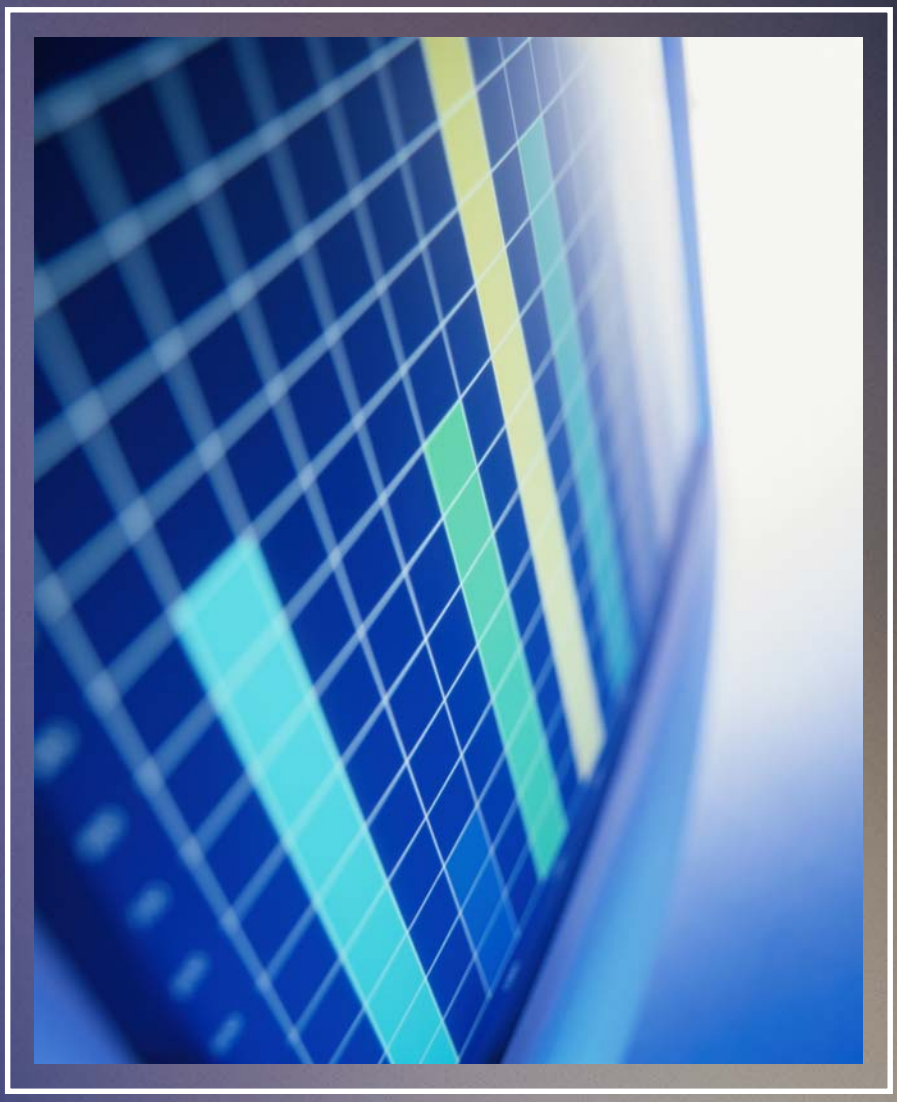
Cost Management Procedures



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Construction Management Association of America

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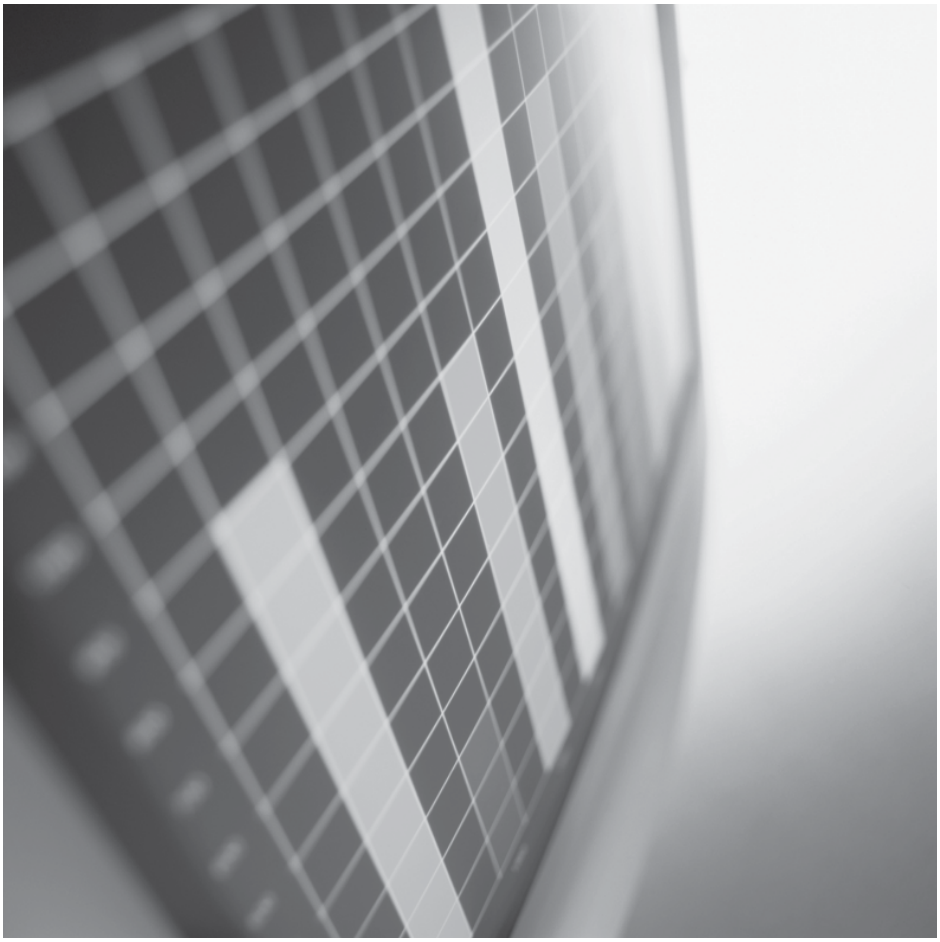
Cost Management Procedures



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Acknowledgements

As is generally the case in any organization such as the Construction Management Association of America (CMAA), a Procedures Manual such as this is not the work of a single individual. Several members of CMAA including Steve Davis, Dean Gale and Mike Parris, all of the Southern California Chapter, ably assisted in this effort. Additionally, Gary Berman, Chair of CMAA's Publication Committee, offered numerous, invaluable editorial recommendations.

James G. Zack, Jr.
Chairman
CMAA Cost Management Committee

Preface

Numerous books have been written over the years concerning the art and practice of construction management, almost all of which have chapters on cost management. This Procedures Manual is intended solely as an overview of the subject of cost management. It is a general guide for owners and construction managers (CMs). As such, it sets forth only the basic responsibilities of the owner and the CM in the management of cost on a typical project from concept to completion.

This Procedures Manual is intended as a supplement to Chapter 3.0, Cost Management, of the *Construction Management Standards of Practice* (3rd Edition, 1999), hereinafter referred to as the *Standards*, published by the Construction Management Association of America (CMAA). This Procedures Manual is intended to be complementary to the *Standards*.

Each construction project will undoubtedly have its own unique tasks and requirements depending on a wide range of factors such as:

- Type of project
- Project location
- Project owner
- Project delivery system
- Renovation or new construction

Further, a CM may only be involved in one particular phase of a project, the construction phase. If that is the case, many of the activities set forth herein will have to be accomplished by others, or perhaps the CM will have to perform these activities during the construction phase.

Therefore, this Procedures Manual should be read with the understanding that the guidance set forth herein may need to be amended to fit the needs of the project, the roles of the owner and the CM, and the CM's scope of work.

It is also important to point out that the roles and responsibilities depicted in this Procedures Manual for the CM may not, in fact, be the contractual duty of the CM to perform. The CM's duties are prescribed by its contract and nothing construed in this Procedure Manual should be used to define what a CM should have done on a project.

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1.0 Introduction and Overview

1.1 Objective

As overly simplistic as it may sound, the objective of cost management is to control the project cost so that the project is delivered to the owner within the owner's budget. Project cost management includes all those processes necessary to ensure that the project is completed within the approved budget. Few project owners have unlimited budgets. Almost all owners have limited project funding available to them. Therefore, one of the procedures that has to be put in place by the owner, or on behalf of the owner by the construction manager (CM), is a system to establish, monitor and control the cost of the project, from project initiation to project turnover and occupancy. Failure to do so means that the project will likely experience a cost overrun.

CMAA defines the term "construction management" as the process of professional management applied to the planning, design and construction of a project from inception to completion for the purposes of controlling time, scope, cost and quality. Under CMAA's definition, construction management refers to the application of integrated systems and procedures, by a team of professionals, for the purposes of meeting the owner's project goals.

One of the goals for the majority of project owners is to deliver the completed project within the budget established for that project. This requires that the CM and others on the project team develop, implement and operate a process and procedures intended to establish realistic costs at the outset of the project and monitor those costs throughout the pre-design, design, procurement, construction and the post-construction phases of the project. Some of the procedures developed by the CM should relate to controlling cost, or stemming cost growth, through these five project phases.

1.2 Cost Management Basics

According to the *Standards,* effective cost management involves the establishment of a realistic project budget, within the owner's cost limitations. Further, it involves application of cost management skills and techniques to ensure the project is planned, designed, procured and constructed in the most economical way, ensuring conformance with the original project requirements.

Project cost management includes resource planning, cost estimating, cost budgeting and cost control. All of these processes are highly interactive and they may be iterative at each phase of the project. While these various processes will be discussed discretely in this Procedures Manual, in reality they all overlap one another and all interact in many different fashions.

Cost control has, therefore, two distinct stages. In the first stage, during preconstruction, the CM should gather cost information from various sources; participate in providing cost estimates at the planning and design phases; have an active role in value analysis; and guard against cost growth. During the second stage or construction stage, the CM will play an active role in the progress payment process, the change order process (to limit scope creep), and the claims process.

Cost control systems and procedures should be consistent with, whenever practical, the owner's code of cost accounts. These systems and procedures should also reflect the need of the owner and the CM to collect cost data in a timely manner and report it in a usable format.

1.3 CM's Role in Cost Management

The *Standards* further define "cost management" as the act of managing all or part of the cost of a planning, design and construction process so as to remain within the owner's budget. The role of the CM is to work with the owner and other members of the project team to put together a plan and a process to manage, monitor and control project costs through all phases of a project.

One author referred to the cost management plan as the "project money plan". (See *Total Construction Project Management*, George J. Ritz). He stated that the project money plan was the financial forecast for the project and noted that it establishes the basis for the control of both project cost and cash flow. The CM, with its background in cost estimating, budgeting, cost control, payment processing, etc. is in the ideal position to develop the cost management plan for the project.

1.4 Organization of the Document

This procedures manual is organized to reflect the various phases of a project. Subsequent sections are organized for project phases as follows:

- Pre-Design Phase
  - Project and Construction Budget
  - Cost Management System
  - Estimating
  - Cost Compliance Monitoring
- Design Phase
  - Design Phase Cost Management
- Construction Phase
  - Construction Phase Cost Management
  - Cost Control
- Post-Construction
  - Project Closeout

Cost management elements, the role of the CM with respect to cost management, and the use of various cost management tools are discussed for each phase of the project.

2.0 Project and Construction Budget

This section covers issues involved with the establishment of a project budget. Conceptual budgeting methods, cost analysis, integration of the owner's objectives and constraints, procurement strategies effecting budgets, resource availability and project conditions relating to budgeting are discussed briefly.

2.1 Introduction

Cost management begins at project inception. Virtually as soon as the project owner conceives of a project concept someone needs to start considering costs. Few project owners ever have unlimited funds. Most project owners are looking for positive Return on Investment (ROI) and thus need to constantly monitor project cost to determine whether they will be able to obtain their desired ROI.

The *Standards* recommend a preliminary cost investigation. This is discussed as a cost management plan assembled by the CM early in the pre-design phase which includes all cost components of the project (e.g., pre-design, design, construction, operation and maintenance, life cycle costs, etc.). Once developed, this cost management plan should be provided to the owner and all other members of the team that have been brought aboard the project, for their review and approval.

Buy-in by all team participants is vital to the success of the cost management plan. From the outset of the project, all project participants must be working toward project delivery within the limits of the approved cost management plan and project budget. After each party approves the cost plan, it becomes the basis and the framework within which the costs of the project are monitored and controlled throughout the planning, design and construction processes.

2.2 Conceptual Budgeting Methods

One of the biggest challenges during the pre-design phase of the project is gaining a thorough understanding of the project definition. The project stakeholders need to arrive at a rough agreement concerning the scope of the project before a conceptual estimate can be made and a preliminary budget established. Some examples of such agreements follow:

- Hospitals—number of beds
- Manufacturing facilities—number of units produced per day or week
- Water and Wastewater Facilities—million gallons per day processed
- Office Buildings—square footage
- Power Plants—megawatt capacity
- Dams—cubic yards of fill

Once agreement on work scope is reached, factors such as project location, project timeframe, etc., must be factored into the calculation in order to arrive at a conceptual budget. A conceptual budget is, therefore, arrived at based upon an estimate of the cost of the project's concept. Such estimates have been referred to by various authors as conceptual estimates,

preliminary estimates, feasibility estimates, order of magnitude estimates, and economic study methods for performing conceptual estimates:

- **Analogous Estimating (Top Down Estimating)—**Uses actual costs of similar *previously performed* projects as a basis for estimating the cost of *this* project. When using this form of estimating, some judgment may have to be applied insofar as project location, project timing, etc. may cause some adjustments to the cost of the previous project.
- **Parametric Modeling—**This form of estimating uses known project characteristics (parameters) in a mathematical equation to arrive at current project costs. Square footage cost, per bed cost, megawatt cost, etc. may all be used in parametric modeling to arrive at a conceptual estimate.
- **Bottom Up Estimating—**The technique involves estimating the cost of individual project components and then summing the total of the project component estimates. For example, in a wastewater treatment plant, the estimator may be able to independently estimate the component costs for primary clarifiers and extended aeration basins on a million gallon per day basis, and then factor in costs for headworks and screening, yard piping and electrical, disinfection facilities and discharge piping. Having arrived at a conceptual estimate for each component of the system, the estimator can sum the component costs to arrive at a conceptual cost.
- **Computerized Estimating —**More common today than ever, there are a number of computer software systems on the market that have national cost databases embedded within them. The estimator can start by inserting conceptual project information into these computer models and arrive at a conceptual estimate based on the data contained within the software.

There are, undoubtedly, other conceptual budgeting techniques available for estimators, but the above covers those most commonly used.

2.3 Interpreting Conceptual Budgets

As noted above, conceptual budgets are based on conceptual estimates. Conceptual estimates are, by their very nature, based only on the most general project information. Thus, the issue becomes, "How does one interpret conceptual estimates?" Or, stated another way, "What is the degree of accuracy or reliability of a conceptual estimate?"

There is no single accepted variance for different types of estimates. Authors generally agree that all estimates should be accompanied by some indication of accuracy (i.e., +/– some percent) but there is no agreement on the percentage variances. For example, when considering conceptual estimates Ritz suggests a level of accuracy of +/– 25% to 30% for what he refers to as feasibility estimates. The Association for the Advancement of Cost Engineering International (AACEI) refers to this estimate as an order of magnitude estimate and defines the accuracy at +50% to –30%. Other authors and other organizations have their own set of variances. Given the level of information that a conceptual estimate and conceptual budget have at the outset, a wide degree of variance must be associated with the projected costs.

2.4 Integrating the Owner's Conceptual Budget

Once the conceptual estimate has been completed and provided to the project owner, the CM must obtain approval or concurrence from the owner. There must be a meeting of the minds between the owner, the CM and others on the project team, as appropriate, concerning the conceptual estimate. Assuming this can be achieved, the owner must adopt the estimate as their conceptual budget. This is a critical point in the life of a project. Based in large part on the conceptual estimate, owners must run their own economic analyses to determine whether or not the project moves forward. ROI calculations, economic forecasts, business models, etc. can all be employed by the owner to determine if the project should proceed.

Occasionally, external factors demand that the project move forward regardless of economic modeling. For example, the owner may have received a court order to upgrade a wastewater treatment facility, expand a jail or prison, or add air pollution control equipment to an existing manufacturing process. Or an owner may be faced with a rapidly increasing school population. In cases like these, compliance with statutes, governmental regulations, or the needs of the public will generally override the typical business process.

The first question requiring an answer at this point is, "How much will this project cost?" The other question the owner must answer at this point is the fundamental question of, "Can I afford this project?" Early in the project the owner must determine how much money they have or can raise to support this project.

