A REVIEW OF VALUE ENGINEERING AS AN EFFECTIVE SYSTEM FOR PLANNING BUILDING PROJECTS

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INTRODUCTION

Often times owners commit substantial funds and resources to a building project prior to defining the specific need for the project, program requirements and cost management procedures. There is a tendency to oversimplify the technical requirements, complex interrelationships and dependencies among the many elements which are characteristic of nearly every building project. This is risky business. The result could be cost overruns, schedule delays, quality control problems, change orders, disputes, litigation or an end product that does not function as intended. If the project result does not meet the owner's or user's needs, it is of no value regardless of price. Many building projects have been unsuccessful because of the failure to conduct a systematic transdisciplinary inquiry of the project owner's needs.

Building projects integrate the principles of business administration, architecture, engineering and the behavioral sciences. The performance requirements of each of the above disciplines as they affect the building project are interrelated in a complex manner through their physiological, psychological, sociological and economic dependencies. The performance requirements of each of the above disciplines cannot be implemented without consideration of the others. For example, the need for energy conservation may adversely impact acoustical, lighting, thermal, and air quality needs. This presents a serious challenge to the project manager who is responsible for programming and delivering a completed building project that is acceptable in all of the performance areas. Conflicts must be resolved in a timely manner between performance mandates, and priorities must be set based on the functions of the building.

Value engineering is a systematic study of project requirements using a multi-disciplined team to identify and eliminate unnecessary costs and poor performance by using functions. Identification, classification and analysis of functions is used to understand the owner's problem, define the program, and provide a solution to the owner's problem or need. It views the different ways to provide the required functions. Projects are undertaken as a solution to the owner's problem or need. This paper describes the value engineering process, phase by phase, its team and time requirements in order to help project managers determine cost effective ways to meet owner requirements.

The primary responsibility of the project manager is to make sure the end product meets the owner's requirements. A thorough and specific written description of the owner's requirements must be established during the planning and pre-design phase of the project and prior to selection of a project site. Value analysis or value engineering (terms which are used interchangeably in the industry) is an effective technique for gathering the project owner's requirements and identifying and reducing unnecessary costs. The late Lawrence D. Miles of General Electric Company is credited with developing the system in the World War II era. His company used the system to find substitute materials or alternatives for other resources which were not readily available because of the war. The use of value engineering spread to the construction industry and other industries as a programming and cost management tool. Project managers in construction and other industries use value engineering to determine how to meet the project requirements for the lowest life cycle cost without sacrificing quality.

Analysis of functions is the foundation of value engineering. A function is a required performance action, described by a two-word verb-noun abridgement without identifying a specific method of performing the action. An example of a typical function might be "furnish space." Conversely, "paint wall" is not necessarily a good function description because it specifically describes a methods to perform the action. The function descriptions should be measurable and quantifiable. Specifically, in a building project, the project owner, with assistance from the value engineering team, identifies and classifies the functions to be served by the proposal building or components of the building.

The owner's objectives are clarified by separating project functions into needed and wanted functions. It is important to distinguish between needs and wants as few owners have adequate funds to achieve all of their goals. The owner often wants more than he can afford; so the owner and the project manager must be able to agree on a project strategy that can be accomplished with available funds. This can be done effectively by having the project owner participate in a value engineering study for his or her particular project. A report based on this study is submitted to the owner for review and implementation of cost saving recommendations. It identifies areas where project criteria changes may be desirable to maximize savings in structures, equipments, materials and methods of design and construction.

Value engineering provides an effective environment for the project team to cooperate, communicate and resist making premature decisions that can result in unnecessary costs and a less than optimal solution to the problem. It provides an organized and expedient system for extracting information from owners and users to make effective project decisions. An optimum solution will result if the project provides the required functions at a price the owner is able and willing to pay.

