and CSI and approved by the AGC), are often used by many engineering firms. In addition, it is becoming more prevalent for an owner to develop a form of contract that is specifically customized to fit its particular needs. Similarly, an engineering/construction contractor may develop its own forms of contract for use on projects in which it acts as the construction/project manager for the owner. There are at least two basic options: (1) use one of the "standard" contracts and customize it to fit a particular project, or (2) use the "boiler plate" or "front-ends" developed by the engineer/contractor for use on projects in which it is responsible for preparing the bidding documents and where the owner does not have its own.

Summary

It is possible to devise a form of contract with appropriate terms and conditions to suit many different circumstances. Some basic considerations leading to the best choice are:

- Clear definition of each party's contractual responsibilities. Shared responsibilities are unsatisfactory, although they are unavoidable in some circumstances.

- The lump sum form of contract provides the best financial risk for the owner, gives the contractor the maximum incentive for early completion, and produces the greatest benefit of competitive bidding. Conversely, reimbursable contracts provide no such incentives. It is dangerous, however, to attempt to use a lump sum contract if the essential conditions are not satisfied-notably, a clear and complete definition of the scope of work.

- The owner must have the contractual right to exercise control adequate to ensure the success of the project, but the temptation to assume excessive control should be resisted.

- Control and responsibility go together-the greater the owner's control, the less responsibility is carried by the contractor.

One last point: the form of contract must be decided early in the project development and the choice must be made known to the engineers before they write the specifications. Obviously, the specification will be much more precise and comprehensive if it is to be used for a lump sum contract than would be required for a reimbursable contract.

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Chapter 11

Commissioning Construction Projects*

The Project Manager and Commissioning

In order to insure that construction projects meet the specification of the designers, it is critical that the project be commissioned. The project manager should insure that this step has not been overlooked when completing the project. All buildings which are LED certified by the U.S. Green Building Council require "commissioning." This chapter will highlight commissioning strategies that the project manager needs to know.

Commissioning and Re-commissioning

What is the difference between commissioning and re-commissioning? Commissioning is a process associated with new construction, while re-commissioning is usually reserved for old or existing facilities. The main goal of commissioning is to ensure that the owner receives what was specified in the design documents, while the goal of re-commissioning is to restore the facility's performance to its initial design specifications, or to make the systems work for the first time. In summary, both commissioning and re-commissioning are quality assurance programs for the owner.

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Reasons for Re-commissioning

There are many reasons that entice owners, managers, and engineers to consider re-commissioning of their facilities. The following are the most common reasons.

- **High energy consumption of the facility.** This is usually a good indication that the facility is not operating very efficiently. The HVAC system is dynamic in nature. The individual components get old and impact the operation of the system. Adding independent, highly technical, and efficient pieces of equipment over time does not guarantee a state-of-the-art integrated system for the facility.

- **Constant occupant complaints.** High numbers of "too hot" or "too cold" calls from the tenants usually raises the red flag about the facility, especially when it encompasses an entire floor or the whole building. It is well documented that up to 70 percent of all tenants' complaints are about the HVAC system. High tenant complaints may lead to vacancies and the loss of revenue. Other issues like poor indoor air quality may dictate a comprehensive evaluation of the facility.

- **Tenant retention.** The inability to maintain occupancy in the building, or to attract new tenants to the facility, may be the most important reason for the owner to re-commission the facility.

- **Maintenance staff complains.** Difficulty in controlling, operating, and maintaining the equipment by the maintenance staff is a good reason to re-commission the facility. Remember that the building engineer has the ultimate control of the building's mechanical system. All controls will be operated at his level of understanding.

- **Protection of assets.** Owners and facilities managers are interested in extending the life of their equipment and in protecting their investment in the physical facilities.

Re-commissioning is time consuming and expensive. No manager will allocate resources to re-commission a well-tuned facility. However, if the facility is experiencing any of the above challenges, then re-commissioning may be the answer.

Initiation of a Re-commissioning Program

Commissioning a new facility is very easy compared to re-commissioning an old or existing building. For a new facility, the design specifications are well documented. Mechanical and electrical control points, as well as other as-built plans, are readily available. The sequence of operation is well defined. To re-commission an older facility you may lack some or most of these resources. For that reason data collection is crucial. The following is a suggested list of what you may need.