2.5 Cost Analysis

The *Standards* point out that during the pre-design phase of the project, the owner may request that the designer develop conceptual design alternatives based on different site locations and/or other project schemes. The CM should prepare conceptual cost estimates for these project alternatives for review by the owner and the designer.

When different project sites are being considered, it is important to fully recognize the cost differentials for items such as site utilities, site access, soil conditions, topography, location, market conditions, labor availability, etc. At this stage of the project, the owner may also request other studies with cost and budget implications such as, life cycle cost studies, energy studies, preliminary cash flow analyses, etc. All such studies should be presented in reports issued by the CM and reviewed with the owner and the designer.

2.6 Development of a Project/Construction Budget

CMAA's *Standards* states that, based on the owner's project goals in terms of performance, quality and time constraints, the CM should develop an estimate of the cost of construction and, if required, the total project cost. The total project cost must, therefore, include the following in addition to the estimated construction cost.

- Land acquisition cost
- Architectural, engineering and other design related costs
- Design contingency costs

- Construction management cost
- Financing cost
- Owner's management cost
- Other costs depending on the nature, type and location of the project

The total sum of all these costs then forms the project budget. It is this budget which some authors refer to as the appropriation estimate. Ritz recommends using a variance of +/– 10% to 20% at this stage. It is this initial budget which forms the basis of the cost control plan. That is, all costs are compared to this initial budget.

Additionally, the *Standards* point out that the level of project definition at the budget estimate stage is typically of a very general nature. CMAA recommends allowing a design contingency of 15% to 25% depending on the information available. CMAA also recommends adding this design contingency to the total estimated construction cost.

In preparing the initial project budget, the CM needs to make the owner aware of the fact that the ultimate cost of the project is highly sensitive to the quality and quantity of systems yet to be defined. The owner must be alerted to the fact that the budget estimate based upon the project concept will change as planning continues and design and construction take place.

2.7 Owner Project Objectives

During the process of preparing the construction and project budgets, the owner must clearly identify their own objectives for the project and the CM must incorporate those objectives into the budgets. Owner objectives for the project almost always have budget implications. It is incumbent upon the CM to draw out this information from the owner in as much detail as possible.

Some examples of owner project objectives might include the following:

- Life cycle cost
- Energy utilization and efficiency
- Quality of interior finishes
- Architectural aesthetics
- Return on Investment (ROI)
- Future expansion
- Marketability of the facility

Owner project objectives can, obviously, far exceed the list of examples set forth above. The point is, if the CM is charged with the responsibility of preparing construction and project budgets, the CM must find out what the owner really expects to get when it occupies the project. Failure to successfully accomplish this task at the outset may doom the project to inevitable cost overruns during design and construction, as well as other problems.

2.8 Project and Owner Constraints

At the same time project objectives are being established, the CM must thoroughly explore both project and owner constraints. A constraint is generally considered a restriction on the project or some activities within the project or some action, which is compelled by an external requirement. Typically, project constraints result in budget implications. If constraints are not clearly identified early in the project, it is likely that the project budget will be overrun later in the life of the project.

Some examples of owner and project constraints, which may have to be factored into the construction and project budgets by the CM, may include the following:

- **Financial, funding constraints** (e.g., to meet appropriation restrictions the project must be under contract no later than or must be completed no later than, a certain date). Cash flow may also be an important project constraint.
- **Time-to-market constraints** (e.g., the fabrication facility must begin production no later than a certain date).
- **Schedule constraints** (e.g., certain buildings in the project must be ready for occupancy no later than specified dates or times).
- **Seasonal, weather-related constraints** (e.g., during rainy periods only one influent pump may be shut down at a time or the project must shut down during certain periods of the year).
- **Work time constraints** (e.g., work may only be performed at night, during selected shutdown periods, on weekends, etc.).

The list of project constraints, like the list of project objectives, may be much longer and more detailed. Again, it is incumbent on the CM to draw out project constraint information from the owner at this early phase of project budgeting. Failure to do so will adversely impact the CM's ability to deliver the project within budget.

2.9 Procurement Strategies

Early in the life of the project, the owner and the CM must decide on procurement strategy for design and construction. Experience has shown that procurement strategy also has budget implications. Some procurement strategies which should be discussed and agreed upon when formulating the preliminary project budget include the following:

- Design-Bid-Build, CM-at-Risk or Design-Build project delivery systems[1]
- Owner furnished equipment or materials
- Firm Fixed Price or Lump Sum contracts, including:

    Late completion damage clauses

    Economic price adjustment clauses

    Incentive fee clauses

[1] Other project delivery systems exist from which the owner may choose.

Cost and cost sharing clauses

Early completion clauses

- Cost reimbursement contracts, including:

Cost plus fixed fee clauses

Cost plus incentive fee clauses

Cost plus award fee clauses

- Unit price contracts, including:

Basic ordering agreement or blanket contracts

Indefinite delivery or indefinite quantity contracts

Time and materials contracts

Job order contracts

Any or all of these are possible procurement strategies, depending on the nature of the project as well as the legal and financial requirements, and contribute to project constraints. All of these procurement strategies will have budget implications which the CM must take into account when arriving at the initial construction and project budgets.

2.10 Resource Availability, Productivity and Other Factors

In addition to the owner's project objectives and identified project constraints the CM needs to know or learn about local conditions to help refine feasibility cost estimates and conceptual project budgets. Such studies are intended to make the conceptual budget more realistic and more attainable.

Some examples of studies include the following:

• **Labor availability** – Is there a good pool of labor locally available? Will contractors have to import labor to the area and pay additional costs to house and feed them?

• **Climate related productivity factors** — Is the job located in an area where severe winter weather conditions impact labor productivity? Conversely, is the job located in an area where severe heat conditions may impact labor productivity?

• **Labor costs** – Is the job in a union only area or will open shop contractors be able to bid the project? What are the prevailing wage rates and are current union contracts close to their time for renegotiation? Are the wage rates subject to the Davis-Bacon Act?

• **Project location** – Is the project located in or near an urban center where site utilities and site access offer little or no challenge, or is the site so remote that these will become large cost factors? If the project is to be located outside the U.S. are there fees endemic to the country in which the project is to be built?

Again, the list of project factors can, and probably should, be much more inclusive. It is incumbent on the CM to identify these factors and include their cost implications in the conceptual or preliminary budget, as appropriate.

2.11 Project Conditions Impacting Budget

Other project conditions, which may need to be factored into the conceptual budget, may also include:

- Allowances (for known but undefined requirements)
- Contingency and/or management reserves
- Cost escalation factors
- Field and General Conditions cost
- Foreign currency fluctuations
- Market conditions for material and equipment

It is up to the CM to identify if such costs are needed for the project and to include them in the conceptual estimate and budget.

2.12 Organizing the Budget

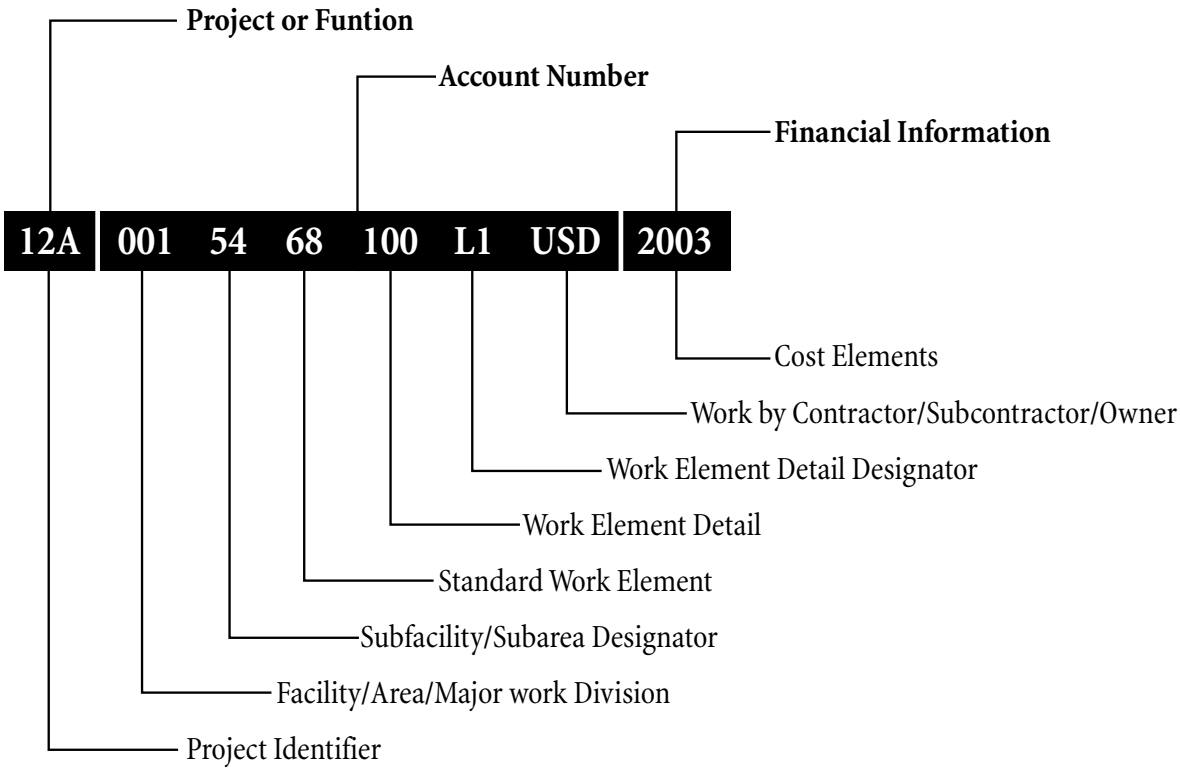
The estimates of construction and project costs need to be organized into project and construction budgets in some standardized format. They should be formatted based upon the work breakdown structure (WBS) utilized by the owner. A WBS is a way to define a project by breaking down the project into all of its various work components and arranging them in a hierarchical structure. Each work element of a WBS should be a separate measurable work activity with a specific project deliverable. A WBS can be thought of as a coding system used to separately identify every activity that must take place on a project. Once established, a WBS not only identifies all project activities and their deliverables, but provides a logical and standardized mechanism for scheduling and budgeting and provides for a uniform system of communication.

In their book *Professional Construction Management,* Barrie and Paulson discuss the concept of the WBS:

> "A WBS describes the work elements of a project in a logical hierarchy which can be used for a number of related management control activities. Integrated management control systems are designed to reflect the interdependence upon cost, schedule, and other parameters. … The WBS is designed to set forth a common numbering system that can be applied at various levels to structure both cost and schedule planning and reporting. Some organizations also prepare the WBS to further indicate individual or departmental responsibility and accountability, to organize drawings and specifications and other applications. An important feature of the WBS is the ability to identify both cost and schedule parameters at various levels of detail."[2]

[2] See Chapter 13, "Cost Engineering", pages 307 – 331.

An example of a WBS code follows:[3]



If the owner does not have a standard WBS, one should be developed and provided by the CM, subject to approval by the owner. The WBS system employed on the project should be consistent with the components of the project and acceptable to all members of the project team.

The CM should review all budgets for completeness and compatibility with established cost limitations for the project and attainability. This latter check (attainability) has to do with managing the owner's expectations. (Most CMs are familiar with the old story of the owner who wants a world class cathedral for the cost of a New England clapboard church. This can happen if project expectations are not managed properly from the outset.) Management of owner expectations starts with the preliminary construction estimate and the ability to fit the project into the budget.

The CM should review its findings with the owner and the designer and make necessary adjustments. It is critical, for cost control purposes, that the assumptions made in preparation of the project and construction budgets be clearly identified and listed. Equally critical are those items *excluded* from the project and construction budgets.

[3] Adopted from Barrie and Paulson, page 309.

[4] It is beyond the scope of this Procedure Manual to discuss how a WBS system should be formulated. If more information on development of WBS systems is desired, the reader is referred to *PMI's Practice Standard for Work Breakdown Structures.*

These also should be identified and listed. Some examples follow:

- Labor costs assume no significant overtime or premium pay
- Concrete costs assume no winter concreting operations or costs
- Crane cost assume use of a single tower crane
- Equipment cost does not include HRSG cost, as these are owner-furnished.

It is recommended that every cost estimate be developed on a standardized spreadsheet format that remains constant throughout the life of the project from preliminary estimates to final cost report at the end of the job. All assumptions or exclusions of significance should be listed along side each cost to which the assumption applies. Each iteration of the cost estimate should contain the assumptions or exclusions unless they were changed in the new estimate. If this is the case, then the changed assumptions should be noted in similar fashion, as follows:

- Labor cost assumption now includes 20% overtime to meet project schedule
- Concrete cost now assumes approximately 1/3 of the concrete placed in winter condition.

2.13 Contingency in the Preliminary Phases of a Project

Soft costs are hard to develop at any stage of a project. During the early or preliminary phase of a project there is little detail known to the project team. Thus, it is hard to develop contingency amounts for estimating and budgeting purposes. Project teams often resort to some national standard for such soft costs but many project owners desire something more concrete.

One approach used by some project teams is to perform a risk analysis of the project. That is, the project team brainstorms every possible thing that could go wrong on the project during planning, design, construction or startup of the project. From this risk analysis, the project team tries to develop some rough order of magnitude costs should any of these risks actually occur. Then, based upon experience, the project team ranks the likelihood (probability) of such an event occurring. The classic risk calculation is then run using the following:

Expected Monetary Value of Risk = Risk Event Probability x Risk Event Value

The key to development of soft costs in this manner is to not overstate the likely cost of each risk event nor overstate the probability of such risk events arising. To do so would so artificially inflate the cost estimate as to render it almost meaningless.

2.14 Summary

The criticality of project budgeting cannot be overemphasized. Analysis of project "failures" all too often leads to the conclusion that an inadequate project budget was established at the outset, thus dooming the project. If the CM does nothing more than help the owner and the design team establish a realistic project budget which adequately takes into consideration the owner's goals and objectives, a reasonable procurement strategy and known project constraints, then the CM will have performed an outstanding service. This is a far harder challenge than this section may have indicated. Unreasonable expectations, unidentified constraints, fuzzy understanding of procurement requirements can all lead to unrealistic project budgets.

3.0 Cost Management System

This section discusses the purpose of a cost management system; how one is developed; cost planning and modeling; and development of a cash flow management system. As the project budget is used to establish specific project parameters, a cost management system is intended to provide tools that help the project team complete the project within the previously established budget.

3.1 Purpose and Objectives of a Cost Management System

The purpose of a cost management system is to help ensure the project is completed within the approved budget. Project cost management focuses on two areas of cost as they are related to the project. First, cost management is concerned with the cost of the resources needed to accomplish all project activities. Second, and equally as important, cost management is concerned with the effects project decisions have on the cost of the project and/or the cost of operating and maintaining the project. Thus, cost management concerns itself with both the cost of delivering the project to the owner and the life cycle cost of the project.

For example, it may be possible to decrease the design cost of a project by eliminating certain design review activities. This will save money in the design phase of the project. However, it is likely that this cost saving decision will result in more design deficiencies which, in turn, will lead to increased construction costs through change orders and claims. Another example would be the determination to specify a lower cost air-handling unit on a new building. One can save construction cost in this manner. If the specified air handling unit uses more electricity or is less efficient to operate and maintain, then the overall life cycle cost of this air handling unit can be substantially more.

Cost management then is intended to focus both on the cost to deliver the project, as well as the overall life cycle cost of the project to the owner.

3.2 Resources to Develop and Implement the System

Development of a cost management system involves several processes. Those processes are summarized below and are highly interactive.

- **Resource planning—** Determine what resources (people, equipment, material, etc.) and what quantities of each resource are needed to accomplish the project.
- **Cost estimating —** Develop an approximate cost of the resources needed to deliver the project.
- **Cost budgeting—**Allocate the overall cost estimated for the project to the various elements or activities involved in delivering the project.
- **Cost control—**Controlling changes that impact the accepted project budget.

3.3 Understanding Cost Planning Concepts

Cost planning involves the first two processes identified above. At the outset of cost planning, the CM needs to clearly delineate the scope of the project in as much detail as possible. As mentioned earlier, during the conceptual stage of a project there is little detailed information available. However, to successfully identify project costs, the CM needs to find out as much detail as possible about scope definition.