Value engineering can be used to select building materials, equipment and systems. Initially the value study team identifies areas for study which represent the highest potential for project savings. The team examines the architectural, structural, mechanical, electrical and other systems for the purpose of identifying and questioning constraints to achieve the required functions at the lowest cost consistent with desired performance actions. The value study team concentrates on the use of alternative materials, building methods and systems to accomplish required functions. Value engineering studies are undertaken to establish project criteria, space requirements and construction project estimates during the planning and programming phase of the project.

VALUE ENGINEERING JOB PLAN

The value engineering team follows a formal and logical plan to carry out a value study from inception to completion. The value engineering job plan divides the value study into different phases that are normally followed in sequence. (However, in actual practice a team may return to a previously completed phase to make revisions prior to making binding decisions). The job plan is often divided into five phases: Information, Creativity, Evaluation, Development and Presentation and Implementation.

Phase 1: Information

The problem is defined in this phase. All of the available information concerning the owner's problem or purpose is assembled. Either one of the following approaches can be used for analyzing functions for any given problem:

A. Define the required functions of the problem, and then list the components that are associated with each function.

B. List the parts or components that make up the project and then develop the functions.

Table 1. Information Phase Function/Component Analysis

Project: Install Equipment

COMPONENT	COST	FUNCTION		
Foundation		Support Weight		
Electrical Panel		Distribute Power	Protect Personnel	Protect Equipment
Equipment Room		Furnish Space	Shelter Equipment	
Air Conditioning Unit		Control Environment	Condition Air	

During the information phase the project is defined and the functions are identified, classified and listed. The areas representing the greatest value opportunities are selected for value study. (See Table 1.)

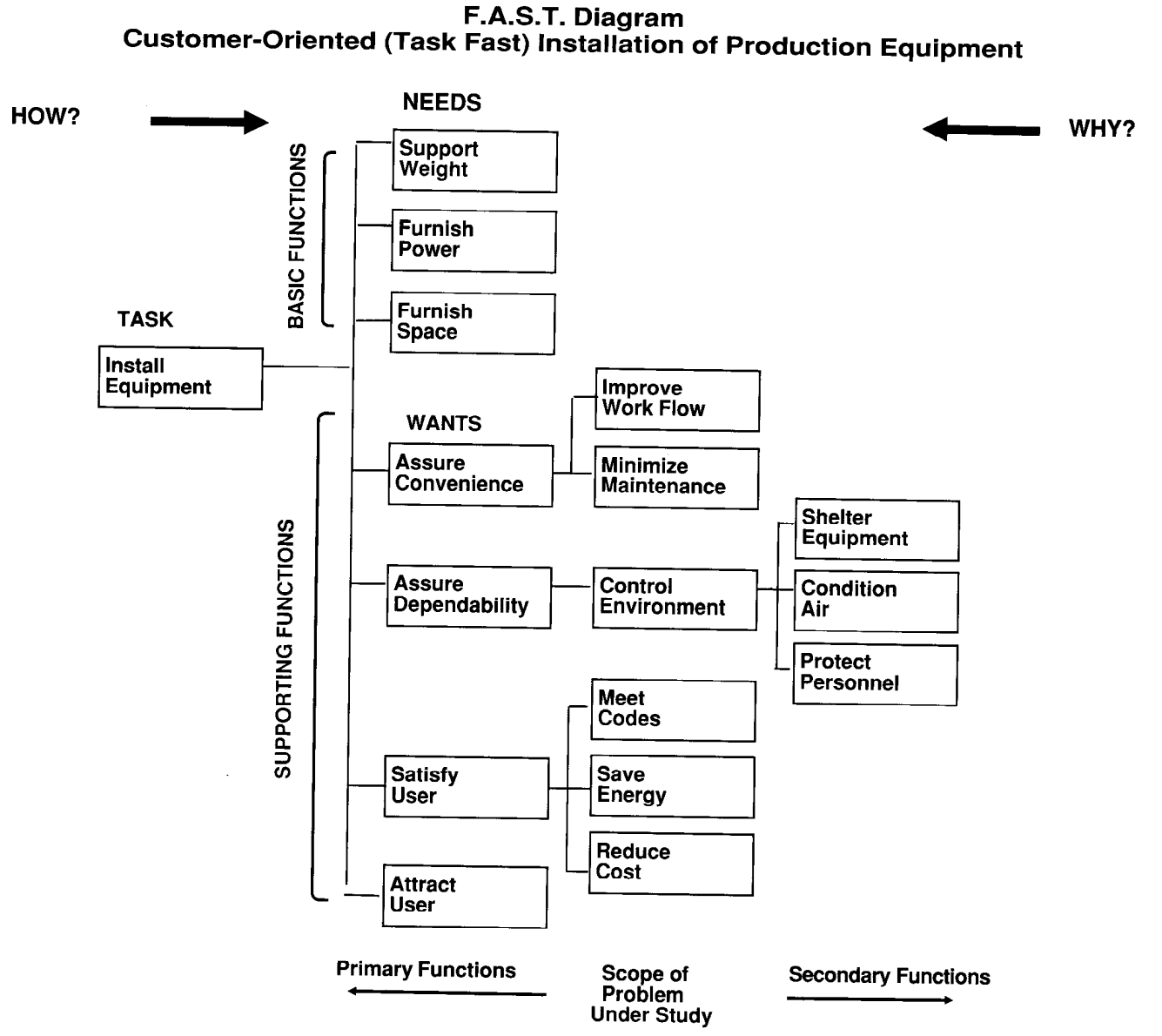
During the information phase, the value engineering team asks questions for each verb and noun consideration. For example:

- What is the purpose of the function or component under consideration?
- What does it cost?
- What does it do?
- What must it do?

Some important data that should be gathered in the information phase - includes:

- Design specifications and graphic data such as flow diagrams and schematics
- Pertinent guides/codes/standards and technical manuals
- Cost figures
- Special information, historical data, schedules and pertinent owner or user requirements
- Persons to be consulted

A F.A.S.T. (Function Analysis System Technique) diagram, sometimes called a Function-Logic diagram, is prepared graphically to show the functions of the project and their relationship to each other. There are two types of F.A.S.T. diagrams—Technical and Task—which are used during the information phase. The value engineering team selects the diagraming method which is appropriate for the specific project. Figure 1 shows a Task F.A.S.T. diagram which graphically provides a means for the owner to distinguish required functions (needs) from desired functions (wants). A Task F.A.S.T. diagram, also known as a "Customer-Oriented" diagram, is used when the function analysis is performed specifically for a customer who is paying for the value study. When all the functions are laid out and classified, it becomes easier for the owner and the value engineering team to evaluate proposed solutions to the problem. A Task F.A.S.T. diagram is useful in the analysis of



The task is the need of the owner or user. It is the reason the owner or user funds the project. To perform the task to "install equipment" it becomes necessary to perform the basic functions: "support weight," "furnish power," and "furnish space. " The standard supporting functions are "assure convenience, " "assure dependability," "satisfy user" and "attract user." The primary functions are the basic and supporting functions placed in a column to the immediate right of the task within the scope of the project. The secondary functions relate to or modify the primary functions.

Figure 1. Function Analysis System Technique Diagram

an overall project because the analysis is not limited to one basic function.

Figure 2 shows a Technical F.A.S.T. diagram which identifies the higher order function, one basic function, critical path functions (not to be confused with critical path activities on a network schedule) and support functions. The basic function is the highest level function within the scope of the project which is included in the critical path functions. Critical path functions are those functions which are absolutely necessary in order to achieve what the owner