- **Utility bills.** Collect electric, natural gas, and any other energy bills. Contact the utilities and request a history of each account for the past few years. Audit these bills and note any spikes or gradual increases in consumption. An energy utilization index (EUI) may be needed, especially if you have similar facilities on the same campus. The EUI will provide information on the total energy consumption of the facility per square foot per degree days.

- **Upgrade and retrofit records and as-built drawings.** Obtain copies of all the mechanical and electrical upgrades and retrofits. This will help determine what upgrades and retrofits were undertaken on the initial mechanical system. Partial as well as complete replacement of an entire system should be clearly defined. This includes, but is not limited to, chillers, boilers, heat exchangers, pumps, variable frequency drives, variable air volume boxes, fan coil units, and cooling towers.

- **Out-sourced services contracts.** Evaluate all the out-sourced service contracts. Unfortunately, most service contracts are

signed with the owner expecting the most qualified technician of the service company to perform the job, while in reality most of the service work for the term of the contract will be conducted by an apprentice. Note excessive repeat calls.

- **Review the PM program.** If the facility has a preventive maintenance (PM) program, then the program should be evaluated. Maintenance staff is the best source on the effectiveness of the program. If more time is spent on reactive than preventive maintenance, then total evaluation of the PM program is needed. If the facility does not have a PM program, then the commissioner should help with the initiation of a new program.

- **Review the sequence of operation.** Every facility should have a written, well defined sequence of operation. If there is no documented sequence, the commissioner should meet with the building staff to determine if there is an agreed-upon sequence. The commissioner should test this sequence, and if any changes are discovered during the testing, these changes, along with the established sequence, should be documented.

- **Tour the facility.** Visit all the mechanical and electrical rooms and note their condition. Special attention should be paid to air handler rooms. Note the condition of the air filters, drip pans, dampers, valves, and coils, as well as the mechanical room itself. Note any override of equipment. Holding the outside air dampers open with a 2 × 4 or by a wire hanger is not considered the best indoor air quality control measure.

- **Check the Motor Control Center panels.** While visiting the electrical rooms, note the status of mechanical equipment on the MCC panels. Remember, if a piece of equipment is in the "HAND" position, then it is overridden and it will stay on continuously, thereby consuming energy and increasing the wear and tear on the equipment.

- **Note the operating status of equipment.** During the tour of the mechanical rooms, note if the chillers are partially loaded, if a Variable Frequency Drive (VFD) is running at 60 Hz, or if the boilers are on when the outside air temperature is in the upper 80s or 90s. Remember, the more the commissioner uses the word "WHY," the more puzzled looks he will experience.

Re-commissioning Case Studies

As an owner-developer-operator, Zions Securities Corporation established the re-commissioning program as a result of its successful commissioning program. The intention of the program was to look at every piece of equipment as a part of a total integrated system. For example, re-commissioning the heating system would involve all the equipment associated with that system: boilers, circulating pumps, heat exchanger, variable frequency drives, expansion tanks, condensate tanks, de-aerator tanks, domestic hot water tanks, make-up water, induction units, steam traps, water treatment, fan coil units, and the main heating coils in the air handler. Of course, some of the buildings may have all these components while others may have a selected few.

Case #1. Re-commissioning of 139 East South Temple Office Building

This 68,000 sq/ft 6-story office building was constructed in the late 1920s. Over the years, the building went through many space utilization changes; one example is from a movie theater on some floors to office space. The windows were retrofitted with new sealed frames, limiting the amount of fresh air being introduced to the building through the windows, frames, and cracks. Over time, around 70 heat pumps were installed in all tenant spaces, each with its own manual controls. The heat pumps operated 24 hours per day, 7 days a week. The heat pumps' water loop temperature was set at 72°F all year round. A small furnace provided the required heating for the water loop. A cooling tower and

a heat exchanger provided the required cooling.

The main reasons for re-commissioning this facility were the high maintenance costs of the heat pumps and the desire to reduce their run time. Tenant thermal comfort as well as retention were the other influential factors. Re-commissioning was able to uncover the following deficiencies and correct them.

- **System pumps status.** The water loop serving the heat pumps had two circulating pumps. According to the building engineer, both pumps were required to be on all the time. The reason stated was, "it has always been done this way." One of the circulating pumps was turned off and for the last four years the system has been operating "on one pump" without problems. These pumps are being alternated at the start of every month.