Once the scope of the project is determined in some detail, the CM can start the process of resource planning. Resource planning concerns itself with identifying the physical resources necessary to deliver a project. For example, in the case of a new building the resources may include the following:

- Designer costs
- Land acquisition and access costs
- Labor costs
- Equipment costs
- Materials costs
- Furniture, fixtures and equipment costs
- Inspection costs
- Permit costs

The basic inputs to resource planning include the following:

- **Work Breakdown Structure (WBS)—**The WBS identifies all elements of the project. From this activity identification process the CM can determine which activities need resources and what resources are needed to accomplish each activity. This becomes the primary input to resource planning.
- **Scope of Work—**As noted above, the scope of work sets forth the description of the project and the project objectives. These help the CM analyze what resources are needed.
- **Historical Information—**In the event the CM and/or the owner are dealing with a project which is similar to one previously performed, the information from the past project can help the CM identify what resources are needed to deliver this project.
- **Resource Pool Description—**In most construction projects this is considered a market survey. That is, the CM should survey the marketplace to determine what resources are available and in what quantity. The CM should determine whether there are sufficient designers in the area to do this work, or will the owner need to look nationally? Is the labor pool adequate to construct the project? Is there sufficient construction equipment of the type necessary available locally?
- **Organizational Policies—**In preparing the resource plan the CM needs to consider the owner's organizational policies concerning the project. For example, is there a part of the project the owner's staff can perform? Or, is it the owner's policy to perform the design in-

house? To save on equipment costs and project delivery time, is it the owner's policy to pre-purchase large equipment items and provide them to the contractor for installation into the project?

Once the resources needed to deliver the project are identified, the CM needs to estimate the costs of the necessary resources. Using the previously established WBS system and resource requirements list, the CM needs to associate costs with each identified resource. The CM can use known resource rates, historical information, cost databases, etc. to estimate the cost of the resources leading to a project budget.

The outcome of resource planning and cost estimating is the development of a cost plan for the project which includes the total project cost for presentation to the owner. The cost plan, then, is the total anticipated project budget, which includes, as best as can be estimated, all costs related to the project. Included in the cost plan are the expected cost of planning, design, construction, land cost, permit fees, financing costs, etc. Upon acceptance by the owner, the cost plan becomes the budget for the project. Based on this budget, performance of the project will be continuously monitored and measured.

3.4 Project Feasibility Studies

During the conceptual phase of most projects, the owner must determine the capital costs necessary to put the project into place. This is necessary for the owner to test the business practicalities of the project. Capital costs must be factored into the owner's business model in order to determine whether the project is commercially practical. Some examples are:

- A project feasibility study may determine the following. If the fabrication facility can be constructed for $10.0 million then the cost of items produced from this new facility will be $21.50/unit. At this price the product will be commercially competitive. If, on the other hand, construction cost increases to $25.0 million then the unit cost rises to $28.50/unit. The product may no longer be cost competitive.
- A commercial office project may need to meet a competitive target rental price of $12.50/square foot in order to be commercially competitive in a local market. In order to accomplish this goal, given other relatively fixed costs (such as land costs, financing costs and design fees) the construction cost cannot exceed $40.0 million. A project feasibility study will be needed to determine how and if this target cost can be met.

In this scenario, the owner is using the estimates of capital cost to calculate impact on the resulting unit cost or rental cost in order to determine whether the project is feasible – capable of being successfully accomplished.

Estimates made during the early phases of a project are sometimes referred to as screening estimates (see Ritz, *Total Project Construction Management*) because owners often screen various project options or alternatives (e.g., size, throughput, location, etc.) to influence the capital cost of the project. For example, both construction and labor cost may be less in a foreign nation. Therefore, the per unit cost may decrease. On the other hand, transportation, tariff, customs, currency conversion, taxation, and training costs may be sufficiently higher to offset any potential costs savings of constructing the project in a foreign nation.

When dealing with publicly funded projects, it is fairly uncommon for the CM to be dealing with a revenue generating project. Construction of a wastewater or water treatment facility, police or fire station, school or library is not generally based upon the same sort of calculation as a commercial project. Typically, a feasibility study for a publicly funded project is trying to determine the most cost effective manner in which to deliver the project. Publicly funded projects are generally driven by the needs of the public (e.g., more schools, better highways, etc.) or by government regulation (e.g., air, water, wastewater, solid waste regulations, etc.). In cases such as these, the determination to perform the project has already been made and the role of the CM is to help the public owner deliver the project in the most cost-effective manner.

Sometimes public projects are desirable but not regulatory driven. For example, a performing arts center may be politically desirable for a municipality, but is hardly forced on a city by government mandate. If this is the case, then the role of the CM in preparing the early or conceptual cost estimate is to help the owner determine how much funding is necessary to deliver this project. In cases such as this, it is not uncommon for the CM to be working with the municipality's bond counsel as the results of the conceptual estimates are often used to determine the amount of bonds to be sold.

3.5 Project Cash Flow

One of the elements of a cost management plan is an estimate of the cash flow requirements for the project. Cash flow, in its simplest terms, is the projected rate at which the owner's cash resources will be expended on the project. Donald Barrie and Boyd Paulson in their book, *Professional Construction Management,* discuss the need for a project cash flow analysis. As pointed out by Barrie and Paulson, the purpose of a cash flow analysis for a project is to identify to the owner an estimate of the gross cash requirements for expenses throughout the project. Additionally, the project cash flow analysis tells the owner when certain amounts of cash must be available. For example, on a $25.0 million project, which is projected to take 36 months to construct, there is no need for the owner to have the entire amount of cash ready for disbursement on day one of the project.

It is also noted that government funded projects are often funded from the proceeds of bond sales. The bonds are typically sold prior to the start of the project and thus the owner will have normally received the proceeds of the bond sale prior to start of work. Knowing that the project cash flow does not require immediate expenditure of all funds and having a project cash flow projection in hand, owners can reinvest most of these funds, using the interest earned to help offset a portion of the project cost. The CM can also project for the owner an appropriate borrowing schedule so that the entire bond amount does not need to be obtained at the beginning of the project, all at once, thus saving some interest expense. The latter often occurs on school projects.

3.6 Developing a Cash Flow Schedule

By the time the cash flow analysis is to be developed, the CM will have already prepared the conceptual budget. In order to turn the budget into a cash flow, the CM must prepare a conceptual project schedule. Once this task is accomplished, the cash flow schedule for the project is developed from the conceptual cost estimate (either construction or total project,

depending on which cash flow the owner wants the CM to develop) and the conceptual project schedule. The CM will plot the money spent versus the time to create a classic S curve depicting anticipated cash flow requirements.

The methodology for preparation of a cash schedule is simple in theory. It starts with preparation of a basic project schedule. Discrete activities must be defined by the CM, including scope of work and duration. Once this portion of the exercise is completed, the CM must cost load each line item or schedule activity. That is, the CM must prepare a cost estimate for each activity on the schedule. Once activities and costs are plotted on the schedule, the cash flow of the project can be determined on a weekly or monthly basis, or any other basis the owner wants to use.

Perhaps the more difficult part of projecting project cash flow lies in the realm of judgement concerning how the project itself will expend monies. The most simplistic cash flow analysis assumes a straight-line cash flow. That is, the assumption is that cash will flow equally throughout the life of the project. Using this assumption, on a $10.0 million, 18-month project, the assumption is that cash will be used at the rate of $555,556/month, and on some projects this may actually be correct. The more likely scenario is that cash flow will be considerably less during the first two or three months of the project, increasing over time to a peak cash flow in the middle of the project and decreasing toward project's end. (This is the classic bell-shaped curve.) The CM should perform this type of analysis when preparing the cash flow schedule.

Two variations of the bell-shaped curve are front-end loaded or back-end loaded cash flow curves. These types of cash flow schedules develop when there is a good deal of equipment buy out and installation either very early or very late in the project, thus skewing the project's cash flow. Again, the CM must perform this analysis based upon experience and knowledge of the project.

3.7 Cost Models for Monitoring Cost

Once the project budget has been prepared and approved by the owner, the CM is most often charged with the responsibility of monitoring and reporting on costs and cost variances. There are a number of techniques or models for monitoring costs. Among them are the following:

- **Planned vs. Actual Costs—**This method is relatively simple and straightforward. Using this model, the CM establishes cost accounts for each element of the project from the approved project budget. Payments are also recorded for each cost element and a comparison made to determine whether the cost element is within budget.
- **Planned vs. Actual Cash Flow—**This model depends upon creation, submittal and acceptance of a cash flow curve for the project. CMAA's *General Conditions of the Construction Contract*, Article 8.2.5, requires that the contractor cost load all construction activities shown on the construction schedule. From this cost loaded schedule a time scaled cashflow curve can be established. Routine payment requests can be plotted on a cash flow curve to create an actual cash flow versus the planned cash flow. (Typically, such cumulative S curve charts are referred to as "banana charts".) This cost model allows the CM to monitor planned versus actual cash flow and extrapolate projected cost and time impacts on the overall project. (While CMAA's documents call for cash flow projections

from the contractor only, there is no reason why an identical requirement could not be levied on the designer. This would allow the CM to monitor design costs.)

- **Cost Trending—**For each cost element of the project and/or the total project cost itself, the CM prepares a series of Estimate at Completion (EAC) calculations using the following model.

  EAC = Actual Cost of Work + Remaining Budget
  Performed to Date

  or

  EAC = Actual Cost of Work + (Remaining Budget/Cost Performance Index)
  Performed to Date

If the CM performs such calculations on a routine basis, the results can be trended and reported upon.

- **Earned Value Calculations—**Earned value has been defined as a method for determining overall percent complete for a combination of unlike work tasks or an entire project. (See *Skills and Knowledge of Cost Engineering*.) Under the earned value concept, a direct relationship is established between percent complete of an activity and the budget for that activity.

  Earned Value = (Percent complete) x (Budget for that activity)

  Percent Complete = (Earned workhours or dollars for all activities)
  (Budgeted workhours or dollars for all activities)

Cost and Schedule Performance can then be monitored and reported on using the following equations.

Budgeted Cost for Work Scheduled (BCWS) = Budgeted workhours or dollars-to-date represent what is planned to be done.

Budgeted Cost for Work Performed (BCWP) = Earned workhours or dollars-to-date represent what was actually done.

Actual Cost of Work Performed (ACWP) = Actual workhours or dollars-to-date represent what was paid for.

Performance against **schedule** is simply a comparison of what was planned versus what was done. Performance against **budget** is measured by comparing what was done to what was paid for. These relationships are expressed using the following formulas:

Schedule Variance (SV) = (Earned workhours or dollars) – (Budgeted workhours or dollars) = BCWP - BCWS

Schedule Performance Index (SPI) = (Earned workhours or dollars to date)/ (budgeted workhours or dollars to date) = BCWP/BCWS

Cost Variance (CV) = (Earned workhours or dollars) – (Actual workhours or dollars) = BCWP – ACWP

Cost Performance Index (CPI) = (Earned workhours or dollars-to-date)/(Actual workhours or dollars-to-date) = BCWP/ACWP

A positive variance and an index of 1.0 or greater indicates favorable performance, whereas a variance of less than 1.0 indicates a negative variance. These relationships may be plotted as cumulative S curves. Such curves can be trended (i.e., used to forecast outcome) and reported on. Such a system is commonly used in government contracting to model and monitor cost and time performance.

The Cost Performance Index calculated is a cost efficiency factor representing the relationship between the actual costs expended and the value of the physical work performed. The Schedule Performance Index calculated above is a planned schedule efficiency factor representing the relationship between the value of the initial planned schedule and the value of the physical work performed (the earned value). Both of these factors can be measured and reported on routinely as part of the CM's cost trending and monitoring program.

3.8 Impact of External Economic Factors

In preparing a cost management plan and cash flow curves for a project, there may be times when the CM has to consider the impact of external economic factors which may exert an influence on the cost of the overall project. Some examples are:

- **Time to market** (e.g., The product to be produced by this project must begin to ship no later than May 1, 2002.)
- **Taxation laws** (e.g., Pollution control equipment purchased and installed prior to March 15, 2001 will receive a favorable tax write off, whereas equipment after March 16, 2001 will *not* receive this tax break.)
- **Funding restrictions** (e.g., The owner can only spend $2.5 million prior to January 30, 2001.)
- **Advance commitments by the owner** (e.g., the Convention Center Authority has contracted for a major national trade show opening on August 1, 2003.)
- **Return on Investment** (e.g., The developer must start selling units at a certain price no later than September 30, 2001.)
- **Calendar restrictions** (e.g., The owner must take occupancy of this school no later than August 15, 2002 or they will have to rent portables for another semester.)

Whenever special external economic factors exist, the CM must factor those into the cost management plan and the cash flow plan. Hard deadlines with high value to the owner may force a shorter time of performance for construction and therefore call for a more aggressive project cash flow. With a compressed schedule the CM must pay close attention to influences affecting the project's scope and quality of work.

3.9 Method of Project Funding

Project funding is typically left to the project owner unless the CM is part of a team that is developing and financing the project. In most cases, the CM will have little to do with project funding. However, the results of the cost management plan may impact the owner's ability to obtain project funding. The feasibility study factored into an ROI calculation may make the difference between project financing and none. Thus, the cost management plan and its various elements may impact project funding.

3.10 Impact of Project Funding Method on Cost and Schedule

There are times when the method of project funding may impact the cost management and cash flow plans. To the extent that it does, the CM must take the project funding method into account. Some examples of this circumstance include:

- **Government grant funding** (e.g., Under the terms and conditions of the grant, the project must be under construction within 100 days after receipt of the grant or a minimum of 10% of the grant or bond must be expended in the first year.)
- **Construction vs. permanent financing** (e.g., The developer needs to convert its construction financing to permanent financing no later than May 15, 2001 in order for the ROI to balance properly.)
- **Expiration of land options** (e.g., Under their agreement, the sale must close no later than June 1, 2002 or the land option expires.)

3.11 Summary

The intended purpose of a cost management system is to establish a system and provide tools that allow the owner and the CM to manage the project budget. It is not sufficient to establish a realistic budget. Tools are needed to manage the project in such a way as to ensure that the project is actually delivered within the accepted budget. Tools such as feasibility studies, cash flow schedules and cost models are all available to help establish and then manage the project budget. These tools need to be employed throughout the project if the CM is to employ an effective cost management system

4.0 Estimating

4.1 Selection of Estimating Techniques

As Ritz noted in *Total Construction Project Management,* the basis of the cost management plan for a project is a reliable project cost estimate, which is the *predicted* cost of constructing the project. As such, the cost estimate should be neither *optimistic* nor *pessimistic*. The CM should set forth its assumptions in making the estimate with respect to scope of work, contracting plan, schedule, labor productivity, construction techniques, estimating methods, etc. Based on this information, users of the estimate can make their own judgement concerning reliability and accuracy.

There are different types of estimates used in construction management at various stages of the project. Ritz identifies four types of estimates while AACEI identifies three, as follows:

Ritz		AACEI	
Type of Estimate	**Accuracy**	**Type of Estimate**	**Accuracy**
Feasibility Estimates	+/- 25 to 30%	Order of Magnitude Estimate	+50% to -30%
Appropriation Estimates	+/- 15 to 25%	Budget Estimates	+30% to -15%
Capital Cost Estimates	+/- 10 to 15%		
Definitive Estimates	+/- 5%	Definitive Estimates	+15% to -5%

Depending on which type of estimate is being prepared, the CM has a range of techniques available. Some examples of estimating techniques which the CM can utilize include the following:

- **In-House Estimating Data Files—**CM firms with a history of multiple projects of a similar type in the past can take past construction cost data and update it for current time and a specific location.
- **Outside Estimating Software Data Files—**If the CM does not have much experience with a particular project type, specific data by project type and location can be purchased from outside vendors for use in the CM's computerized estimating system.
- **Outside Estimating Services—**An alternative is to hire the services of an outside estimating firm and provide it all known project data. This outside service then produces the estimate and sends it back to the CM.
- **Standard Cost Indexes—**Standard cost data can be obtained from a number of sources. Use of this cost data as modified by the local knowledge and experience of the CM can assist in producing a reliable cost estimate. Cost indexes available include the following:

  General Purpose Cost Indexes—These can be obtained from Engineering News-Record, the Department of Commerce, the Bureau of Reclamation, R.S. Means Construction Cost Data, Richardson Estimating Services, Conceptual Cost Estimating, etc.

Contractor Price Indexes—This group of specialized indexes includes those compiled by the Austin Company, Fruin-Colnon, Turner Construction Company, Smith Hinchman & Grylls Associates, H.F. Campbell, etc.

Valuation Indexes—This group of indexes includes those compiled by the American Appraisal Company, Boeckh Company, Marshall and Swift Services, Handy-Whitman, etc.

Special Purpose Indexes—These include those compiled by Nelson Refinery, Port Authority of New York/New Jersey, U.S. Environmental Protection Agency, the Bureau of Labor Statistics, various State Highway Departments, Guthrie, etc.

Location Indexes—These adjustment indexes are compiled by Engineering News-Record, R.S. Means Construction Cost Data, etc.

- **End-Product Unit Method—**This method can be used when the CM has sufficient experience and historical data with a particular project type to relate end units with construction costs. For example, cost of a hospital project based on the number of beds.
- **Scale of Operations Method—**This estimating method uses historically derived empirical equations to obtain an estimate of approximate costs for different sizes of the same type of facility. For example, if the known cost of a 300 GPM pump is $50,000 then a 500 GPM pump from the same manufacturer can be factored up to or estimated at $75,000.
- **Ratio or Factor Methods—**There are many ratio or factor methods available for use by the CM. Some of the more typical methods include :

  Multiple of Equipment Cost Method—Most commonly used in chemical and process plants, this method depends on a calculation of the cost of the equipment in the facility multiplied by some historical factor to estimate the total project cost.