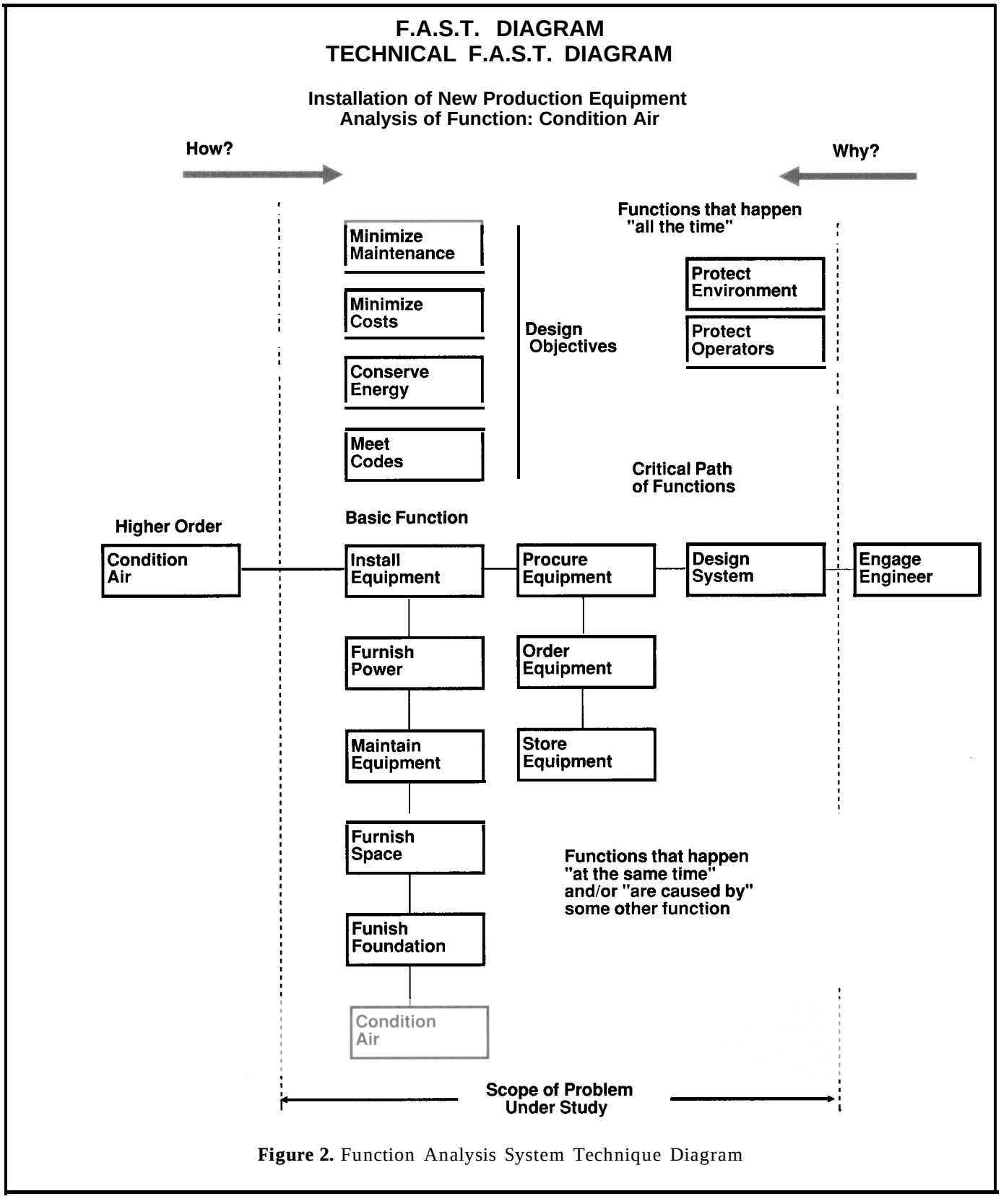


Figure 2. Function Analysis System Technique Diagram

wants. The critical path functions sequentially describe how or why another function is performed. The critical path is limited by scope lines on both sides. To identify the critical path function to the right of a given function on the F.A.S.T. diagram, ask how the function is performed. To identify the critical path function to the left of a given function on the F.A.S.T. diagram, ask why the function is performed. The higher order

function is the one that satisfies the needs of the owner or user. It is just outside the scope of the problem or project. Supporting functions assist the critical path functions in performing their job. Technical F.A.S.T. diagrams are often used in the analysis of smaller, finite functions that represent a portion of an overall project.