- **Furnace problems.** The hot water supply was set at 90°F, which was too low a setting for the boiler. The boiler coils were plugged and the modulating valve that controls the mixing of the building heat pumps' loop and the boiler hot water was not working properly. The boiler hot water supply temperature was raised to 130°F and the modulating valve was repaired. The boiler has been working very well ever since.

- **Heat pump maintenance.** The maintenance of the heat pumps was out-sourced to a service company. After reviewing the maintenance records, it was clear that many of the service calls were repeat calls of "low" or "high" Freon charge. Frequently, these calls were on the same heat pump. The service company was replaced and service calls were drastically decreased.

- **Heat pumps' controls.** An audit was conducted on the heat pumps to identify their locations and conditions. A new building automation system (BAS) was installed that con-

trolled the heat pumps. An occupancy schedule was implemented that reflected normal business hours. The heat pumps were turned off during evenings, weekends, and holidays. An after-hours charge program for tenant use was initiated and tenants were billed monthly for this service.

The BAS graphics simplified the monitoring and troubleshooting of the beat pumps.

- **Zoning problems.** For many years, one of the first-floor tenants who was located above a ramp to a loading dock complained about cold space temperature. During winter months cold air infiltrated this office and the large windows did not help. All cracks were sealed and an electric baseboard heater was installed under the windows. The start/stop operation of the baseboard heater was controlled by the BAS. The tenant complaints stopped.

- **Indoor air quality test.** An indoor air quality test was conducted on all floors. All the readings were good.

Re-commissioning Results of 139 East

The re-commissioning of this facility resulted in lower energy and maintenance costs, reduced run time on the heat pumps, as well as a new revenue source to the owner. The re-commissioning program was started in the 1997, for that reason all the kW and kWh comparisons were based on the year before the re-commissioning started. Table 1 shows the electrical power saved by the re-commissioning program.

Total kWh saved since 1996 was 226,569. Total kW saved since 1996 was 1,222. Cost savings at 2.50 per kWh and $7.60 per kW (current energy costs charged by Utah Power) are $14,951.43.

Other savings and revenue sources gained by the re-commissioning process were:

- **New revenue source**. Additional revenue was created by billing the tenants for their after hours usage of the HVAC.

Table 1. Electric Power for 139 East

Year	*kW*	*kWh*
1996	5,551	1,162,546
1997	5,322	1,148,147
1998	5,120	1,054,548
1999	4,989	1,058,374

- **Reducing the run time on the heat pumps.** By reducing the run time, the wear and tear on the heat pumps was lowered and the life expectancy was increased.

Please note that other systems were commissioned but not included in this report, such as CCTV and fire systems. These systems are beyond the scoop of this chapter.

Case #2. Re-commissioning of the Temple View Center Office Building

This 48,284 sq/ft 8-story office building was constructed in the late 1930s. During the early 1980s the entire building went through a major renovation. New energy-efficient windows were installed. Variable Air Volume (VAV) boxes were installed with Direct Digital Controllers (DDC) controllers; however, these controllers were stand-alone, and every service call required a ladder to connect to the DDC card at the side of the VAV box. Heating was provided by a district heating service in the form of steam to the building's heat exchanger. Two hot water pumps circulated the heated water to the heating coils of the VAV boxes. Each floor was served by one cooling-only air handler controlled by a time clock. A chiller with three separate compressors (80 tons) provided cooling for the air handlers. Two full floors were vacant for many years.

The main reason for commissioning was due to complaints regarding tenants' thermal comfort. When the building was fully

occupied, tenant calls increased drastically. Complaints of "too hot" as well as "too cold" were frequent. Re-commissioning uncovered the following deficiencies and corrected them.

- **Hot water pumps tripping off.** Every morning at 10:30 a.m. the Variable Frequency Drive (VFD) that controlled the heating pumps tripped off. A power analyzer indicated a voltage spike at the same time every day. Further investigating revealed that the power company changed substations at that time. A new transformer was installed on the VFD that corrected the problem. This took care of most of the "too cold" complaints.

- **Air handlers service.** An audit of the air handlers revealed that many of the cooling coils were dirty and plugged. All were pressured cleaned. One air handler experienced low chilled water flow through its coils. The inside of the coils was chemically flushed to restore flow to its original design specification. Damper service was conducted on all air handler and a few damper operators were replaced.