  Lang Factors—Lang Factors are standard multipliers for use in specific situations the CM is dealing with. Lang factors were developed for use in estimating various processes in the chemical manufacturing industry and were based upon a study of various chemical production facilities.[5]

  Hand Factors—Hand Factors expand on the Lang Factors approach by using the individual components of permanent equipment or systems. Each factor converts the cost of the equipment item to its share of the *total* construction cost. The sum of all factored line items yields the total estimated project cost. [6]

- **Physical Dimensions Method—**This type of estimate is based upon the physical project dimensions such as length, area, volume, etc. For example, a gas pipeline project may be estimated using the number of lineal feet times the diameter of the pipe times an average depth of the pipe.

[5] See Lang, "Simplified Approach to Preliminary Cost Estimates", Chemical Engineering, June 1948.

[6] See Hand, "Estimating Capital costs from Process Flow Sheets", *AACEI Cost Engineers Notebook* or "From Flow Sheet to Cost Estimate", *Petroleum Refiner*, September 1958.

- **Parametric Estimates—**As the name indicates, this type of estimate is based on certain parameters that reflect the size or scope of the project. Parametric estimates are most commonly used in the building construction industry for preparing approximate estimates. Typically, parametric estimates are used after the preliminary design phase is completed.
- **Quantity Take-Off Method—**This is the most detailed type of estimate. To perform this estimate the CM has to have the completed design documents in order to take off or measure and catalogue the various quantities of work to be performed. To this sum the CM then adds in labor, labor productivity, equipment, overhead, etc.

There may be other methodologies used in estimating costs. As the amount of project information available increases, so does the amount of effort necessary to perform an estimate, as does the accuracy of the estimate itself.

4.2 Identifying Factors for Conceptual Estimating

At the conceptual stage of the project, there is little detail. It would appear that the minimum amount of information necessary to perform a conceptual estimate would include the following:

- **Project type—**School, commercial office building, hydroelectric facility, petrochemical facility, etc.
- **Project size or capacity—**Number of classrooms, offices, megawatts per day, product, gallons per day, etc.
- **Project location —**This is needed to estimate labor and material costs, camp costs, etc.
- **Project schedule—**The CM needs this information to calculate overtime costs, field general conditions costs, etc.

The more information the CM has at this stage, the more reliable the estimate. However, users of a conceptual estimate must constantly be reminded of the wide variance in estimated costs (i.e., +50% to -30% according to some) due to the lack of specific information. That is, the conceptual project cost cannot be relied on too heavily.

4.3 Parameters for Cost Estimating

Parameters—defined as any of a set of physical properties whose value determines the characteristics or behavior of something. In general terms, the following is a list of parameters for a definitive estimate for a general building project. Various types of projects, of course, have various parameters. The following list is intended to give the reader an idea of what sort of parameters should be considered.

Design phase

Architectural layouts and elevations

General specifications and bidding documents

Structural/civil design and arrangements

Plumbing and HVAC plans and specifications

- Electrical plans and specifications
- Finishes, furnishings and equipment

Construction phase

- Contracting and procurement strategies
- General
  - Product
  - Process description
  - Capacity
  - Location—general and specific
  - Basic design criteria
  - General design specifications
- Site information
  - Soil conditions
  - Site clearance
  - Geological and meteorological information
  - Roads, paving and landscaping
  - Property protection
  - Site accessibility
  - Shipping and delivery conditions
- Engineering
  - Plot plan and elevations
  - Routing diagrams
  - Piping line index
  - Electrical lines
  - Fire protection
  - Sewer and water systems
- Quantity take-offs
  - Classifying the work
  - Describing items of work
  - Determining dimensions of items of work
  - Extending the dimensions

- Labor, including:
  - Direct wages
  - Fringe benefits
  - Labor taxes
  - Other labor burdens
  - Labor productivity
  - Labor supervision
- Materials, including:
  - Quantity take-off amounts
  - Delivery costs
  - Taxes
- Major equipment
  - Finalized sizes
  - Materials
  - Appurtenances
- Equipment, including:
  - Mobilization
  - Demobilization
  - Fuel, oil and gas
  - Maintenance
- Subcontractor bids and quotes, including exceptions
  - Field general conditions, including:
  - Bonds
  - Permits
  - Insurance
  - Mobilization
  - Professional services (i.e., scheduling, structural engineering, etc.)
  - Safety equipment
  - Small tools and expendables
  - Field supervisory staff
  - Temporary facilities
  - Travel and lodging
  - Miscellaneous costs (i.e., clean-up, punchlist, etc.)
  - Demobilization

- Home office overhead, including:
  - Salaries of home office staff
  - Employee benefits
  - Professional fees
  - Insurance
  - Office lease, rent or ownership costs
  - Office supplies
  - Depreciation
  - Maintenance
  - Job procurement and marketing
  - Travel and entertainment
  - Advertising
- Miscellaneous costs, including:
  - Freight and shipping
  - Start-up training and costs
  - Import-export duties
  - Financing costs
  - Escalation costs
- Schedule
  - Project duration
  - Interim milestone dates
  - Late completion damages
  - Early completion bonus
- Special inspection requirements
- Permit costs (if not obtained by the contractor)
- Bid alternates
- Bid allowances
- Mark-Up costs
  - Contingency
  - Profit

As noted above, different types of projects may call for different cost estimating parameters. The CM should become aware of these differences when preparing the take-off.

4.4 Concepts of Range Estimating

Another form of estimate commonly used by CMs is the concept of a range estimate. In construction, range estimates are more typically used when negotiating changes to the base bid work or settlements of construction claims and disputes. In situations such as these, the contractor is not bidding the project in a highly competitive environment. In the typical change order scenario, the owner has directed a change to some requirement of the work of the project and requested the contractor to provide a cost and schedule estimate of the impact of the change.

Typically, project owners will ask the CM to prepare an independent estimate of the cost of the change as a "check estimate" against the contractor's price for the change. Most CMs prepare a single cost estimate of the changed work. That is, they estimate the changed work in isolation of all other ongoing work and provide a recommended price and time impact, if any exists.

Range estimating looks at this situation in a different light. Range estimating develops a proposed cost for the changed work, but then incorporates a combination of sensitivity analysis, simulation and heuristics which enable the CM to:

- Identify the probability of overrunning the target estimate
- Determine the maximum likely deviations above and below the target estimate,
- Isolate and rank the reasons for, and likelihood of, a cost overrun in the changed work

Range estimating in the cost estimating field is analogous to PERT scheduling in the scheduling field. That is, it uses probability estimates in the course of calculating costs.

It is not within the purview of this procedures manual to go into detail on the issue of range estimating. Readers interested in further information on the topic of range estimating are referred to *Cost Engineering* containing various articles on this subject, written by Michael W. Curran and others.

4.5 Quantity Survey-Based Cost Estimate and Procurement Strategies

Quantity surveying is more European than American. In fact, many major European universities offer four-year degrees in the field of quantity surveying and most European cost engineering associations "charter" (certify) quantity surveyors.

In brief terms, when an owner is approaching a project using a quantity survey technique, they will retain a CM to do a complete take-off of all elements (or units) of the project. The CM will take-off all units (doors, windows, partitions, luminaires, conduit, plumbing fixtures, electrical connections, HVAC units, etc.) and establish a list of items to be priced in the bid. Once all units have been priced and the price for each item extended, the CM adds up all unit prices to arrive at a total project cost.

This is the classic unit price contract. The bidder has the right of reliance on the quantity take-off and the units listed and need not perform its own take-off to validate the accuracy of the take-off provided. In such a system, each unit price must be "fully loaded" (i.e., direct costs, overhead costs, contingency costs, profit, etc.). Typically, the contract is awarded to the bidder with the lowest total price based on price extensions and additions of all unit prices quoted. Based on this system, it can be said that there is no exact contract sum at the time of bidding. What the owner has are the unit prices provided by the bidder and the estimated units. As the units increase or decrease, so does the contract cost.

During the life of the contract, the contractor is paid on the basis of units installed into the project. Units installed are typically calculated by the quantity surveyor based on field surveys of work in progress. At the end of the job, the final units installed are surveyed and paid for. In some contracting systems, this requires a "final quantity adjustment change order" to adjust the contract amount to equal the actual units installed.

4.6 Applications of Quantity Surveys to Cost Estimating

CMs who perform numerous projects on a quantity survey basis often create and maintain a company database of actual costs for typical units involved in many projects. This database of actual costs can be used as a very accurate estimating tool. For example, if a CM works on commercial office building projects routinely, it will likely have costs on standard items such as interior and exterior doors, windows and related hardware; luminaires; carpeting; wall coverings; etc. By maintaining such costs in a database format, costs can be updated to reflect the most current costs utilizing various cost indices. Additionally, such costs can be updated to reflect the appropriate location factor. In any event, cost databases from quantity surveys of numerous projects can form an excellent estimating tool for the CM.

4.7 Summary

There are a wide variety of cost estimating techniques available to the CM. They range from quite simple to very complex and, depending upon when they are applied in the project's life, have varying degrees of reliability. The objective of the CM should be to gather all pertinent information and apply the best technique available at the appropriate stage of the project. This should be done in order to keep project cost estimates as up-to-date as possible. The CM must keep refining the project cost estimate in order to keep the owner properly informed concerning the status of the budget. The various estimating techniques set forth in this section are all available to accomplish this goal.

5.0 Cost Compliance Monitoring

Equally as important as estimating and budgeting and critical to the success of cost management, is the issue of cost monitoring. That is, the CM must, at the outset of the project, implement a system to capture cost data and monitor costs as they are incurred in order to compare actual to planned costs. Additionally, a cost management plan must be formulated early in the project to determine how cost variances will be dealt with should they occur.

5.1 Objectives of the Cost Management Plan

A cost management plan is a written document describing how cost variances will be managed and dealt with. That is, a cost management plan outlines different responses to major and minor problems. A cost management plan may be formal or informal, general or detailed. It depends on the size, cost and complexity of the project and the sensitivity of the owner and the CM to cost variances.

The cost management plan is based on the current project budget. It focuses on maintaining the cost; that is, delivering the project to the owner within the approved budget. The objective of the cost management plan is to set forth decision making processes in the event that cost variances arise during the performance of the project. The decision making processes set forth in the plan focuses on who makes what decisions and what sort of decisions should be considered under certain sets of circumstances.

5.2 Developing Project Contingency

Contingency, as used in budgeting, is defined as funding set aside or planned to cover possible future events that may or may not occur. When developing a project budget, a CM must alert the owner to the range of value of cost estimates at various stages of the project. For example, when preparing an initial budget estimate based on order of magnitude estimate numbers, the range of values is +50% to –30%. That is, a $10 million initial estimate could be as high as $15 million or as low as $7 million. These cost ranges obviously decrease as the project progresses and more is known about the project. However, to properly prepare for changes in cost, a contingency line item should be included in each estimate. The contingency line item probably should be based on the maximum up side of the estimate's range of values. That is, in the example above, the initial budget may be $10 million with a contingency of $5 million. This should cover all generally known risks at each level of cost estimating.

Based upon this discussion, contingency accounts should be established at each phase of the project as follows:

Preliminary estimate phase	+50%
Budget estimate phase	+30%
Design & bid estimate phase	+15%
Construction phase (new construction)	+10%
Construction phase (reconstruction)	+15%

5.3 Developing and Implementing a Cost Monitoring and Compliance System

Of first priority with respect to a cost monitoring system is the determination of what cost elements of the project are to be monitored. Some argue that tracking pay items under a contract is sufficient for the purpose. On small, short term, projects this may be acceptable.

Larger more complex projects generally tend to have higher visibility and greater sensitivity in most owner organizations. It is these projects that are more likely to encounter cost overruns due to their size and complexity. In larger projects, items other than pay items may need to be monitored. Some cost items, which can be routinely monitored, tracked and trended, include the following:

- Actual vs. planned project cash flow
- Actual vs. planned labor hours
- Actual vs. planned activities from a cost loaded schedule
- Project earned value calculations

Once these (or other) cost items are identified, a cost monitoring system can be established. Data can be collected from a number of sources and monitored. The key, however, to a successful cost monitoring plan is what occurs when the monitoring system indicates a budget variance. It is one thing to collect and analyze data. Effective cost monitoring depends on rapid identification of cost variances and sound decision making concerning those budget variances in a timely manner.

5.4 Specifying Cost Monitoring Methods

Once the owner's cost monitoring plan has been agreed upon, the CM must write certain requirements into the contract documents in order to capture the necessary data in a timely manner. Some examples of specifying cost monitoring are:

- If the owner chooses to monitor labor hours incurred versus those planned, the CM should specify:

    1. A resource loaded construction schedule identifying labor hours as one of the resources to be used. This will establish the planned labor.

    2. Submittal of the contractor's certified payroll on a weekly basis to establish the actual labor.

The CM can then track and plot the actual versus the planned labor to determine if the plan is being followed and, if not, to determine probable project impact.

- If the owner chooses to monitor actual versus planned cash flow, then the CM should specify submittal of an approvable cash flow curve around the time of the contractor's Notice to Proceed. The CM can then plot the planned cash flow and record the actual cash flow on a routine basis as the project progresses.

Other cost monitoring requirements can be written into the contract documents, provided that the owner and the CM determine which cost elements are to be monitored prior to the project bidding.

5.5 The Internet and Cost Monitoring

One of the more recent developments in the field of construction management is the use of the Internet. Originally designed as a simple communications tool among researchers, it has now become ubiquitous in modern life in the United States and many other countries. Many projects now have project websites where all information on the project is stored, including drawings, specifications, changes, RFI's, change orders, project budgets, project photographs, status reports, etc. All project participants generally have access to the website for information purposes. Changes to project documents on the website are typically limited to certain key people on the project team but access for viewing purposes is fairly wide open.

In terms of cost monitoring, the current project budget (in sum or in detail) can be posted on a project website. All project participants can see, at all times, the budget versus actual cost figures as they are routinely updated. Further, costs on the website can be trended using standard cost engineering techniques to predict likely outcome. In this manner, everyone involved in the project can stay updated concerning cost. Costs will be continually monitored and reported on and the likelihood of surprise correspondingly decreased.

5.6 Summary

A key role the CM can fulfill on a project is to recommend cost monitoring techniques to the project owner. CMs are aware of the need to monitor costs in order to ascertain compliance with the budget. CMs should generally be aware of how to monitor costs on a project. Action needs to be taken early in a project to determine what costs should be monitored, when they should be monitored, how they should be reported and what actions should be taken in the event cost variances arise. The time to establish a cost monitoring system is at the beginning of the project, not once cost variances have been identified.

6.0 Design Phase Cost Management

This section deals with project cost control during the design phase. That is, it does not address the cost of the design itself, but rather, deals with the cost impact of decisions made during the design phase.

6.1 Estimating Cost and Budget Impacts During Design

The *Standards* discuss design phase estimating in the following manner. The approach to managing costs during the design process should be proactive and not reactive. The CM should participate with the design team by providing timely cost advice and information. Properly done, this can significantly reduce the potential need for redesign due to cost overruns at the time of design completion or project bidding.

Following the approval of the construction budget for the project, the CM should provide ongoing cost management services to ensure that the budget is adhered to as the design is developed by the designer. A uniform cost estimating framework should be established and maintained by the CM from project inception through pre-design, design, procurement, and construction phases of the project. The application of a uniform framework facilitates consistent cost reporting and the ready identification of cost changes as the design develops.

Generally, estimates should be prepared by the CM to the level of detail available on the drawings and specifications, supplemented by notes and verbal data provided by the owner and the designer. All verbal data should be confirmed in writing and noted in the estimate.

At the conceptual, schematic and design development stages of a project, cost data on a per parameter basis by element and project type is appropriate. Since these data are usually historical, they should be adjusted for time, location and other factors influencing costs.

At preliminary design and final design document phases, cost data at a unit price level are more appropriate. This permits pricing of the individual components of the trade or element (i.e., concrete, reinforcing steel, forms, etc.). These data need to be verified and adjusted as necessary before use.

Parameter or unit prices are generally composite or “all in” rates. That is, they include labor, materials and equipment as a single unit price. If required for the project, each quantity can be priced with the labor, material and equipment costs segregated.

When developing estimates of construction cost during the design phase, all available specifications should be carefully studied, since many designers include items in the specifications which have significant cost implications, even though those items are not depicted on the drawings. The CM must pay close attention to the “boilerplate” contained in the contract documents to determine their impact on project costs.

Estimates of escalation in construction costs should be computed based on a monthly rate from the date of the estimate to the midpoint of construction. As the project moves into the construction document phase, the escalation cost may be refined by escalating major components of the project in accordance with the time of the contract award. There are a variety

of sources from which estimated cost escalation data can be obtained. All escalation data should be carefully reviewed.

