PT&C'S APPROACH TO TOTAL COST MANAGEMENT

Introduction

PT&C has been providing cost engineering services since 1982 to federal government clients including the State Department, U.S. Army Corps of Engineers, Department of Defense (Army, Navy, Air Force), GSA, DOE and EPA. We have established ourselves as the leader in providing cost engineering services to the federal government and have developed a proven systematic approach.

Successful project life cycle starts with planning and development. If proper cost estimates and schedules are not developed and managed during planning and development, the project is in danger of unnecessary cost and time overruns, resulting in potential change orders and delay claims in the project execution. PT&C believes in developing a defined work breakdown structure, parametric estimates, detailed cost estimates during the design phases, value engineering ideas, design schedule and cost/resource-loaded construction schedule to protect our client's interest in developing a project on time and within budget.

Work Breakdown Structure

The work breakdown structure (WBS) is the key to successful cost management. The WBS is defined as a task or result oriented hierarchy of activities necessary to the attainment of an objective. The hierarchy can be visualized as an inverted tree. There are three (3) necessary components to an effective project baseline: a technical scope of work; a cost estimate; and a schedule. The WBS is the single element common to all. It is the structure around which each of the three components is developed. Because the WBS is hierarchic, it allows the scope, cost estimate and schedule to be viewed at the detail, intermediate and summary level. Each can be "rolled up" to the desired level.

The Scope

The scope is a detailed description of the tasks or results required to meet the objective. It often includes the building's location, overall requirements for space, number and type of tenants, number of floors, structural system, exterior building enclosure system, level of expected finishes, mechanical and electrical systems and any other details necessary to describe the project in full. The scope must delineate the technical, legal and business (operational) limits of the effort and be presented in a manner that allows for the preparation of the cost estimate and schedule. If the scope is not presented in a manner that facilitates the creation of a WBS, it will be necessary to restate it in a manner that will.

The Cost Estimate

The cost estimate is an attempt to "model" the scope in terms of dollars. Generally this effort begins with the quantification of each task or activity at the detail level. Those portions of the scope that identify results must be converted to tasks. The tasks are quantified, then priced. This generally means the cost of labor, material; equipment, services and related costs are calculated for each detail item. Using the WBS, these costs can be rolled up to any desired level. At any appropriate level the costs of overhead, fees, contingency and escalation can be applied. The WBS provides a checklist that all necessary items have been costed.

The Schedule

The network schedule - also called a critical path schedule - presents the identified tasks in the WBS in the most logical order in which they can or must be accomplished. The schedule presents this order against a timeframe called a calendar. The advantage of a network schedule over a bar chart is that the relationship between tasks (e.g. Task 13 must be completed before Task 14 can start) can be developed and maintained at the detail level. The network schedule can be resource-loaded at the detail level and report the project resource requirements by day, week, month, etc. The WBS provides a checklist that all the elements of the scope have been considered in the scheduling process.

Parametric

Parametric estimating is the ability to use historical projects by structuring their detailed line items into smaller groupings or assemblies with a relationship to known variables. Through these variables or parameters, a new estimate can be generated from an old estimate. This gives a greater assurance of accuracy than just assigning a square footage cost to the project.

The purpose of parametric estimating is to provide a detailed estimate that can conform to a standard WBS, such as a building system index. By basing the estimate on historical construction cost data and using a database of material prices, the accuracy of the estimate will increase. This is, however, only a tool and should be used by an estimator whose past experience and judgments remain vital to the preparation of a usable estimate. The computer should provide mathematical computations, sort the data and update the database and data files while the estimator reviews the quantities generated by the computer and applies judgment on their application.

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There are many uses for this type of estimating process. An estimator might use this approach as a quick check on a final estimate to confirm that no major cost items have been neglected. In addition, a parametric estimate can also be used to generate detail for the early budget stages of design when there is no formal design drawn on paper. With the use of multiple construction systems (assemblies), the estimator can perform a value analysis on the different systems to determine the lowest-costing system.

Assemblies make up the most important parameter breakdown for construction. It is within the assemblies that the actual construction tasks are stored. The assembly approach to estimating is critical for assuring the accuracy of the estimate. Assemblies are smaller collections of related items and tasks that have been combined to form a distinct function or task. When arranged into a meaningful building system, assemblies form the building blocks for the program. When organized, they can be used to store and retrieve data in logical functional units. The estimator should generate a comprehensive list of required assemblies. It also should be noted that if such a standard structure of assemblies is not provided when creating the models, they will not be consistent with future additions to the database.

Parametric estimating is more advantageous than the more commonly used quantity takeoff method as it allows the estimator to concentrate more time on reviewing the detail of the estimate. Also, because of the nature of the early stage estimates, the scope and design may change. When the design changes, new drawings are issued and the quantities change. The result is that a completely new takeoff must be performed before an estimate can be produced. Parametric estimating assures that, after an estimate is generated, having a project placed on hold does not waste effort. In addition, it can be prepared during any stage of design development with easy modifications as the scope of the project changes.