- **Cooling needs.** The first week after the final two floors were occupied, the "too hot" calls started coming when the outside air temperature reached 90°F. The chiller was checked and serviced and the cooling tower was cleaned. However, the chilled water temperature was climbing even though the chiller was running at 100 percent load. Conducting a load test for the building reveled that another 20 tons of cooling was needed to satisfy the cooling demand. A new chiller was installed and the problem was corrected.

- **Building controls.** The chiller as well as the air handlers were controlled by time clocks. The VAV boxes had DDC controls but were stand alone. A BAS was installed to monitor and control the air handlers and the VAV boxes. The settings on all of the VAV boxes were set the same.

Re-commissioning Results of
Temple View Center Office Building

By uncovering and correcting the deficiencies, the goal of improving tenant thermal comfort was achieved and in addition, one significant lease agreement was extended. Other systems, like the fire system, were re-commissioned but not included in this chapter.

Case #3. Re-commissioning of
Gateway Tower East

This 289,475 sq/ft 19-story office building was constructed in the mid 1960s and is currently being remodeled. The three-pipe system, one for heating, another for cooling, and the third for the common return, is being replaced. Separation of the heating and cooling system is being done in stages. The leaky induction units around the perimeter of the building are being removed one floor at a time. A new BAS has been installed in the building, replacing the old pneumatic controls with DDC. The boiler plant has three new boilers. New air handlers are being installed, with each air handler supplying air to 2 floors. As soon as a floor becomes vacant, the upgrade work begins.

The main reason for the current re-commissioning of this building is to determine the proper installation, programming, and performance of the newly installed systems. The following are the current deficiencies uncovered and the steps taken to correct them.

- **Boiler plant sequence of operation.** The design specification called for the two big boilers to turn off during summer time. A small boiler was supposed to satisfy the domestic hot water demand of the building. Re-commissioning of the boiler plant indicated that the entire boiler plant stayed on all year long because the water flow through the small boiler was too high. A new small circulating pump and a control valve were installed at the boiler and the water flow problem was corrected.

- **Boilers cycling on and off.** The boilers were cycling on and off all the time. The "low fire" was set manually on the boilers' control panel. All switches were turned to the correct settings.

- **Domestic hot water shortage**. The building has two domestic hot water (DHW) tanks, one supplying floors 1-10 while the second tank supplies floors 11-18. The tenants on the lower floors complained that the DHW supply was out every day by 10:00 a.m. The DHW tank had a 4-ft 2-cycle bundle, while the design documents called for 6-ft 4-cycle bundle. The bundle was replaced and the DHW supply problem was corrected.

- **Induction units and chillers protection.** This building has a 3-pipe system, one for chilled water, another for hot water, and a third for the common return. Since the induction units use heating and cooling water, most of the mixing between the chilled and hot water took place at the induction units. The main induction unit's modulating valve was leaking through, causing more hot water to go to the chillers. In 1998, the rupture disk on the chillers was ruptured twice due to high water temperature in the evaporator. The cost to fix the last rupture disk and add Freon to the chiller was nearly $14,000. The modulating valve for the induction units was replaced. A high-temperature alarm was programmed to the BAS to alarm the building staff of the evaporative high water temperature.

- **VFD running at 60 Hz.** The VFD controller on the 6th floor air handler, which was updated two years earlier, was running at full speed (60 Hz) all the time without being able to satisfy the tenants. This particular air handler supplied air to the 5th and the 6th floors. The air balance report indicated high static pressure at the elbow of the duct work separating the two floors. The duct work was corrected, which resulted

in increased air flow to the tenants on both floors. The VFD speed is currently controlling at 35 to 40 Hz during the day.

- **Air handlers' piping.** The chilled water supply line was piped backward to the cooling coils on three air handlers, thus affecting six floors. The piping was corrected.

- **Chilled water flow.** The chilled water flow was too low to the air handlers. The VFD that controlled the chilled water circulating pumps was set too low. The chilled water flow had been set low due to the vacancies caused by the HVAC remodeling, Upon the completion of the remodeling and new tenants, nobody remembered to increase the water flow. The water flow was corrected.

- **Cooling towers fill and equalizing lines.** Four original cooling towers shared the same fill valve as well as an equalizing line and worked in sequence. When a fifth tower was added, the fill line was extended to the other towers but the equalizing line was not connected. Thus, every time the old towers activated the fill valve, the fifth tower flooded over. A new line was installed to equalize all the cooling towers. The flooding problem was corrected.