To verify that the project remains within the construction and project budgets, it is recommended that (at a minimum) the following estimates be prepared by the CM at the various stages of the design process:

- **Program estimate at planning completion—**Upon completion of the planning process, and prior to initiation of design, the CM should prepare a program estimate. Such an estimate is intended to assess the probable cost of the approved plan. The purpose of this estimate is to determine whether the plan can be delivered within approved budgetary constraints.
- **Completion of schematic design—**The CM should prepare a schematic design cost estimate based on measurement of parameter quantities from the designer's schematic design stage submittal. It may also be possible to measure approximate quantities for certain elements of the project at this stage.
- **Completion of preliminary design—**The CM should prepare a preliminary design cost estimate based on measurement of approximate or parameter quantities from the designer's preliminary design submittal. As the mechanical and electrical designs typically lag behind the civil, architectural and structural designs, preliminary design estimates often contain approximate quantities for the architectural, structural and civil works and parameter quantities for the mechanical and electrical components.
- **In-progress final design (this may vary from 60% to 90% complete)—**Cost estimates prepared from working drawings and specifications should be based on quantity estimates for all major components. Any alternates to be called out in the bidding documents should also be quantified and estimated, as they become known during the design phase.
- **Completion of bidding documents (including any bid addenda issued)**—At completion of the bidding documents, the CM should prepare the definitive estimate for use by the owner in establishing its project construction budget. This estimate should include quantities for all portions of the designed project plus an estimate of allowable contingency during construction. Although bids should be received shortly after this point, this cost estimate is necessary for many owners in order to advertise for bids. For example, many states require that a public owner have a formal written estimate of the final design prior to advertising for bids. Some public owners require such estimates in order for the county or city council to pass the formal motion authorizing bid advertisement.

Each project must be evaluated based on its unique conditions and characteristics. Design contingencies should be set for each of these cost verification stages. The design contingency level should reflect the level of accuracy it is reasonable to expect from cost estimates at the various stages of the project's development. The project team should work together to develop the percentage allowable for design and construction contingencies on an individual project basis.

6.2 Evaluating Design Detail—Changes and Impacts on the Budget

As noted earlier, preliminary or conceptual budgets are prepared and adopted when little detail is known about the specific project. Owner decisions are made early on in the life of the project based upon these early budgets. One of the roles of the CM, therefore, revolves around monitoring cost and guarding against cost growth during the design phase. As more specific project information becomes available, the CM should prepare each of the above cost estimates.

After preparation of each cost estimate, the CM should compare the current cost estimate with the previously established budget to determine congruence. That is, is the project still within its accepted budget? If it is, then this needs to be reported to the owner and the project team. If the project has outgrown its approved budget, this too needs to be reported to the owner and the project team. The project team needs to carefully consider the situation and reach a determination on either of the following two alternatives:

- How to pull the project back into the budget?
- Should the project budget be modified? If so, by how much?

Either of these two options is viable, depending upon the circumstances. What is not a viable option is for the CM to prepare an estimate that indicates cost growth beyond the approved budget and not inform the owner or the project team.

6.3 Establishing an Effective Value Analysis Program

The *Standards* define value analysis as studies used for the purpose of optimizing value in project designs. Value analysis is sometimes referred to in the CM industry as value engineering. Value engineering is typically employed on a project *about to* go into the construction phase. Thus, value engineering is most frequently applied to the planning and design phases of a project. Value analysis, on the other hand, is a term applied to a value study of something *that has already been* designed. Value engineering can also be utilized during construction, but such efforts are usually associated with Value Engineering Change Proposals (VECP's).

Value engineering has been described as a multi-discipline, systematic and proactive function that is targeted at the design itself. The objective of value engineering is to develop a facility or item design that will yield the least life cycle cost or provide the greatest value to the owner, while still meeting all functional, safety, quality, operability, maintainability, durability and such other criteria established for the project. The purpose of value engineering and value analysis is to identify potential changes, unlike bidability and constructability reviews, which are not intended to make changes but rather to confirm that the design can be reasonably bid and built. Value engineering may actually result in an increase to the construction budget while, at the same time, reducing the project's life cycle cost

In the context of cost monitoring and cost control, value engineering can be employed as a major tool in initially developing or refining designs to meet target cost maximums. That is, value engineering is a good tool to use when "designing to cost".[7]

[7] Additional information on the formal Value Engineering process and the requirements to become a Certified Value Engineer, contact the Society of American Value Engineers (SAVE), Northbrook, Illinois.

Based on the above discussion, a CM should consider establishment of a value engineering and value analysis program as part of their overall cost management plan. Value engineering properly applied during the planning and design phases should help maintain cost control in the pre-construction phase of the project. This can be performed by the CM or may require use of an external value engineering consultant. Value analysis can be applied and VECP's considered during construction in order to help maintain cost control. These two cost control tools may assist the CM and the owner in preventing cost growth.

The CM should play a large role in both value engineering and value analysis. Value engineering is a process that may rely upon a Certified Value Specialist (CVS) as the team leader. And, many government funded projects specifically require this as a part of their overarching legal and regulatory scheme. If the CM has CVSs on staff, then they may take the lead. Otherwise, the CM should become part of the Value Engineering team looking primarily at the construction related aspects of a project. Likewise, the CM can take the lead on a value analysis team, provided they have qualified personnel to fulfill such a role. In the event they do not, then the CM should be a part of the value analysis team looking at construction related items.

6.4 Alternative Systems, Methods, Components and Materials

In performing value engineering or value analysis, the CM and the project team need to focus on the potential for alternative systems, methods, components and materials being employed on the project to achieve cost savings without sacrificing any of the project's goals and objectives. The general process for recognizing and analyzing alternatives utilized in value engineering and value analysis is briefly outlined below:

- **Information gathering process—**The primary question in this process is what are the operational and other requirements that must be satisfied to make this project a success?
- **Functional analysis process—**This process identifies what functions are involved in meeting the project requirements identified above. Consideration must be given to: What basic functions are involved in meeting facility requirements? What secondary functions are associated? Which are essential? How is the function accomplished in this project design? What is the worth or value of each function?
- **Creative process—**Here the question to be asked is how many ways can each function be performed or accomplished? This develops a set of options for further consideration.
- **Analytical process—**After consideration of each option developed above then various combinations of ideas must be tested through economic analysis, life cycle cost analysis, trade off analysis, sensitivity analysis, decision analysis, etc. The question to be asked and answered in this process is which combination of options meets the project requirements and provides the greatest value or is most cost effective on a life-cycle basis?
- **Proposal process—**Once the above is accomplished, the CM must make written proposals to the owner and designer, complete with reasoning for making such recommendations.

6.5 Trade Off Factors in Value Analysis

The *Standards* point out that during the construction phase, the CM should perform component studies on materials, systems, equipment and accessories to ensure that economical and competitive components are selected consistent with the construction budget. Trade off studies (a form of value analysis) should be fully documented with the CM's recommendations and submitted to the owner and the designer for their consideration.

It is not possible to provide a definitive list of trade-off factors to be considered in value engineering and value analysis that would cover every type of project. Each project is different and owner's goals and objectives for similar projects may differ widely. In general terms, the basic trade off factors to be considered by the CM should include:

- Construction cost savings vs. life cycle cost
- Material capital cost savings vs. operations and maintenance cost
- Procurement capital cost savings vs. operations and maintenance cost
- Current space savings vs. future space opportunities and costs

Fundamentally, value analysis needs to concern itself with current cost savings and cost control in the near term versus overall life cycle costs. The CM cannot fall into the trap of recommending a short term cost saving which ends up costing the owner a great deal more over the life of the project. For example, it is almost always possible to find an air cooling unit for less cost during construction. However, if the cheaper unit requires more maintenance over it's twenty year life and consumes four times the amount of power as compared to a more expensive unit, then there may be no real cost savings for the owner.

6.6 Summary

Cost management must be practiced during the project's planning and design phases, not started only after construction commences. The CM needs to manage costs throughout the entire life of the project. Most of the largest changes to the project are likely to be made during the preconstruction phase of the project. In order to maintain project budget, the CM must monitor changes during design and estimate and report on their likely impact to overall project cost.

7.0 Construction Phase Cost Management

Cost management is critical to project success. Cost monitoring procedures need to be implemented during construction. The CM should develop a system that helps establish a reasonable schedule of values and insures prompt payments to contractors for work performed. CMs also need to establish a system to manage the cost of changes and claims.

7.1 Specifying Cost Monitoring and Management Procedures

A cost management plan describes how cost variations will be dealt with and managed should they arise. The plan should address the following questions at a minimum. Who will track cost for variations? How will variations be identified? Who will be notified? How will variations be considered?

As noted previously in Sections 5.1 and 5.2, during the contract document preparation phase the CM and the owner must determine which costs will be monitored during construction. This decision must be reached early in order to incorporate cost reporting responsibilities into the bidding documents. Requirements such as the following must be included in the contract documents prior to bidding if the CM and the owner expect to receive the correct information from the contractor in a timely manner.

- Schedule of values
- Frequency, dates and form of payment applications
- Earned value information
- Resource loaded CPM schedule and schedule updates
- Submittal of certified payroll information
- Submittal of general conditions or field office overhead cost
- Submittal of equipment rates or inclusion of a standard equipment rate manual in the contract documents
- Submittal of the contractor's proposed daily delay cost calculations[8]

Once the CM and the owner choose which specific costs are to be monitored, consideration needs to be given to the issue of who controls the most up-to-date information concerning each specific cost item? In some cases, the CM can monitor and report on costs without special input from others. For example, in monitoring planned vs. actual cashflow, once the schedule of values is put in place, the CM need only record the monthly payment application value on a routine basis. In other cases, the contractor has better access to cost information. If this is the case, then a specification requirement can be fashioned and incorporated into the contract documents to require this information be provided to the CM.

[8] An uncommon but excellent strategy to keep in check unreasonable claims from contractors for delay damages is to add to the bid form a section requiring the bidder to quantify their damages per day for every day the project is delayed.

7.2 Contingency Management

The creation and management of budget contingency during the planning and design phases of a project is primarily a theoretical exercise. The CM and the owner are planning contingency funds, but no real money is produced and set aside. However, once the contract is bid or let, contingency takes on a different form. That is, at the time the project is bid, the CM and the owner find out what the cost of construction will be (assuming no major problems with the design, no substantial project delays, no unknown underground conditions, etc.). The reality is, however, the CM and most owners know full well that (1) changes to the project are likely during construction and (2) everything will not go as well as planned or designed.

Based upon this recognition of reality, the CM needs to discuss and agree upon a contingency account that has real funding. Typically, discussion of this type stays in the hypothetical realm with the owner during the design and bidding period. That is, the CM and the owner may talk about a contingency fund of "x"%. At the time of contract award, however, the owner should establish a true contingency account with actual funding. At the same time, groundrules need to be formalized concerning who can access the contingency fund, under what circumstances, what reporting is required, etc.

The most frequently asked question concerning contingency management is "what is the appropriate amount of contingency to set aside?" There are varying answers to this question. Schwartzkopf's book, *Calculating Lost Labor Productivity in Construction Claims*, succinctly summarizes a number of studies concerning "average cost growth" on construction projects, as follows:[9]

Study	Year(s)	Low %	High %
Building Research Board, National Research Council	1977 – 1984	5.7%	11.5%[10]
Veteran's Administration	1974 – 1985	3.9%	8.8%
U.S. Census Bureau	1976 – 1984	2.2%	10.0%[11]
U.S. Census Bureau	1976 – 1984	(11.9%)	14.7%[12]

Schwartzkopf concludes that average cost growth will be in the range of 5% to 10%. It is, therefore, recommended that a 10% contingency fund be created at the time of contract award to provide for cost growth. If the project is a remodel of an existing facility, perhaps the contingency amount should be higher due to the likelihood of unforeseen conditions.

[9] See pages 44 – 48.

[10] Studied US Army Corps of Engineers and Naval Facilities Engineering Command.

[11] Studied 59,155 private projects over 8 year period.

[12] Studied 21,934 State and local government projects over same 8 year period, but many were unit priced contracts.

7.3 Understanding the Risks of Project Budgeting

Ritz, in his book *Total Construction Project Management*, makes the following statement concerning project budgets:

> "The purpose of the project budget is to set a cost, or money target, for each material, labor, and subcontract cost on the total project. Since all the financial aspects of the project revolve around it, the project budget must be realistic when compared to the actual expected cost of the project."

In considering the risk associated with project budgeting, Ritz points out that budgets are generally derived from cost estimates. To have an achievable budget, therefore, one should have a realistic cost estimate. In some cases, however, the project owner may have a budget set (based upon a previously established business plan) well prior to any design or cost estimate.

The CM's biggest risk in preparing budgets for owner approval lies in formulation of the cost estimate. A major risk in preparing estimates is that, all too frequently, owners treat estimates as cost "warranties". The danger in this situation is twofold. First, if the owner actually believes that the estimate is a guarantee of cost, the owner may not arrange for sufficient monies to fund the project, especially if the bid comes in higher than the estimate or if there is substantial cost growth during construction. Second, disappointed owners may take legal action against the CM alleging negligence in preparation of the cost estimate. For this reason, the CM should include qualifying language in its contract with the owner in the event that the bids come in higher than the estimate. Additionally, the CM must work hard to manage the owner's expectations concerning cost estimates throughout the project.

Another risk in preparing project budgets, especially at the early stage of a project, is that project owners tend to focus on single numbers, whereas cost estimates are actually ranges of numbers. Let's look at an example. Assume that a budget estimate has a variance of +30% to –15%. Thus, if the cost estimate for construction at the budget estimate phase shows a $10.0 million construction cost, then this means that the estimate has a low value of $8.5 million (-15%) to a high value of $13.0 million (+30%). This is a spread of some $4.5 million or 45% of the $10.0 million cost estimate. If the CM simply presents the $10.0 million cost on its own, with no qualifying statements then the initial project budget will be based on this number. The result is that this budget is probably inaccurate. Thus, it is the likely that the cost will exceed $10.0 million.

The CM must continually manage the owner's expectations with regard to cost and budget. All cost estimates should be very clear on the amount of variation in the estimate. Further, all budgets need to have an appropriate amount of contingency in order to deal with cost variations. One of the key roles that a CM plays during construction is to manage these contingency funds. Tight control of contingency funds must be exercised throughout the project. If contingency is not managed carefully then these funds will likely be committed early in the project on project "betterments" (i.e., changes that are nice to have, but not necessary to meet the goals of the project), leaving no contingency funds later in the project.

One way for the CM to exercise control over contingency funds is to establish a specific contingency account. Once this account is established a formal policy statement should be issued concerning who can commit the funds and under what circumstances the funds can be committed. Finally, a formal routine part of the cost reporting system should be a report on the status of the contingency funds.

7.4 Specifying, Developing and Implementing An Effective Schedule of Value

The CM should continue monitoring and managing costs through the completion and closeout of construction. Part of cost management during construction is the continual monitoring of the percentage of project completion. When a contract is bid and awarded on a lump sum basis, the CM must obtain a schedule of values from the contractor.[13]

The *Construction Dictionary* defines a schedule of values as "A statement furnished by the contractor to the architect or engineer (or CM) reflecting the portions of the contract sum allotted for the various parts of the work and used as a basis for reviewing the contractor's applications for progress payments". The *Standards* define a schedule of values as "A list of basic contract segments in both labor and material, where each line item consists of a description of a portion of work and a related cost and the sum of the lines of the contract equals the total contract price. Generally used to determine progress payments to contractor(s)".

The *Standards* state that when the percentage of completion of scheduled activities method is to be used in determining the contractor's progress payments, the CM should, in conjunction with the contractor, determine a schedule of values for each of the scheduled activities. When the percentage of completion by division of work is to be used in determining the contractor's progress payments, the CM should, in conjunction with the contractor, determine a schedule of values for each bid package. This information should be used as the basis for all future progress payments to the contractor.

In either case, establishment of a schedule of values should occur either before or shortly after award of the contract and must be reviewed and mutually agreed upon by the parties to avoid under or over-payments during the course of the project. To achieve this, a specification requirement that the contractor must submit its proposed schedule of values to the CM within "x" working days after issuance of the Notice of Award (or Notice to Proceed) can be included in the contract documents. To make such a requirement enforceable, contract language to the effect that no progress payment will be made until the schedule of values has been submitted, reviewed and approved by the CM can also be added.

The apportionment of indirect costs and profit to the pay items must be carefully accomplished to ensure equitable reimbursement to the contractor and to avoid front end loading. This is a situation where all the concrete in the early part of the project is priced at $90.00/cy in place while the same concrete at the tail end of the job is priced at $45.00/cy. Front end loading is normally attempted to give the contractor some up front funding to help

[13] It should be noted that when a contract is bid on a unit price basis, no separate schedule of values is required, as the listing of unit prices constitutes the schedule of values.

offset bidding, bonding, mobilization and other early job costs which are typically not reimbursed by the owner as pay items under the contract. Mobilization payments are sometimes used in order to avoid the issue of front end loading. Finally, the schedule of values should be detailed enough to allow accurate evaluation of progress payments throughout the life of the project. Once established, the schedule of values should reduce payment disputes.