It is essential for the estimator to establish general parameters for use in constructing their estimate. Examples include building by gsf, footprint area of building, square feet, heating by total BTU of heating required, and lighting by the number of light fixtures. These parameters are then used to relate historical cost data to the construction project being estimated.
Once the estimates are broken down into a hierarchy of assemblies, they need to be consolidated into a parametric database of models. Before an estimator can generate a parametric estimate, the estimate data models must be created, and if used with computer software, entered in the database. Because the model's basic requirement is based on a quantitative takeoff of past estimated projects, the estimates must be broken down in a manner that allows the estimator to determine if the data is applicable to the current project. Also, by standardizing the process, future projects can be added to the model's database to further increase the selection of project choices.

In general, parametric estimation techniques do not depend on the completed design steps. Instead of disrupting the design process, they enhance it by quickly providing alternate design costs. The fundamental weakness of parametric estimation is that it is only as accurate as the input data provided. The number of unknown parameters also affects the accuracy of the final product. However, this disadvantage is greatly outweighed by costs and time saved in preparing the estimate. Furthermore, as the number of different project models in the parametric database grows, so does the estimator's ability to prepare parametric estimates on other early stage projects.

Cost Estimating

PT&C's Design Phase Cost Control System is based upon the premise that the early establishment of a quantified, accurate and specifically structured project budget, coupled with ongoing interactive budget monitoring and reporting, leads to a cost conscious design team capable of responding to budget constraints without adversely impacting the project.

Order-of-Magnitude/Program Estimate

The purpose of the "Order-of-Magnitude" Estimate is to establish a suitable construction budget for the project and set up a format (construction cost model) that will facilitate cost control throughout the design process. The estimate is typically based upon a Scope Definition Work Session, the Project Program of Requirements and estimator experience, judgment and assumptions.

Scope Definition Work Session is typically a one- or two-day meeting to communicate a clear definition of all known or assumable project scope parameters. This session centers on developing a thorough understanding, in both quantitative and qualitative terms, of the Project Program of Requirements. A primary objective of this meeting is for the group to establish some of the major building system and site parameters upon which the estimate will be prepared.

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From the information gathered at the Scope Definition Work Session and the Project Program of Requirements, PT&C quantifies the project in as much detail as is practicable at this early phase. Unit costs appropriate to the understood quality level and the project location are applied to all quantifiable items and reasonable allowances are made for non-quantifiable items. The estimate includes all direct construction costs, subcontractor and general contractor overheads and fees, contingencies and escalation. The estimate is prepared in a building systems format that will facilitate value engineering and cost control throughout the design process. This procedure typically requires ten working days after the Project Scope Work Session and receipt of any subsequent information.

After initial review of the draft estimate, a meeting is scheduled to jointly review the draft and discuss any questions or comments. The primary purpose of this meeting is to assure that the estimate accurately reflects everyone's understanding of the project scope. After this meeting, PT&C makes any required modifications to the estimate and submits final copies of the Order of Magnitude Estimate. This document, upon approval by the Owner, becomes the project budget and is used as a baseline for cost control as design progresses.

Normally, the Design Phase Project Cost Control System continues to be utilized for estimates at the Conceptual, Schematic, Design Development, Construction Documents and Bid Analysis Stages of a project's development. The later stages of design may also call for Value Engineering or Alternative Design Analysis.

Conceptual Estimate

This cost estimate is used to identify and examine construction cost differentials between various conceptual designs and the Project budget based upon previously developed information, conceptual design drawings, discussions of the design team, and the cost engineers' experience, judgment and assumptions. This estimate refines and further quantifies the program budget to reflect details of each design concept.

Schematic Estimate

The Schematic Estimate assures adherence to the project budget and provides a basis for cost control and value analysis based upon schematic documents, information from preceding submittals, detailed project quantification and application of unit costs.

Alternative Design Analysis/Value Engineering

This step provides the design team with an opportunity to develop alternative design solutions having significant cost impact, thereby assuring a maximum facility at the least cost while still maintaining the required quality level. Value engineering interacts with the design team throughout the entire design process by identifying design alternatives and providing cost analyses and constructability reviews.

Design Development Estimate

Cost engineering at the design development level assures adherence to the project budget and provides a basis for cost control and value analysis during the remaining design phases based upon Design Development documents, preliminary specifications, detailed project quantification and application of unit costs.

Construction Documents Estimate

This estimate assures final adherence to the project budget and provides a basis for analyzing contractor bids and/or negotiating construction contracts based upon construction documents, project quantification (like a typical contractor), and application of unit costs appropriate to the specified materials and methods.