- **Impact of the cooling towers on other systems.** The cooling towers serve two purposes: provide condenser water to the chillers and provide free cooling through a heat exchanger to the air handlers whenever the outside air temperature is below 38°F. The constant flooding of the towers resulted in diluted and ineffective water treatment. The lack of good water treatment caused the towers to start plugging, which in turn plugged the condenser side of the chillers as well as the heat exchanger. All these systems had to be opened and cleaned in order to remove the scales.

- **Eddy current test on the chillers' tubes.** Since the scaling on the condenser tubes of the chillers were difficult to remove

with regular cleaning brushes, more aggressive treatment was used. The tubes were chemically cleaned which in turn raised a concern about their integrity. An eddy current test was conducted, and the tubes were fine.

- **Free cooling heat exchanger**. The flooding of the cooling tower and the lack of proper water treatment caused the heat exchanger to scale and to lose its efficiency. The heat exchanger was opened and all the plates were cleaned. While the heat exchanger was opened, more plates were added to restore and increase cooling capacity.

- **Chiller plant controls.** The building engineer manually operated and sequenced the chillers at the chiller plant. The delay in switching between free cooling and mechanical cooling during fall and spring was a constant source of complaints. A new control system was installed on the chiller plant and connected to the main BAS. In addition to controlling the chillers, heat exchanger, and cooling towers, the new chiller plant controls simplified the tenant after-hours cooling. With a switch of a key, the tenants are able to start their floor air handler and at the same time start the chiller if needed. The tenants are now billed for all their after-hours usage.

- **BAS software maintenance.** Re-commissioning uncovered a serious problem with the software maintenance of the BAS. Since the entire HVAC system is being upgraded one floor at a time, quite a few pieces of equipment are being added, replaced, or eliminated. Consequently, many control points are either inactive or not connected to any equipment. However, these points were still programmed and were showing status and temperatures on the front end computer since they were never deleted from the controls system. The operation staff was not sure which points were real and which were not. A software maintenance audit was conducted on the BAS and all deleted equipment were removed from the program.

This audit will continue until all renovations in this building are completed.

Re-commissioning Results of Gateway Tower East

The re-commissioning of this facility resulted in the correction of many design, installation, and programming errors. In addition, the power savings by properly controlling and cleaning the chillers, the heat exchanger, and the cooling towers is very apparent. In spite of the addition of three new air handlers, re-commissioning still resulted in lowering chiller run time and energy consumption. Table 2 shows the electrical power saved by the re-commissioning program when comparing 1997, the base year, to 1998 and 1999.

Table 2. Electric Power for Gateway Tower East

Year	*kW*	*kWh*
1997	20,335	7,727,000
1998	19,112	7,099,000
1999	19,511	7,335,000

Total kWh saved since 1997 is 1,020,000 and total kW saved is 2,047. Cost savings at 2.50 per kWh and $7.60 per kW (current energy costs charged by Utah Power) is $41,057.20.

Additional savings are expected since re-commissioning is currently underway for this building. At this time, other savings and revenue sources gained are:

- **Reducing the run time of the chillers.** Before re-commissioning, chillers were turned on when the outside air temperature was below 40°F. Presently no chillers are needed until the outside air temperature is above 55°F.

- **Reducing the run time on the boilers.** Before re-commissioning, the entire boiler plant was running all year long. Pres-

ently, a small boiler is on, June through September, thus reducing the wear and tear on the boilers.

- **New revenue source**. Additional revenue was created by billing the tenants for their after hours usage of the HVAC.

Conclusion

Re-commissioning should be used as an project management tool to optimize performance, improve efficiency, and lower energy consumption. As demonstrated in the above case studies, designing, upgrading, and installing management equipment does not by itself guarantee performance or energy savings. Re-commissioning allows energy managers, as well other professionals, to go back and verify that their designs, upgrades, installations, and operations are working as intended.

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Chapter 12

Case Study: Microbial Abatement of a Moldy Hotel*

The Project Manager and Mold Remediation

Toxic mold is a growing concern as several states require remediation of this problem. The project manager faces many challenges in finding solutions to microbial abatement as illustrated in this case study.

This chapter illustrates the multifaceted approach required by the project manager. The reader is urged to contemplate how to incorporate the principles of project management and leadership learned in this book to solve the abatement problem. Apply the principles of sound planning and use the computer tools presented to manage the schedule and other challenging aspects of this project.