7.5 Schedule of Values and Prompt Payment Requests Evaluation

An acceptable schedule of values should allow faster progress payment reviews. That is, the schedule of values establishes the value of work items. In this regard, the CM simply needs to check that the work items on the progress payment application conform to the schedule of values. The real work concerning payment requests will then be reduced to determining how many units of each work items have been put in place during the payment cycle.[14]

Prompt payment is a very serious issue throughout the construction industry. Most contract documents have fairly strict processing timeframes for review and approval of payment applications. For example, CMAA's General Condition Article 11.3 requires that the CM make a recommendation to the owner concerning the progress payment within fourteen days after receipt of the payment application.

Many states and the federal agencies have adopted prompt payment statutes. Failure to pay on undisputed payment requests within the statutory timeframe generally subjects the owner to interest penalties on the unpaid sum. If the CM is the cause of the delay, the owner may look to the CM for payment of all or a portion of this extra cost. If the owner is processing payment requests on its own, the CM may need to provide assistance to help avoid such extra costs.

Finally, some standard form contract documents allow the contractor to abandon its performance of the work if the owner fails to pay undisputed amounts within certain timeframes. (See, for example, CMAA General Conditions Article 13.1 or the Design/Build Institute of America [DBIA] General Condition Article 11.4.1.3.)

7.6 Specifying, Developing and Implementing an Integrated Cost-Loaded Schedule

Another way to establish a schedule of values on a more discrete basis is to require the contractor to cost load the construction schedule. Language in the contract documents to the effect that "All on-site construction activities shall be cost loaded and the sum of all cost-loaded activities on the schedule shall equal the contract amount, at all times" will accomplish this purpose. In such a case, once the project's baseline schedule and cost loading are approved, the listing of cost loaded activities is the project's schedule of values. In this manner, each on-site activity on the project has an associated cost.

Some owners, concerned with an unbalanced schedule of values, write provisions into their contract documents requiring that no single activity can carry more than a certain percentage of

[14] A practice becoming more commonplace is for the CM to make the determination of the contractor's progress for each activity in preparation of the application for payment. The contractor's responsibility is to accept the CM's observations or discuss any differences of opinion.

the cost of the project. For example, a clause may be included in the contract documents that no activity can have a value exceeding 1% of the cost of the project.

The advantage of this system is that the schedule of values is more discrete and can be more readily used for change order pricing. The disadvantage to this approach is that the schedule of values will be considerably longer and more complex. In any event, if the CM and the owner choose to use this system, the requirement must be clearly included in the bidding documents so that all bidders are aware of the requirement.

The contractor will develop the cost-loaded schedule by allocating the cost details of its bid to the construction schedule. Such cost loading requires that the contractor allocate its general conditions cost or field office overhead costs to the activities on the schedule. It must also allocate markup costs (i.e., home office overhead, contingency and profit) and bond costs to the activities on the schedule.

Once the baseline schedule and cost loading are approved, the monthly payment application process will, of necessity, include submittal of an updated schedule showing the status of all pay items accomplished during the reporting period. The CM will have to review the schedule update for accuracy with respect to both time and percentage of completion for all activities worked on during the reporting period.

In the event that a schedule activity is started but not completed within the monthly reporting period, the contractor will status that activity with the percentage complete status. The completion percentage times the activity value yields the payment amount owed less applicable retainage. The CM's role, in such a situation, is to review and confirm the percentage completion claimed.

7.7 Developing and Implementing an Effective Change Order Control System

Changes and constructive changes are a continuous threat to cost control throughout design and construction of a project. Even for those owners who naively announce at the outset of the project "there will be no change orders on this project", changes will occur.

Change order control is more of an art than a science. The concept of controlling change orders is not as easily implemented during construction as during planing and design. During construction, change orders often arise from situations beyond the control of the CM and the owner. (Examples include third party delays, differing site conditions, force majeure events, etc.). In situations such as these, the role of the CM is to mitigate damages by administering the change order process promptly and in accordance with the terms and conditions of the contract documents. Change orders which may be subject to "control", are those caused by owner staff who simply "want things a little better than the designer included". These change orders may be avoided through use of some of the techniques listed below.

Change order control and change order management really involves the leadership of the people involved or associated with the project. There are no exact solutions to this issue. Some of the more successful ideas include:

- **Written notice requirements—**The contract documents should have strong, strict and enforceable written notice requirements. That is, whenever the contractor believes it has been directed to make a change to the work without receipt of a properly executed change order, it is required to notify the CM in writing and await the CM's direction concerning the changed work. This gives the CM the ability to stop those actions, which may be a change, but are not warranted, justified, or intended.
- **Written change order requirement—**Contract language should be included which states the contractor is not entitled to payment for changed work unless it is in receipt of a properly executed change order or a written directive to proceed with the changed work. This is intended to stop "verbal changes" to the work because the contract alerts the contractor to the fact that it may not be able to recover on a verbal change directive. On the other hand, the CM and the owner will be required to create a set of change documents and use them promptly when they want changed work performed.
- **Project warrants—**One of the more common occurrences in the industry is when the contractor advises the CM that "your inspector ordered me to make this change, so you owe me." The CM often responds with the statement that "inspectors have no authority to issue changes" and the contractor responds with "how was I supposed to know that?" To avoid such arguments, each project team member authorized to deal with the contractor should have a "warrant" (a written document) signed by the owner setting forth their duties and responsibilities. Some warrants may say, "This individual has no authority to issue or direct changes to the work". Other warrants may limit the individual's authority to changes not to exceed a certain sum. The concept is to let everyone on the project know who has authority to direct changes and who does *not*, a point that is delineated in the project's procedures manual.
- **Delegation of authority—**One of the major problems with changes is the amount of time to process them through many owners' organizations. Delay in the decision making process concerning changes can be very expensive in the long run. To avoid such situations, the CM and the owner may negotiate a delegation of authority policy. For example, a field project manager may have authority to issue change orders with a value not to exceed $25,000 on their own signature. The head of the CM team may be delegated authority up to $50,000, while all changes over this amount may have to go to the owner's governing board. The idea is that if delay in change orders can be reduced, the cost of the changes can also be kept down.
- **Change Control Board—**On some megaprojects, Change Order Control Boards are created for the specific purpose of reviewing and approving the larger, more complex, design-related changes. Typically these are changes that are beyond the expertise of the CM and have a potential for design related ramifications. Such boards are often modeled on the old Configuration Management or Configuration Control Boards initially used by the Department of Defense in the 1960's. Such Boards are generally made up of senior staff involved in project design and operations, along with top management officials from the owner staff who have ultimate budget authority and responsibility. Those individuals proposing such major changes must present persuasive arguments concerning the

proposed change to the Board, along with appropriate supporting data. The Board will convene to consider such proposed changes, recognizing that each change before it is large, complex and will, if approved, change the basis of design. The Board will also understand that such changes will likely have a significant impact on the project budget. The role of the CM in situations such as this is most likely to be limited to preparing revised budget and schedule estimates for the Board prior to its meeting to help it understand the potential budget and schedule ramifications of each potential change.

- **Change Order Policy—**Some owners have established a policy that whoever proposes the change order has to personally appear before the owner's decision- making body to justify why the change should be made. The practical effect of such a policy is to put a lot of pressure on project team members *not* to make changes unless they are truly needed.
- **Budget contingency—**All CMs are aware that change is going to happen during construction. Most owners know this as well. However, some owners fail to establish a budget contingency at the time of award to handle the cost of changes. The failure to do so may cause delay in the issuance of changes while appropriate funding is arranged which in turn, can cause the cost of the changes to increase. The CM should work with the owner during the time between bid opening and contract award to establish a management reserve or budget contingency to handle changes to the work. A process also should be in place to refill the budget contingency if, during the course of the project, the initial contingency funds are entirely depleted.

There probably are additional change order control mechanisms that can be employed. During the design period the CM should consider all possibilities, discuss them with the owner, and reach an understanding on how change will be controlled once the project goes into the construction phase.

7.8 Factors Governing Cost Changes During Construction

In accordance with the *Standards,* and as part of the overall cost control system during the construction process, the CM should establish and implement a change order control system. Once it is agreed between the CM and the owner that there should be an adjustment to the contract price (and/or time), determining the amount of the adjustment that is fair and equitable is having a thorough understanding of the scope of the changed work and a matter of obtaining supporting data as proof of costs.

The CM should prepare an estimate of the cost of the change order listing the anticipated labor, materials, equipment, subcontract work, contractor's overhead and profit, as well as any justified impact costs. The effect of the change on the current updated schedule should also be analyzed for any identifiable time impact. This effort should be completed by the CM in advance of receiving the change order pricing from the contractor so that an evaluation of the proposed price can be made independently and without delay.

Generally, there are three ways to price change orders:

- **Forward Pricing—**The change order pricing is done prior to the start of, or early in, the performance of the changed work. The estimates of costs might itemize production rates,

crew composition, hours and equipment. Material cost should be listed and substantiated with written cost quotations and price lists. Markup including overhead, profit and bond should be added. If this can be accomplished successfully between the owner and the contractor, "mutual accord and satisfaction" language can be included in the change order.

- **Actual Pricing—**This is sometimes referred to as force account or time and materials (T&M) work. The pricing is done while the changed work is being performed and, thus, represents actual costs based on job cost records of manhours consumed and material and equipment used. Comprehensive cost records are imperative. On force account or T&M work, the work should also be documented and verified daily by both the CM and the contractor.
- **Post or Retroactive Pricing—**Change order pricing is done after the work has been completed and no records were maintained nor were job cost records segregated between base contract and changed work. Cost estimates, similar to forward pricing, are produced to quantify the scope and cost of the work. This scenario often occurs because the contractor does not provide timely notice of the change and the work has been performed before the CM got involved.

In forward pricing of change order work, the CM should consider the following special factors when evaluating labor production rates:

- Status and condition of the work
- Relative size and capability of the contractor
- Size and complexity of the change
- Climatic conditions
- Mechanization possible
- Labor agreements
- Trade practices
- Learning curve
- Additional supervision required by the change

When evaluating material and equipment costs, the CM should consider the following special factors:

- Value of salvaged material
- Odd lot sizes that add to cost
- Special delivery costs
- Potential higher price for proprietary items
- Cost escalation since bid opening
- Storage costs that may be necessary

- Premiums for payment and performance bonds
- Additional insurance coverage
- Additional inspection and testing costs required to perform the changed work
- Price paid for unused inventory

While impact costs, if any, may be difficult to quantify, the following issues need to be addressed:

- Changes in sequence of work
- Changes in means, method or manner of performance for the work
- Discontinuity of the work
- Premium time incurred to avoid delays
- Congestion of work area
- Mobilization and demobilization
- Effect on other contractors
- Loss of efficiency and/or productivity

The CM should also consider the potential for schedule-related or time extension costs such as:

- Extended general conditions
- Extended field office overhead
- Extended or unabsorbed home office overhead
- Extended insurance costs

Large impact costs, if any, can sometimes be determined by the following:

- Actual cost of identical work performed
- Reasonable estimate of the cost of the work if a change had not been encountered, compared to the estimated cost of change order job conditions, or compared to the actual cost of work performed if retroactive pricing was used
- Audit of the contractor's job cost records to determine actual costs

Overhead and profit allowed on change order work is often established as fixed percentage rates in the contract documents. If they are not, the CM will need to agree on these rates before change orders are executed.

7.9 Specifying, Developing and Implementing a Cost Evaluation System for Potential Claims

It is not within the scope of this manual to discuss when, how and under what circumstances the CM should evaluate claims and potential claims from the contractor. However, assuming that legitimate claims do arise, typically the CM is charged with the responsibility of leading the settlement negotiations on behalf of the owner. As with the change order pricing discussed earlier, the CM should prepare an independent estimate of claim costs prior to analyzing the contractor's claimed costs.

The elements of pricing the claim settlement (often referred to as the equitable adjustment) are the same as those referred to earlier in pricing a change order. The advantage to pricing claim settlements, typically, is that all work involved in the claim has generally been performed prior to the time the CM has to negotiate the cost of such work. Thus, the same factors that are listed in Section 7.8 are applicable to the pricing of claims.

The CM should place particular emphasis on an audit of the contractor's job cost records. In a claim situation against the owner, the contractor has the burden of justifying its entitlement to the claim and proving the damages resulting from the claim (i.e., cost and time impact). The CM's challenge is to determine whether the costs claimed were (1) actually incurred by the contractor and (2) were reasonably caused by the claim situation. The questions of what actual costs were incurred can be resolved by auditing the contractor's job cost records.

With this in mind, the CM should advise the owner to include an Audit Clause in the construction contract with provisions that flow this clause down to all subcontractors, suppliers and vendors at all tiers.

7.10 Summary

Cost management during project construction is one of the primary responsibilities and most important roles the CM can fulfill. The CM needs to establish formal cost monitoring and management procedures for the project; help develop realistic schedules of value; and process payment applications rapidly. Additionally, the CM should establish an effective system to control change orders and contain both scope creep and cost growth. Finally, the CM should implement a system for evaluating the cost of legitimate claims in order to successfully negotiate resolution of such situations.

8.0 Cost Control

The CM should establish effective cost control systems during construction in order to control the project budget and help deliver the project within the accepted project budget. The CM normally participates in bid review and evaluation. A part of effective cost control should involve productivity studies and impact analyses.

8.1 Utilizing Manhour Analysis for Productivity Studies, Impact Analyses, and Efficiency Losses

Assuming the owner has required a resource-loaded schedule from the contractor during the construction phase of the project, the CM will be in a position to perform routine productivity analyses. Calculations can be made from the accepted, as-planned schedule to determine what productivity has to be accomplished in order to meet plan. With this baseline in hand, the CM can then monitor ongoing field activities to calculate actual contractor productivity on selected portions of the project. To the extent that the contractor is at or above planned productivity, the project is probably on schedule (barring unforeseen conditions or offsite delays). If the contractor is continuously failing to meet planned productivity, then it is likely that the contractor is behind schedule and problems have or will develop. Knowing this information as early as possible will allow the CM to report such facts to the owner and together they can work with the contractor to change this trend.

Productivity studies and impact analyses also play a large role with respect to changes and claims on a project. In analyzing the impact of changes and claims on the contractor, it is not uncommon for the CM to be faced with allegations of lost productivity or lost efficiency from the contractor. Most contractors tend to use "national studies" such as the Leonard Study or the productivity studies published by the National Electrical Contractor's Association (NECA) or the Mechanical Contractor's Association of America (MCAA). Such claims from contractors are frequently accompanied by charts from one of these studies to "prove" the lost productivity encountered by the contractor due to changes in the work.

Typically, owners resist making payment of claims based on such proof. Owners counter such allegations, and rightly so, with the argument that these are national studies totally unrelated to this project and this particular situation. The CM, of course, is then charged with the responsibility of analyzing the contractor's claim and preparing an estimate of the lost productivity cost owed to the contractor.

It is not within the purview of this Manual to outline how such a claim analysis should be performed. It is, however, appropriate to set forth some guidance concerning how such costs can be calculated, once the determination is made that the owner owes the contractor something for the owner-caused loss of productivity.

Although still controversial in some jurisdictions, the most appropriate means of measuring lost productivity on a project is the "measured mile" analysis. William Schwartzkopf, in his book *Calculating Lost Labor Productivity in Construction Claims*, offers the following brief discussion of this technique:

"When changes are issued after the start of a project, it may be possible to measure the impact of the changes using a measured mile analysis. A measured mile analysis compares an unimpacted portion of the project with the impacted portion. If a sufficient portion of the project has been performed prior to the changes and the work quantities are known, then it may be possible to calculate a productivity baseline by taking the physical units of work installed and multiplying by the estimated unit rates to determine the earned hours. The earned manhours are then compared with the actual manhours expended. The manhours expended during the impact period can then be compared to the manhours earned during the impact period by taking the units performed during the impact period and extending them by the estimated unit manhour rates. This ratio can be compared with the baseline ratio. This allows a comparison of the productivity between the two periods so the productivity impact of change orders can be quantified. This type of measured mile analysis is termed an *earned value analysis.*

When unit rate productivity data is available for the same type of work for both periods, a similar analysis can be done. The measured mile analysis in simplified form is illustrated in the following formula:

$$\text{Productivity Change} = \frac{\text{Unit Productivity Rate During Impacted Period}}{\text{Unit Productivity Rate During Unimpacted Period}}$$

The advantage of this type of analysis is that it factors out all estimating issues because it focuses only on actual unit costs during an unimpacted period and actual unit costs during an impacted period. It can be difficult to find unimpacted areas on projects that are complex and suffer compounding problems."