Bid Analysis/Contract Negotiation

This step provides for detailed comparative analysis of the bids/proposals and recommendations for contract award or contract negotiation strategies. The cost estimate is prepared and organized by bid items to increase the speed of comparison and negotiations.

Quality Control

PT&C has multiple cost engineers at each discipline, with top management personnel in charge of scheduling manpower and automation resources, to provide quality assurance and review at all stages of estimate preparation. Our in-house manpower schedule is maintained on computer and updated weekly, with the backlog of contracted work projected over a twelve-month period. Our staff is ready and able to devote full attention - technical staff, support personnel and automation resources - to begin work immediately. PT&C takes pride in interpreting client needs, quickly defining the scope of work required and proceeding after proper authorization. Senior management personnel review all cost engineering work prepared by our staff before submission.

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Value Engineering

Value Engineering is an objective tool for assuring the most cost-effective design of a project. The purpose of a Value Engineering Study is to ensure that a project will achieve its basic required function at the least possible total cost without degrading its quality when considering performance, reliability and maintainability.

Value Engineering is most effective when implemented during the early stages of design. The process differs from other cost-reduction approaches—it is function-oriented. Evaluation is performed considering use value, esteem value, cost value and exchange value. Of course, compliance with project criteria must also be maintained including initial cost, maintainability, aesthetics, proven quality, life cycle cost, energy impact and potential redesign time.

A Value Engineering report discusses the value analysis methodology used to accomplish the study and includes information from team participants as well as economic information, cost analysis, cost model, function analysis and creative idea listing.

The methodology itself is divided into three distinct parts: (1) Preparatory Set-Up; (2) Value Engineering Team Study Procedures; and (3) Post Study Procedures. It embraces an approach that systematically gears the participants towards their understanding of the project's function while simultaneously identifying high cost/low worth areas to be explored for potential development into alternative solutions.

PREPARATORY SET-UP

As with any in-depth study about to commence, it is imperative that all necessary background information related to the project be obtained as far in advance as possible. Compiling project information into cost and graphical functional analysis models relating to design, construction and operational requirements is essential as it forms the basis of comparison for the study. Innumerable data such as funding limitations, criteria, utility costs, operational needs, imposed constraints, climatology, soils analysis, calculations, etc., must be part of this analysis.

VALUE ENGINEERING TEAM STUDY

A Value Engineering Team Study (VETS) is normally accomplished within a 40-hour period using a comprehensive systematic process known as the VE job plan. Several versions of the job plan are described in current VE literature; however, they all adhere to the same basic systematic approach. Regardless, the job plan focuses on high cost/low worth areas in a design leading to the development of alternative solutions for decision-makers' consideration. The VE job plan is divided into five independent phases.

Information Phase *(1)*

The design of any project is the cumulative result of an owner's desires, requirements and corporate decisions coupled with the designer's talent, ingenuity and experience. This "marriage" must be understood and reviewed by the study participants in order to fully comprehend the project's function. It is precisely for this reason an overview of the design and requirements are normally presented by the designer at the commencement of the VETS. Based on this overview, coupled with previously gathered information, a cost model, along with functional analysis worksheets, is developed for each major construction element.

- <u>COST MODEL</u> - A cost model is prepared for the project using an organizational chart layout delineating the major construction elements. This model serves to break out the costs of different construction elements for comparison purposes. It also becomes the first indicator of high cost areas for future potential alternative solutions.

- <u>FUNCTIONAL ANALYSIS</u> - Analysis of the functional requirements of a project is the heart of all VETS and its formulation leads to assurance that the project accomplishes its basic function. This analysis, in terms of as designed costs versus probable worth, is the fundamental principle in a VETS used to reduce the cost of the project without eliminating necessary elements.

  The use of this analysis benefits the study participants by forcing them to think in terms of specific basic functions and their associated costs. Its use further extends the team's gained knowledge of the project design while generating initial concepts which will eventually result in alternative solutions for potential savings.

  In preparing the function analysis worksheets, the team further identifies high cost areas and their respective cost/worth ratios are computed. The larger the ratio of the elements, the higher the potential for savings.

  Thus, the second tool of a VETS to indicate high cost areas is accomplished.

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It is noted that the as designed costs used in the function analysis are derived from the project estimate which has been provided by the designer or owner. The worth of an individual element is an approximation founded in the team participants' experience, knowledge and expertise. Again, the use of this technique reinforces and stimulates each participant to generate alternative solutions to achieve the required basic function at a lesser cost.

Speculative or Creative Phase *(2)*
This phase is the crux of a VETS evolving from the knowledge gained in the information phase and the generation of the cost model and function analysis. It normally employs the use of a brainstorming session geared to the creation and listing of associated ideas for each discipline or system of the project. This method of idea creation is continually prodded by repeatedly answering the question, "what else can provide the basic function", for each discipline, element or system under scrutiny.