Abstract

A hotel constructed with an exterior insulation finish system (EIFS) had problems with water penetration of the building shell. This resulted in substantial mold growth in greater than 100

*Presented at 22nd World Energy Engineering Congress by Michael S. Crandall, M.S., CIH, CIAQP

rooms in the ten-story hotel. Microbial abatement was completed in about three months. Standard microbial abatement procedures were used. These included containment with critical barriers, airlocks, curtained doorways, the use of negative pressure, HEPA filtration, and worker protection. The hotel configuration and demands of this project created interesting abatement design problems. The problems included a bathroom in every guest room, abatement on multiple floors at a time, concurrent abatement and re-construction, and freezing temperatures. This presentation shows how these problems were dealt with to successfully complete the project.

INTRODUCTION

A 10-story hotel in a small mid-western city in the U.S. was constructed using the barrier exterior insulation finish system (EIFS). The hotel was constructed in the late 1970's. Since that time, many buildings, commercial and residential, have been constructed using this system. In the 1990's large-scale moisture problems have been discovered on buildings across the country as a result of the inability of intruding water to escape the wall cavity. Figure 12-1 is a typical barrier EIFS wall section. This hotel wall was not built with the cavity insulation or vapor retarder as shown in this figure.

In 1997 the hotel management hired a contractor to replace the caulk sealant between the large EIFS panels on the hotel. The winter of 1997 was the winter of an el niño weather pattern resulting in an unusually wet winter in the mid-west. In the spring of 1998, large areas of mold were appearing on the interior guest room walls. Wind-driven rain may have penetrated the EIFS through faults in the caulked joints and pinholes in exterior finish and basecoat layers of the panels caused by erosion.

Over a period of several months, more and more guest rooms were found to have moldy wallboard behind vinyl wall covering. Eventually, over 100 rooms in the hotel were affected. Hotel man-

agement had an industrial hygiene consultant investigate the problem. Environmental sampling identified several different fungal species growing on the wallboard, including *Penicillium sp., Aspergillus sp.,* and *Stachybotrys sp.* Air levels indicated that some of the spores from these molds were airborne. These are all molds that can cause health problems like allergy, asthma, and potentially more severe lung disease to exposed people. These problems eventually led to closing the hotel for exterior repair and mold abatement in the fall of 1998.

Microbial Abatement

An abatement contractor was hired and microbial abatement specifications were written. The abatement began on the 10th and 7th floors of the hotel in December 1998. It was completed in February 1999.

Microbial decontamination projects involve the disturbance of hazardous materials. Disturbance of microbial amplification

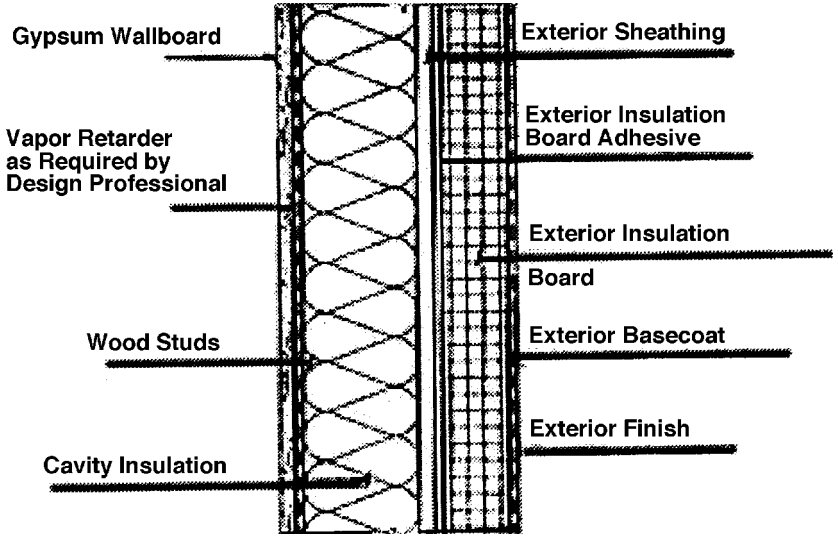

Figure 12-1. Typical barrier EIFS wall section.

sites can literally release millions of spores into the air. It is important to choose the abatement contractor carefully. They should know the basics of building containment systems, establishing negative pressure enclosures, have good health and safety plans, and a trained and reliable workforce. Appropriate training is required for respiratory protection, clean-up procedures, and potential health hazards associated with the microorganisms to be removed. Many asbestos abatement contractors have made the transition to microbial abatement because the work is similar and their workers have much of the required training.