Schwartzkopf goes on to point out that when performing such a study, the CM needs to isolate and attempt to factor out other cost variables which can affect labor productivity but which are not related to changes in the work. Among the factors listed, Schwartzkopf includes the following:

- Weather
- Contractor management problems
- Extended overtime
- Acceleration
- Delay
- Crowding of trades
- Type of work being performed

Schwartzkopf concludes his discussion of this type of cost calculation with the statement that while it can be difficult to find unimpacted work and isolate these other factors, "…actual measurements of productivity variances are often superior to predicted measures of productivity loss".

In the event that a measured mile analysis is not possible on a project, the CM may be required to use alternative analytical techniques such as the national studies referred to above as modified by the factors Schwartzkopf mentions; comparison studies of this project with other similar projects; or comparison of this project with historical databases, etc.

8.2 Bid Evaluation, Review and Contract Award

The *Standards* note that bid openings may be structured as private or public, depending on project requirements and owner responsibilities and obligations.

If the CM is to receive the bids, the CM should hold unopened sealed bids in tight security. The CM should assist the owner in recording bid receipt times in a formal procedure. At the established time, the CM should assist the owner with the bid opening and should record all bids on a bid comparison form similar, if not identical to, the bid form. Early bids should not be opened prior to the designated time and late bids should be formally returned to the bidder unopened. Bid corrections, if any at all, should be processed in strict accordance with the terms of the Instructions to Bidders.

The CM should assist the owner in evaluating the bids for completeness, responsiveness, and pricing and should coordinate this evaluation with any technical review that may be required by the design professional. The CM should review all bids for potential bid errors and should correct such errors in accordance with the bidding document's Instructions to Bidders (e.g., mathematical errors when extending unit prices) or notify the owner of errors when faced with more serious or non-correctable issues.

All bidder exceptions and clarifications (if any are allowed by the Instructions to Bidders) should be resolved by the CM in a manner suitable to the owner. The CM should review all bid alternates with the design professional and make appropriate recommendations to the owner concerning such bid alternates. If the bidding documents contain a bidder responsibility submittal, the CM should perform the required checks on bidder responsibility and report its findings to the owner.

Once this is accomplished, the CM should compare the apparent low bidder's bid price with the construction budget to determine whether the bid conforms to or exceeds the budget. If the apparent low bid exceeds the budget, the CM needs to work closely with the owner and the designer to determine the appropriate course of action. Some options in this situation include:

- Reject all bids, redesign and rebid the project.[15]
- Negotiate with the apparent low bidder (if the owner's organizational policies allow such a course of action and/or applicable statutory requirements governing the procurement action, if any, provide for such an alternative).
- Exercise the right to use bid alternates as a way to reduce project cost. In order to use this cost control method, during the design phase the owner, the designer and the CM should prepare some alternative bid scenarios (including both additive alternatives and deductive

[15] The owner should include a provision in the bidding documents stating that it has the right to reject all bids and relet the contract package.

alternates) and include them in the bidding documents along with appropriate instructions in the Instructions to Bidders. At bid opening, the owner can choose these alternates in order to "make the project fit the budget". It should be noted that there might be some legal limitations on the use of bid alternates.[16] Owners need to check with legal counsel when considering the use of bid alternates to ensure a thorough understanding of legal requirements in their jurisdiction.

- Adjust the project budget to allow award of the contract.

Any and all recommendations made by the CM for contract award should be in writing, giving the reasons for the decision and include copies of the bids and the bid comparison for the owner's use.

8.3 Problems with Unbalanced Bids

A problem that CMs have to be prepared to address are unbalanced bids.[17] An unbalanced bid situation arises whenever the costs of certain items of work in the bid are significantly understated or overstated. In such situations, mark up and possibly direct costs have been added to or shifted away from these work items to other items of work in the contract. This may happen for a number of reasons that the owner is entirely unaware of.

There are at least two types of unbalanced bids:

- **Mathematically Unbalanced Bids—**This is a situation where certain bid items or certain pay items in a schedule of values does not carry its appropriate share of the markup cost (and perhaps not even all of the direct cost). This results in certain bid or pay items being underpriced while others are overpriced.
- **Front-End Loading—**In this situation, costs are moved from activities that will be performed late in the project and added to work items that will be performed early in the project.

Unbalanced bidding tends to arise when the contractor either (1) needs monies early in the project in order to help finance the job; or (2) has reason to believe that the estimated quantities in the bidding documents are in error and a potential significant profit is possible if the bid is "properly" unbalanced. ("Properly" in the sense that the contractor has added or deleted money from the bid items that have substantial quantity variations.)

The problem later manifests itself, from the owner's perspective, if the bid is mathematically unbalanced and there are significant quantity variations. In such a situation, the owner may be faced with overpaying or not being able to recover an appropriate amount for the work that varies. In terms of a front-end loaded bid, the problem may arise if the owner terminates the contractor for default and calls upon the surety to complete the work. The surety may seek to invalidate its obligations on the basis that the owner overpaid the contractor. Problems can also

[16] See, for example, *Matter of John C. Grimberg Company*, Comp. Gen. No. B-283013 (February 2, 2000).

[17] For a more thorough discussion of unbalanced bidding see "Unbalanced Bids and Avoiding disputes Relating to Them", Frank A. Manzo and Steven Tell, *1997 Wiley Construction Law Update*, Wiley Law Publications, New York.

arise if work that is improperly priced in the bid is subject to change; the change order pricing may be skewed due to bid unbalancing. Problems also arise in negotiating an appropriate schedule of values if bid unbalancing has occurred in a lump sum bid situation.

To protect themselves against unbalanced bids, owners often insert language in the Instructions to Bidders to the effect that if the bid is considered unbalanced by the owner then the owner has the right to declare the bid non-responsive and reject the bid. Notwithstanding such language in the bidding documents, courts have not uniformly supported the owner's right to reject the bid for bid unbalancing.[18] It appears that the bid must be "materially unbalanced" or so substantially unbalanced as to materially harm the owner's position if the contract is awarded.

In their article Manzo and Tell offer five potential recommendations to discourage unbalanced bids.

- Use of a mobilization payment line item in the bid to provide some up-front money and alleviate, at least in part, the contractor's need to front-end load the bid.
- Provide the low bidder the opportunity to rebalance the bid, provided that the total bid amount does not change at all.
- Reject the unbalanced bid and award to the next lowest bidder.
- Use optional bid items to increase risk associated with unbalanced bids thus discouraging them.
- Reject all bids and rebid the entire project.

In any event, the CM needs to be alert to this problem and guard against it at bid time. If it is determined that the apparent low bid is unbalanced, this needs to be immediately called to the attention of the owner and its legal counsel.

8.4 Interaction and Relationship Within the Project Team

The project owner is "first among equals". It is its project and its money. And, after all is said and done and construction is complete, it is the owner and its staff who will have to live with the project for it's projected life. Having said this, the owner, all too often, has the least amount of experience with project planning, design and construction. Because of this lack of experience, the owner frequently has little understanding of cost management and cost control with respect to the design and construction of a project.

Designers are typically much more concerned with technical issues and/or project aesthetics than project costs. Contractors are concerned primarily with performing its work within its own budget (which is unrelated to the owner's budget) and making a profit on its work.

This leaves the CM in sole possession of the role of cost manager and cost control specialist. Cost estimates and budgets must be prepared by the CM for approval by the owner. The CM must monitor project costs throughout the planning and design process by working in close

[18] See, for example, *Protest of Severn Companies*, GSBCA No. 9353-P 88-3 B.C.A. (CCH) 20,850 (1988).

conjunction with the owner and the designer to limit scope creep and cost growth. The CM must closely monitor owner, designer and contractor actions during construction to limit cost growth.

The CM must focus on cost, monitor cost, detect cost variances and bring them to the attention of the owner early enough that cost growth can be controlled and contained. On many projects, the CM may be the only team member with an understanding of the issues involved with cost management and cost control. Thus, on many projects, the CM is the only team member who can fill this key role.

8.5 Responsibilities and Management Structure of Project Management Team

A project management team can be organized in many forms. Whatever the structure of the project team, all communications, especially those concerning cost or time, must include the CM. Whether communications are routed through the CM or simply copied to the CM may be irrelevant insofar as the CM's cost management responsibilities are concerned.

Because project cost is so easily influenced, both positively and negatively, the CM must be involved in all project meetings. As the project's cost manager, the CM must be kept informed regarding all discussions and all decisions related to project time, cost, scope, etc. The CM must be given the responsibility and the authority to gain access to all information, to monitor all project costs and to raise a red flag whenever there are potential or actual budget variances.

8.6 Summary

The final step in the overall cost management procedure is for the CM to establish and implement a formal cost control system that encompasses the bidding and construction process. The CM's involvement in bid evaluations must include both conformance to bid requirements as well as to cost control. During construction the CM must be involved in all project communications in order to monitor the project for cost control purposes.

9.0 PROJECT CLOSEOUT

Depending on the terms and conditions of the CM's contract, the CM's cost management responsibilities may carry on beyond completion of construction. The *Standards* specifically mention CM obligations with regard to the following:

- Final payment
- Contract closeout, including:
  - Certificate of substantial completion
  - Final lien waivers
  - Final payment application
  - Release of retainage
  - Final cost accounting

Obtaining final lien waivers from all subcontractors, suppliers and vendors will help ensure that all project participants have been properly paid and will deliver a lien-free job to the project owner. Processing the final payment to the prime contractor and releasing retainage is also, generally, a function of the CM. And, to the extent that there are claims at the end of the project, the CM will normally be involved in claim analysis and either settlement or defense of such claims.

Additionally, the CM may be called upon to provide a written report summarizing total project cost, listing all change orders, and identifying any unresolved issues which may have a cost impact. The CM should also prepare and file a "lessons learned" report setting forth the causes of all cost variances, the reasoning behind the actions taken and other types of lessons learned from the cost control perspective. This will aid the owner when responding to inquiries concerning the project and assist if there is a future project audit performed by an outside agency. It will also assist the CM and its staff on future projects.

10.0 GLOSSARY OF TERMS[19]

Absorption—The process of distributing indirect or overhead costs over any defined cost base such as labor hours, labor dollars, material dollars or total cost dollars, so that, at the end of an accounting period, the indirect costs are totally "absorbed".

Activity—A basic element of work, task or measurable amount of work that must be accomplished in order to complete a project. An activity occurs over a given period of time, utilizes resources and produces a deliverable for the project.

Activity Duration—The length of time, from start to finish, estimated or actual, in working or calendar day time units.

Addenda—Written or graphic instruments issued prior to the date for opening of bids, which interpret, clarify or modify the bidding documents.

Advanced Pricing—Pricing prepared in advance of work performance.

Allocable Cost—A cost that is assignable or chargeable to one or more activities on a project.

Allowance—Additional resources included in an estimate to cover the cost of undefined requirements of work or money prescribed in the bidding documents intended to pay for specifically identified items of work.

Assumption—A supposition on the current situation or a presupposition of the future course of events used in preparing cost estimates.

Audit—The systematic examination of records and documents and the securing of evidence by confirmation, physical inspection or examination.

Authorization—A sanctioning or approval by an individual or a body with the right, authority and power to do so.

Award—Notification to a bidder of the acceptance of its bid.

Award Fee—A contractual provision by which the owner determined the fee paid to the contractor on the basis of performance on the project.

Backcharge—A cost caused by defective or deficient work by the contractor deducted from or used to offset the amount due to the owner.

Ball-Park Estimate—A very rough cost estimate made with some knowledge and confidence that the estimate is within a reasonable range of exactness (or "somewhere in the ball park").

Baseline Cost Estimate (BCE)—An estimate of the cost of the project baseline work scope. The BCE is the first detailed estimate and is normally required for high-level decision making concerning the project.

[19] The definitions herein have been drawn from a draft, unpublished document entitled *Glossary of Cost Management Terms*. This document is in the process of being published by the Association for the Advancement of Cost Engineering, International, Morgantown, West Virginia.

Beneficial Occupancy—Use of a project by the owner for its intended purposes (i.e., functionally complete) although other contract work, nonessential to the function of the occupied section, remains to be completed.

Benefit Cost Analysis—An analytical approach to solving problems of choice. It requires (a) the definition of objectives; (b) identification of alternative ways of achieving each objective; and (c) the identification for each objective or alternative which yields the required level of benefits at the lowest cost. It is often referred to as **Cost Effectiveness Analysis** when the benefits of the alternatives cannot be quantified in terms of dollars.

Benefit-to-Cost Ratio—Benefits divided by costs, where both are discounted to a present value or equivalent uniform annual value.

Best Estimate—Usually, but not necessarily, the most likely value (the value that occurs most frequently in a set of values).

Bid—An offer or a price to perform the work of a contract.

Bidding Documents—The advertisement for bids, instructions for bidders, information available to bidders, bid form with all attachments, and proposed contract documents (including all addenda issued prior to receipt of bids).

Boiler Plate—A popular slang term used to describe the standard language of a set of contract documents (generally including the General Conditions and Requirements, Special Provisions and Instructions to Bidders).

Bottom-Up Models—Uses a method of estimation that estimates each component of the project separately and the results are combined (or rolled up) to produce an estimate of the entire project.

Budget—A planned allocation of resources. The planned cost of needed materials is usually subdivided into quantities required and unit costs. The planned cost of labor is usually divided into the workhours required and the wage rates (plus fringe benefits and taxes).

Budget Authorization—An administrative action by management approving an operating budget for use on the project.

Budget Cost of Work Performed (BCWP)—The sum of the budgets for completed portions of in-process work, plus the appropriate portion of the budget for level of effort and apportioned effort for the relevant time period. BCWP is commonly referred to as **Earned Value**.

Budget Cost of Work Scheduled (BCWS)—The sum of the budgets for work scheduled to be accomplished (including work in process), plus the appropriate portion of the budget for level of effort and apportioned effort for the relevant time period.

Budget Estimate—An estimate offered for budgetary and planning purposes only. It does not constitute a firm commitment that the work can or will be accomplished for this amount.

Budgeting—The process of translating approved or negotiated resource requirements (manpower, equipment and materials) into a funding profile or time-phased financial targets and goals.

Capital Budgeting—A systematic procedure for classifying, evaluating and ranking proposed capital expenditures for the purposes of comparison and selection, combined with the analysis of the financial requirements.

Capital Expenditure—Expenditure made for the acquisition of or addition and betterments to fixed assets.

Cash Flow—The net flow of dollars into or out of a project. The algebraic sum, in any time period, of all cash receipts, expenses and investments.

Ceiling Price—The maximum exposure of a customer in any cost sharing relationship.

Change—Alteration or variation to a scope of work and/or the schedule for completing the work.

Change in Scope—A change in objectives (either in quality or quantity of the specifications and/or material), work plan, or schedule that results in a material difference from the terms of an approved budget.

Change in Sequence—A change in the order of work initially specified or planned by the contractor.

Change Order—A document directing a change in scope.

Claim—A written statement requesting additional time and/or money for acts or omissions during the performance of the work.

Code of Accounts—A systematic numeric method of identifying various categories of costs incurred in the progress of a job. The segregation of engineering, procurement, fabrication, construction and associated project costs into elements for accounting purposes, for example.

Conceptual Schedule—A conceptual schedule is similar to a proposal schedule except that it is usually time scaled and is developed from the preliminary design of the project.

Configuration—The arrangement of the parts or elements of a project.

Configuration Control or Management—The systematic evaluation, coordination, approval or disapproval and implementation of all approved changes in the project after formal establishment of the project configuration.

Consumables—Supplies and materials used up during construction including fuel and lubricants, utilities, welding supplies, worker's supplies, medical supplies, etc.

Contingency—An amount added to an estimate or a budget to allow for changes that experience shows will likely be required.

Contingency Fund—Money set aside to provide for unforeseen expenditures or for anticipated expenditures of an uncertain amount.

Contract Budget—The cost of the contract plus the actual or estimated cost for authorized changes, which have not yet been fully priced.

Contract Change Authorization—A document used by the owner or the CM authorizing changes to the scope of work of the project. This authorization is usually for interim coverage (i.e., authorizes changed work to start) and is eventually replaced with a formal change order.

Contract Change Proposal—A formal price proposal to performed work changed under the contract.

Cost Accounting—The historical reporting of disbursements and costs and expenditures on a project. When used in conjunction with a current working estimate, cost accounting can assist in giving the precise status of the project to date.

Cost Analysis—A historical and/or predictive method of ascertaining for what purposes expenditures on a project were made and utilizing this information to project the cost of a project as well as costs on future projects.

Cost Benefit Analysis—A technique for assessing the range of costs and benefits with a given option, usually to determine feasibility. See **Benefit Cost Analysis**.

Cost Breakdown Structure—A system for subdividing a project into system elements and sub-elements, functions and sub-functions and cost categories, to provide for more effective management and control of the project.