Creativity is stimulated by the interjection of an idea that leads, by association, to another and another. Creation of an idea is independent of an individual's expertise. Therefore, the team participants interact with each other sparking mutual interest. An architect's thought regarding a plumbing solution is just as valid as a civil engineer's idea regarding an electrical distribution change.

Judgment of ideas is strictly forbidden to encourage free flow thinking and the generation of a large quantity of ideas. During this phase, no idea is discounted nor routinely rejected, for it may be the seed leading to a solid, viable alternative.

It is noted that the creative idea listing should be scanned and reviewed by the designer and owner for ideas which may not have been developed by the team due to time constraints or misunderstood parameters/criteria.

Analysis or Judgment Phase *(3)*
During this phase of the VETS, the team jointly analyzes and judges all ideas generated during the creative phase. A thorough discussion ensures each ideas' advantages and disadvantages are examined. Ultimately, those ideas deemed to have the greatest potential for savings, or would provide an improvement to the project, are then further developed. Ideas found to be unworthy or not in the best interest of the project are rejected.

Ideas passing the aforementioned scrutiny are ranked on a scale of 10 to 1, with the most desirable ranked at 10. Only those ideas ranked 8 and above are normally developed into viable alternatives. In cases where an idea's cost cannot be sufficiently developed, but would represent an improvement to the project, a Design Suggestion (DS) is written for potential use. This ranking system is used since time constraints preclude the development of all ranked ideas.

Although this phase of the VETS would now be completed, the creative idea listing is continually re-evaluated during the development phase; both from the potential of a late addition to the list and from a better understanding of the particular area of the project as ideas are developed. This may lead to ranking changes, combining/consolidation, or rejection of ideas. It is, therefore, possible that some initially high ranked ideas are not developed into firm alternatives.

Development Phase *(4)*
This phase of the VETS develops each of the ideas passing judgment into a complete and concise alternative. The ideas are described in terms of as designed solutions and alternatives proposed, and take into account all costs attributed to the alternatives including life cycle cost comparisons where necessary. Their advantages and disadvantages are listed and may include a short narrative explaining salient features. Supporting sketches and calculations, where appropriate, are also presented with all required takeoffs and cost worksheets. Alternatives are presented in the same numerical order as in the creative idea listing sheets to facilitate their cross referencing. Ideas developed into viable alternatives are included in the section entitled "Study Results".

Presentation or Recommendation Phase *(5)*
This last phase of a VETS consists of presenting the developed alternatives in both written and oral formats.

Review of the written report by all interested parties forms the basis of the oral presentation during which final decisions are rendered regarding the alternatives to be incorporated into the design or rejected.

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POST STUDY PROCEDURES

Post study procedures include the preparation and compiling of the VETS report incorporating the alternatives developed during the study.

After receipt of the report, the owner and designer review and analyze the alternatives and prepare a short response, either accepting the alternatives (or accepting with modification) into the design or presenting reasons/justification for rejection. Upon completion of all reviews, final implementation decisions are made.

Scheduling

Since 1982, PT&C has provided to project owners, developers, designers and general contracting firms a full range of construction consulting services that include design and construction scheduling, cost engineering, value engineering, construction claims administration and project management services.

PT&C offers the best of both worlds: senior scheduling experts from a contracting background who know building construction projects firsthand; and the resources of computer technology, allowing schedules to be plotted and changed on a daily-weekly-monthly basis, as necessary, to meet project requirements. Our in-house staff of knowledgeable scheduling personnel further enhances our Critical Path Method (CPM) scheduling capabilities.

PT&C offers a full range of schedule management services utilizing computerized CPM scheduling techniques, including the following:

- Pre-Design (Conceptual) Scheduling
- Design Scheduling
- Pre-Construction Scheduling
- Construction Scheduling
  - ✓ Summary/Milestone Schedules
  - ✓ Detailed Construction Schedules
  - ✓ Monthly or Weekly Job Site Scheduling Meetings
  - ✓ Monthly Schedule Progress Reports to Management
  - ✓ As-Built Schedules
- Claims Preparation

Through the combination and modification of these services, PT&C can tailor schedule management programs to meet the specific needs of any client. Our highly trained personnel have prepared and modified CPM schedules on virtually all types of projects for various owner agencies — with excellent results.

Conclusion

Since 1982, PT&C's approach to cost engineering has been systematic and proven with the private sector and local, city, state, federal and international government clients. Early and consistent involvement by a cost engineering team throughout the project's design is the key to successful project delivery. Cost engineering provides immediate savings by reducing project risks in terms of scope increases during design, which in turn increases cost; potential change orders; increased construction time; and potential delay and cost claims during construction.