Proper remedial project design is critical to prevent potential human and environmental impacts from the release of microorganisms. The first step in any microbial abatement project is the elimination of the source of water/moisture. The microbial abatement specifications contain components for worker safety, decontamination protocols, and environmental protection.

Worker Safety

1. Comply with appropriate OSHA Standards, e.g. hazard communication and respiratory protection.

2. Use appropriate respiratory protection, which normally includes full-face mask with HEPA cartridges. Use full-body protection, e.g. TYVEK® coveralls with hood and foot protection.

Decontamination Protocols

1. Collect appropriate environmental samples to identify the microorganisms present and to define the scope of work.

2. Remove contaminated porous materials and debris.

3. Dispose of all contaminated materials (waste may be regulated depending upon the substrate and local regulations).

4. HEPA vacuum all vertical and horizontal surfaces.

5. Wipe all non-porous surfaces with a cloth dampened with water:bleach solution (10:1).

6. Ventilate the area with clean air with at least 96 air changes (i.e. 4 air changes per hour for 24 hours).

7. Visually inspect the area and, if clean, conduct appropriate clearance sampling (air spore counts, surface spore counts, etc.).

Environmental Protection

1. Determine the need for regulated areas, negative pressure containment systems, and occupant relocations.

2. Shut down ventilation systems serving the work area and install critical barriers. Seal all return air openings from the area.

3. Construct an appropriate work area containment system. This system could be a simple regulated area with critical barriers or a fully contained area with double layers of polyethylene sheeting on walls, floors, decontamination units, and negative air filtration devices for depressurization.

4. Employ a continuous pressure differential monitor between the inside and outside of the contained area. The monitor should have a printout of the pressure differential and an alarm to warn of a loss of pressure differential. The target AP should be -0.02 inches of water gauge.

5. Control access to the regulated area.

6. Double-bag or wrap all waste material and dispose through the decontamination unit.

7. HEPA vacuum all material removed from the regulated area.

8. Collect environmental samples for quality control.

Hotel Project

The hotel was closed for repair and microbial abatement in October 1998. Many rooms had up to 100 square feet of wall covered with mold. The worse areas were in rooms at the ends of the building, but many rooms along both sides had significant damage. Figure 12-2 is a typical floor plan for the guest room tower. Room furnishings not obviously affected by the mold were removed by workers wearing protective gear (coveralls and respirators) and placed in trailers. At the end of the abatement work, the decision was made to replace all mattresses and upholstered sofas, chairs, and loveseats. Room curtains were dry cleaned and then stored.

The regulated area was an entire floor of the hotel. The entrance to the area was through an airlock constructed in the elevator lobby. This airlock was framed with 2 × 4 lumber and the walls were two layers of 6-mil polyethylene. There was a three-flap curtained doorway at each end of the airlock. This also served as the decontamination area. Inside the regulated area, all doorways that did not lead to a guest room and the ceiling were cleaned and covered with a critical barrier, two layers of 6-mil polyethylene sheeting taped at all edges and seams. All supply and exhaust air grilles in the hallway and guest room baths were sealed with duct tape. Guest room heater/air-conditioning units were removed and

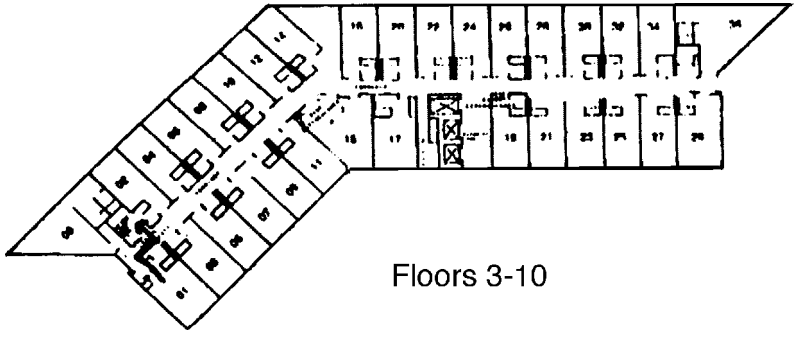

Figure 12-2. Typical hotel floor plan.

the openings were insulated and sealed with plastic and duct tape. Air filtration devices (AFDs) were connected to the outside through these room openings. About fifteen AFDs were distributed across the floor to achieve the desired negative air pressure inside the containment. A manometer at the entrance to the airlock monitored negative air pressure inside the regulated area.