Cost Control—The application of procedures to monitor expenditures and performance against progress of projects; to measure variance from authorized budgets and allow effective action to be taken to achieve minimum costs.

Cost Estimate—A judgement or opinion regarding the cost of a project, commodity or service.

Cost Growth—The net change in an estimated or actual cost amount over a base figure previously established.

Cost Management System—A system which proposes that an estimated planned value can be placed on items of work to be performed and once that work is completed that same planned value can be considered to be earned.

Cost Model—A compilation of cost estimating logic that aggregates cost estimating details into a total cost estimate.

Cost Overrun—The amount by which a contractor exceeds either the estimated contract cost or the final limitation (ceiling) of the contract.

Cost Underrun—The amount by which actual contract cost is less than either the estimated contract cost or the final limitation (ceiling) of the contract.

Cost Variance—A cost overrun or cost underrun. Deviation from the baseline plan as determined by a comparison of the actual costs with the planned costs.

Defective Cost or Pricing Data—Certified cost and pricing data subsequently determined to have been inaccurate, incomplete or not current as of the effective date of the certification.

Design Parameters—Qualitative, quantitative, physical or functional value characteristics that are inputs to the design process.

Design to Cost—A management concept wherein rigorous cost goals are established during project development and the control of systems costs to these goals is achieved by practical tradeoffs between operational capability, performance, cost and schedule.

Detailed Estimating—The logical buildup of estimated hours and materials by use of design documents, or other data whereby each operation is assigned a time value.

Deviation—A departure from established requirements; a nonconformance with contract requirements; a variance from budgeted cost.

Duration—The time planned to accomplish an activity.

Earned Hours—The time in standard hours credited to a workman or group of workmen as a result of their completion of a given task or group of tasks.

Earned Value—The periodic consistent measurement of work performed in terms of budget planned for that work.

Empirical Cost Estimating—The step-by-step creation of a cost estimate based only on the skills, knowledge, intuition and working files of a proficient cost estimator.

Enhancement—A change which increases the value of something.

Equitable Adjustment—A change in the contract price and/or time to compensate the contractor for expense or delay incurred due to the actions or lack of action of the owner or the owner's representative or other occurrences, or to compensate the owner for contract reductions.

Escalation—The provision in actual or estimated costs for an increase in the cost of equipment, material, labor, etc. over that specified in the contract or estimate due to continuing price level changes over time.

Estimate—To evaluate and calculate the approximate quantity, cost or extent of a given item or task. Calculation of the total resources required to perform a task and the cost of such resources.

Estimated Cost—The conversion of estimates into dollars by the application of rates and factors.

Estimated Cost at Completion—The current estimate of what the final cost will be for a specific task consisting of actual costs-to-date plus the estimated cost of the remaining work to be accomplished.

Factored Items—Labor or material estimated by the application of a factor to a labor base of hours or dollars.

Feasibility Study—The study of the applicability or desirability of any management or procedural system from the standpoint of advantages versus disadvantages in any given case.

Field Labor Overhead—The sum of the cost of payroll burden, temporary construction facilities, consumables, field supervision and construction tools and equipment.

Field Order—A written order issued to the contractor which orders minor changes in the work but which does not involve an adjustment in the contract time or price.

Forward Pricing—The prospective pricing of overhead and labor rates in advance of specific contract negotiations.

Fragnet—A portion or fragment of a CPM network usually used to illustrate changes to the whole network schedule.

General Overhead—The fixed cost in the operation of a business. General overhead is most often associated with office, plant, equipment, staffing and expenses thereof, maintained by a contractor for general business operations, which are not specifically applicable to any given job or project.

Historical Cost Data—An estimating term used to describe a set of data reflecting actual costs of past projects.

Home Office Cost—Those necessary costs involved in the conduct of everyday business which can be directly assigned to specific projects or end products, such as engineering, procurement, expediting, legal fees, audit fees, inspection, estimating, taxes, travel, reproduction, communications, etc.

Idle Equipment Cost—The cost of equipment that remains on site ready for use but is placed in a standby basis. Ownership or rental costs (but not operations costs) are still incurred even while the equipment is idle.

Impact Cost—Added expenses due to the indirect results of a changed condition, delay, or changes that are a consequence of the initial event. Examples of such costs include premium time, lost efficiency and extended overhead costs.

Independent Cost Estimate—A cost estimate developed in organizational channels separate and independent from program channels and having the express purpose of serving as an analytical tool to validate or crosscheck program-developed estimates.

Interest Cost—The service charge for the use of money or capital, paid at agreed intervals by the user and commonly expressed as an annual percentage of principal.

Job Cost—The cost arrived at by the method of cost accounting, which collects charges for material, labor and allocated overhead in the production of a specific project.

Labor Burden—Taxes and insurance the employer is required to pay by law, based on labor payroll, or on behalf of or for the benefit of labor.

Labor Factor—The ratio between the workhours actually required to perform a task under project conditions and the workhours required to perform an identical task under standard conditions.

Labor Productivity—The rate of output of a workman or groups of workers per unit of time, usually compared to an established standard or expected rate of output.

Labor Variance —The difference between the standard hours priced at the standard rate and the actual hours priced either at the standard or the actual rate.

Life Cycle—The stages and processes through which a project passes during its development and full operational use, or the useful life of a project.

Life Cycle Cost—The total cost to the owner of the planning, design, construction and operation of a project over its complete life cycle, including disposal (if appropriate).

Life Cycle Cost Estimate—A cost estimate that covers all costs projected for the project's life cycle.

Location Factor—An estimating factor used to convert the cost of an identical project from one location to another. The factor takes into consideration the impact of climatic conditions, local infrastructure, local soil conditions, safety and environmental regulations, taxation and insurance regulations, labor availability and productivity, etc.

Management Control Systems—The systems (e.g., planning, scheduling, budgeting, estimating, work authorization, cost accumulation, performance measurements, etc.) used by owners, designers, construction managers and contractor to plan and control the cost and scheduling of the work of a project.

Management Information System (MIS)—An orderly and disciplined accounting and reporting methodology which provides for the accurate recording of data and timely extrapolation and transmission of management information used in the decision making process.

Management Reserve—A portion of the total allocated budget withheld for management control purposes rather than designated for the accomplishment of a specific task or set of tasks.

Mark-Up—As variously used in construction estimating, includes such percentage applications as general overhead, profit, contingency and other indirect costs. When mark-up is applied to the bottom of a bid sheet for a particular item, system or other construction price, any or all of the above items (or more) may be included, depending upon local practice.

Mitigation of Damages—To take all possible measures to avoid damage and delay and, if not avoidable, to reduce or lessen the extra costs incurred due to the occurrence of an event.

Most Probable Amount—An ambiguous term, which frequently refers to the mean value but sometimes refers to the mode. In a normal curve, the mean, mode and median are all the same so that this ambiguity is no problem. In real life, there is a difference and the reader must ascertain what the author means by "most probable".

Notice of Award—The written notice of acceptance of the bid by the owner to a bidder stating that, upon compliance with the conditions precedent enumerated therein, within the time specified, the owner will sign and deliver the agreement.

Notice to Proceed—A written notice issued by the owner to the contractor authorizing the contractor to proceed with some or all of the work of the project and establishing the date for commencement of the contract time.

Overhead—A cost or expense inherent in performing an operation which cannot be charged to or identified with a part of the work and therefore must be allocated on some arbitrary base believed to be equitable or handled as a business expense independent of the volume of production.

Overhead Rates—Indirect dollars per hour or cost-to-cost relationships that mathematically reflect the distribution of overhead costs over a labor or cost base.

Parametric Cost Estimate—An estimate derived from statistical correlation of historic system costs with performance and/or physical attributes of the system.

Performance Measurement Baseline—The time-phased budget plan against which contract performance is measured. It is formed by the budgets assigned to scheduled work elements plus the applicable indirect budgets.

Phased Construction—As most commonly used today, implies that construction of a facility or a system commences before final design is complete. Phased construction is used in order to achieve beneficial use at an advanced date.

Present Value—The value of a benefit or cost found by discounting future cash flows to the base time.

Present Value Factor—The discount factor used to convert future values to present value.

Pricing, Forward—An estimation of the cost of work prior to actual performance. It is also known as **Prospective Pricing**. Forward pricing is generally used relative to the pricing of proposed change orders.

Pricing, Retrospective—The pricing of work after it has been accomplished.

Probability—A measure or value of how likely a condition or event is to occur. Ranges from 0% to 100% or 0.00 to 1.00.

Out of Scope Change—A contract change that is considered outside of the contractual statement of work and will result in an adjustment to the contract cost and price.

Production Rate—The maximum number of work items produced in a given time period.

Productivity—Relative measure of labor efficiency, either good or bad, when compared to an established base or norm as determined from an area of great experience. Alternatively, productivity is defined as the reciprocal of the labor factor.

Productivity Factor—A factor arrived at by comparing the direct workhours required to accomplish a given task, divided by an established base.

Project Budget—An operating cost amount provided for all elements of a project.

Project Control—The ability to determine project progress and status as it relates to the approved budget and/or schedule.

Punchlist—A list generated by the owner, designer, construction manager or contractor of items of work on the project yet to be completed by the contractor.

Purchase Order—An executed document authorizing a supplier to deliver materials or equipment or perform services, which, upon acceptance, constitutes a purchase contract.

Quotation—An expression of price and the contractual terms under which a contractor would be willing to furnish items, work or services.

Range Estimating—A risk analysis technology which combines Monte Carlo sampling, focusing on a few key variables, and heuristics (or rules of thumb) to rank critical risk elements. The approach is used to establish the range of the total project estimate and define how contingency should be allocated among the critical elements.

Range of Accuracy—The values between the top and the bottom of the range. For example, if the outcomes might be from $100 to $1,000, the range is $900 while the range of accuracy is $100 to $1,000. Usually, the range of accuracy has defined upper and lower limits (such as 10% confidence and 90% confidence; known as 10.90 range of accuracy).

Reserve—Something saved for future use. An amount of funding set aside for savings, contingencies or other purposes.

Residual Value—The scrap value of a piece or equipment or some materials at the end of the economic life of a system.

Resource Histogram—A graphic display of the amount of resource required as a function of time on a graph. Individual, summary, incremental and cumulative resource curve levels can be shown.

Resource Leveling—A process whereby resources are sorted out among tasks and activities to identify and avoid conflicts between scheduling and availability.

Restraint—An externally imposed factor affecting the scheduling of an activity. The external factor may be a resource, such as labor, cost or equipment or, it can be a physical event that must be completed prior to the activity being restrained.

Retention—Usually refers to a percent of the contract value (5 or 10 percent) retained by the owner until work is finished and testing of equipment, etc., is satisfactorily completed.

Return on Investment (ROI)—Usually defined as net income divided by investment amount. There are three ways of expressing ROI. **Return on Assets** equals net income divided by total asset cost and reflects the amount earned from the investment of all financial resources committed including liabilities and owner's equity of funds invested in assets. **Return on Owner's Equity** equals net income divided by funds invested by stockholders and reflects the amount earned on funds invested by shareholders. **Return on Invested Capital** equals net income divided by long term liabilities plus stockholders' equity and focuses on the amount earned from relatively permanent capital investments.

Risk Uncertainty. The potential hazards or problems inherent in any activity. A measurable probability of consequence associated with a set of conditions or actions.

Risk Analysis—The second phase of risk management, which includes the quantification of the effect of all uncertainty (risks) on a project. Usually done by identifying risks and quantifying each risk's probability of occurrence and potential severity of impact (typically expressed as a range of values or probability distribution).

Risk Assessment—The first phase of risk management, which includes the identification of risks, or uncertainties, which may impact a project.

Risk Control—Implementation of the risk management plan. The last phase of risk management.

Risk Management—All of the steps (phases) associated with managing risks—assessment, analysis, mitigation, control.

Risk Mitigation—The third phase of risk management, developing a plan to manage the risks should they arise during the performance of the project.

Rough Order of Magnitude (ROM)—A budgetary or planning figure that is usually a rough preliminary figure with a generally accepted range of +50% to —30%.

Schedule Variance—In cost terms, the difference between the Budget Cost of Work Performed (BCWP) and the Budget Cost of Work Scheduled (BCWS). At any point in time it represents the difference between the dollar value of work actually performed (accomplished) and that scheduled to be accomplished. In scheduling terms, an ahead-of or behind-schedule condition or a deviation from the baseline schedule.

Scope Change—A deviation from the project scope agreed to in the contract. A scope change may consist of an activity either added to or deleted from the original scope. A contractor change order is needed to alter the project scope.

Shop Drawings (or Submittals)—All drawings, diagrams, illustrations, schedules and other data which are specifically prepared by or for the contractor to illustrate some portion of the work and all illustrations, brochures, standard schedules, performance charts, instructions, diagrams and other information prepared by a supplier and submitted by the contractor to the designer or construction manager to demonstrate understanding of and compliance with the provisions of the contract documents.

Should Cost Estimate—An estimate of contract price, which reflects reasonable achievable economy and efficiency**.** It is generally accomplished by performing an in-depth analysis of cost and cost effects. Its purpose is to develop realistic cost objectives.

Solicitation—An official document or notice, seeking prospective contractors to submit bids or proposals.

Specification, Design (Prescriptive)—A design specification providing a detailed written and/or graphic presentation of the required properties of a product, materials or piece of equipment and prescribing the procedure for its fabrication, erection and/or installation.

Specifications, Performance—A statement of required results, verifiable as meeting stipulated criteria and generally free of instruction as to the method of accomplishment.

Standard Adders—Cost elements which are added to every cost, estimated after the initial estimate of costs for material and labor, etc. Standard adders may include general and administrative cost, overhead, profit, etc.

Standard Cost—The normal, expected cost of an operation, process or product including labor, materials, equipment, and overhead charges, computed on the basis of past performance costs, estimates or work measurement.

Status Report—A report reflecting the situation as of a specified date with respect to programs, functions, activities, projects or processes.

Subcontract—Any agreement or arrangement between a contractor and any person (in which the parties do not stand in a relationship of an employer to an employee) and where neither party is the owner.

Substantial Completion—Work (or a specified part thereof) which has progressed to the point where, in the opinion of the designer or construction manager, it is sufficiently complete, in accordance with the contract documents, so that it can be utilized for the purposes for which it is intended.

Sunk Cost—A cost that has already been incurred and which should not be considered in making a new investment decision.

Take-Off—Measuring and listing from drawings the quantities of materials required in order to price their cost of supply and installation in an estimate and to proceed with procurement of materials.

Target Cost—A cost objective value established by negotiation for incentive type contracts, the target cost is used as a basis for agreement on target profit and target price, and serves as the base point for calculating cost sharing incentives or performance awards.

Temporary Construction Cost—Includes costs of erecting, operating and dismantling non-permanent facilities such as field offices, workshops, staging and storage yards, etc., and providing associated services such as utilities.

Time and Material Work—A change order or a contract providing for the purchase of supplies or services on the basis of direct labor hours at specified hourly rates (which include direct labor, overhead and profit) and materials, at cost.

Time-Phased—The spread of resources (such as labor, funds, materials, etc.) tasks or key milestones and activities displayed by appropriate time period.

Unexpended Balance—The amount of budget authority previously granted but still unspent and available for future expenditure. The unexpended balance is equal to the sum of the obligated and unobligated balances.

Useful Life—The period of time over which an investment is considered to meet its original objective.

Value Analysis—A systematic and objective evaluation of the function of a project and its related cost to ensure optimum value. As a pricing tool, value analysis provides insight into the inherent worth of a project.

Value Engineering—A practice function targeted at the design itself, which has as its objective the development of design of a facility or item that will yield least life cycle costs or provide greatest value while satisfying all performance and other criteria established for it.

Variance—In cost control the difference between actual cost and forecast budget cost.

Variation in Estimated Quantity—The difference between the quantity estimated in the bid schedule and the quantity actually required to complete the bid item. Negotiation or adjustment of price for variations is generally called for when an increase or decrease exceeds a specific percentage designated in the contract.

Work Authorization—A company instrument, memorandum or document which authorizes work to be accomplished on a contract, project or program.

Work Breakdown Structure—A management technique for subdividing the total job into its component elements, which can then be displayed (identified) in a manner to show the relationship of these elements to each other and the whole project.

Work Directive Change—A written directive to the contractor, issued on or after the date of the agreement and signed by an authorized individual, ordering an addition, deletion or revision in the work, or responding to differing or unforeseen physical conditions or emergencies under which the work is to be performed as provided in the general conditions. A work change directive may or may not change the contract price or time but is evidence that the parties expect that the change directed by a work change directive will be incorporated in a subsequently issued change order following negotiations by the parties as to its effect, if any, on the contract price or time.

Work Measurement—A technique employed independently, or in conjunction with, cost accounting for the collection of data on labor hours and production of work units, so that the relationship between the work performed and labor hours expended can be calculated. The objective of a work management system is to determine how long it should take an employee to perform assigned work and to identify opportunities for improvement.

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