The decontamination procedure began with removing room carpet, then stripping vinyl wall covering, followed by removing contaminated material. Workers wore **powered air-purifying respirators (PAPRs)** with full-face pieces, hooded coveralls, and gloves. Frequent cleaning with HEPA vacuums kept debris accumulation minimized.

The areas were cleaned following decontamination. All surfaces were thoroughly HEPA vacuumed. A brush was used to help dislodge debris in cracks and crevices. Nonporous surfaces were wiped with a cloth dampened with water and bleach (10:1) after vacuuming. After a 24-hr ventilation period, the areas were cleaned again.

The last stage of the project was clearance sampling. In this project air samples were collected using Air-O-Cell® particle samplers. Ten-minute samples were collected at a flow rate of 15 liters per minute. Samples were collected in ten guest rooms per floor, the elevator lobby outside of the contained area for each floor, and an outdoor location. Two samples were collected at each location. The samples were analyzed using light microscopic techniques. Spore counts indoors were compared to outdoor air.

Problems Encountered During Abatement and Solutions

The first problem to be solved was how to get clean replacement air to the abatement areas. The solution was to construct a tunnel from the hotel lobby doors to the elevators. Two elevators were enclosed inside the tunnel. Outdoor air could then travel up the elevator shaft to the floors under negative pressure. All eleva-

tor doors were sealed with critical barriers except for the elevator doors to the abatement areas.

Within each room there were sources of microorganisms that would not be removed as part of this abatement. These sources needed to be addressed so that they would not interfere with the clearance of the area after decontamination. One source was moldy wallboard in the bathrooms and the other was moldy wallboard that was the inner layer of the EIFS. Since the offending moisture source would not be addressed in the bathrooms (condensed water from showers, overflowing toilets and sinks, etc.), only deteriorated wallboard was removed and replaced. Other wall areas of mold were cleaned by HEPA vacuuming and then sealed with white pigmented shellac. The high alcohol content (-60%) helped to denature the microorganisms.

The moldy inner EIFS layer was handled similarly, but none of it was removed. The entire exposed surface was cleaned by brush and HEPA vacuum, then coated with an anti-microbial paint. As long as no moisture was introduced after coating, any surface contamination under the sealant should be controlled.

There were a few problems that had to do with abatement on two floors at a time. The outdoor air tunnel and two elevators solved one problem. Because of time constraints, reconstruction and demolition were also occurring simultaneously. Because the floors under decontamination and cleaning were negatively pressurized, any type of debris from adjacent floors was an interferent during cleaning and clearance sampling. A minimum one-floor buffer zone was absolutely necessary. However, both construction debris and demolition debris nullified cleaning and clearance sampling at least once during the project. Every time the manager had to pay for 25 to 50 additional clearance samples he was reminded that he could not get ahead of the abatement.

The more uncontrollable problem was the cold weather. Unit ventilators had been removed from the 7th through 10th floors at the outset of the abatement project. The abatement areas were under negative pressure so all leakage was into the building. When the temperatures dipped below freezing outside there were

thousands of feet of water pipe to be concerned about inside. To make matters worse, the hot water recirculating pump broke down. The abatement began on the 7th and 10th floors so that heat could be introduced to the center and top of the guest room tower as soon as possible. When these floors were cleared, new heating/air-conditioning units were installed. The lower floors still had heat because the second through fifth floors did not have any mechanical systems removed yet.

Another problem with conducting abatement in cold weather involved clearance sampling. The clearance criteria were to compare indoor air samples to outdoor air samples. The indoor samples should be lower in total numbers of spores than the outdoor samples. The dominant fungal species in the indoor air should be similar to those in the outdoor air. The marker species (*Stachybotrys* in this case) should not be present. The problem in cold weather is that with freezing temperatures and snow, which there was plenty of, outdoor fungal concentrations get very low. There was no good way to solve this problem. Reliance on someone experienced in the interpretation of sampling results and a good cleaning crew minimized these effects.

Conclusion

This project was relatively complex and involved several competing priorities. At times work was proceeding on EIFS repair, mold abatement, and building construction simultaneously. The mold abatement part of the project was something new for most of those involved. Problems such as those discussed here are ordinary in all projects. Experienced workers and cooperation were key elements in the success. In the end the hotel was back in business on schedule.

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