After the functions are identified and classified on the F.A.S.T. diagram, costs are estimated and assigned to each of the functions. Since the areas to be estimated are not typically well defined during the information phase of project development, the value engineer must rely on conceptual estimating techniques that are applicable when there is a limited amount of information regarding the project scope of work. Instead of taking off detailed quantities on a unit cost basis, estimates are prepared on a square foot basis, because detailed drawings and specifications are not available. The value study team analyzes those functions and components that represent the highest cost, parts or functions of the facility problem to be studied. Pareto's Law of Distribution states that in any area a small number of elements will represent the major costs. Value is defined as the lowest cost to perform a function reliably. During function analysis a value engineer looks for value mismatches so that they can be eliminated or reduced.

Value mismatches occur where a project provides high cost components or functions with low acceptance by the owner.

Phase 2: Creativity

The creativity phase starts after the problem to be solved has been defined and the project functions have been identified and classified in the information phase. During the creativity phase, techniques are used to generate alternative solutions to perform the functions that were listed and assigned costs during the information phase.

Just as there are many different ways to solve a problem, such as construct a facility, there are many solutions to one function. The value specialists use brainstorming and other creativity techniques to develop new ideas that will satisfy function requirements.

The most important rule in the creativity phase is to avoid generating alternative solutions until the problem is thoroughly understood—do not attempt to solve problems until the information phase is completed.

Value engineers use the three-step process of mind tuning:

Step one- Determine what the project and components should accomplish. For example, consider installation of a new process in a manufacturing facility: (1) save energy; (2) reduce costs; (3) save time; (4) minimize maintenance.

Step two-Determine what the owner is trying to do for the customer: (1) speed delivery; (2) improve quality; (3) reduce cost.

Step three- Develop a concise statement answering what precisely must be achieved.

Consider asking these types of questions to improve creativity:

- Can the function or component be eliminated, modified, combined or minimized?
- Are aesthetic features justified?
- Can modified specifications reduce cost?
- Can simplified design and construction methods reduce costs?
- Will operation and/or maintenance costs be reduced by design changes?

It is important to break the problem down into manageable segments, discuss the problem to be solved with others, and suspend judgment until the evaluation phase. There is no such thing as a stupid solution during the creativity phase-all criticism of solution is reserved for the evaluation phase.

Phase 3: Evaluation

In this phase the impractical solutions to perform the functions are deleted, including those that solve some functions, but cause problems for others. High-cost components that can be traced to functions considered by the owner to be of low value (value mismatches) are eliminated or reduced. The remaining ideas are put on a feasibility matrix and ranked according to criteria developed by the value study team. The objective of the evaluation phase is to determine the best possible solution to the problem. The alternative solutions which were generated during the creativity phase are thoroughly reviewed and evaluated to assure that the highest value and significant savings are realized. (See Figure 3.)

Evaluate by comparison the advantages and disadvantages of each alternative. Some factors to be considered when comparing the advantages and disadvantages of alternative solutions in the evaluation phase of a building project might include:

- Construction time
- Construction cost
- Maintenance and operation cost
- Constructability
- Appearance
- Versatility

It is the responsibility of the project manager or value specialist to test each alternative solution against the owner's criteria for required function, performance, cost and maintenance and to select solutions which most effectively and economically meet the standards. Refine alternatives, keeping the good candidates for further development during the development and presentation phase. Normally the alternatives with the greatest cost reduction potential are selected.

Phase 4: Development and Presentation

The objective of this phase is to re-analyze the best alternatives selected during the evaluation stage. Develop the alternatives in detail and prepare a presentation to the owner or the owner's management.

During this phase, specific recommendations are made to the owner. Select one alternative as the best value for implementation. Two other alternatives should be developed as options, if the first choice is rejected by the approval authorities.

The following procedures should be followed for the development phase:

A. Research the alternatives in sufficient depth to enable the development of

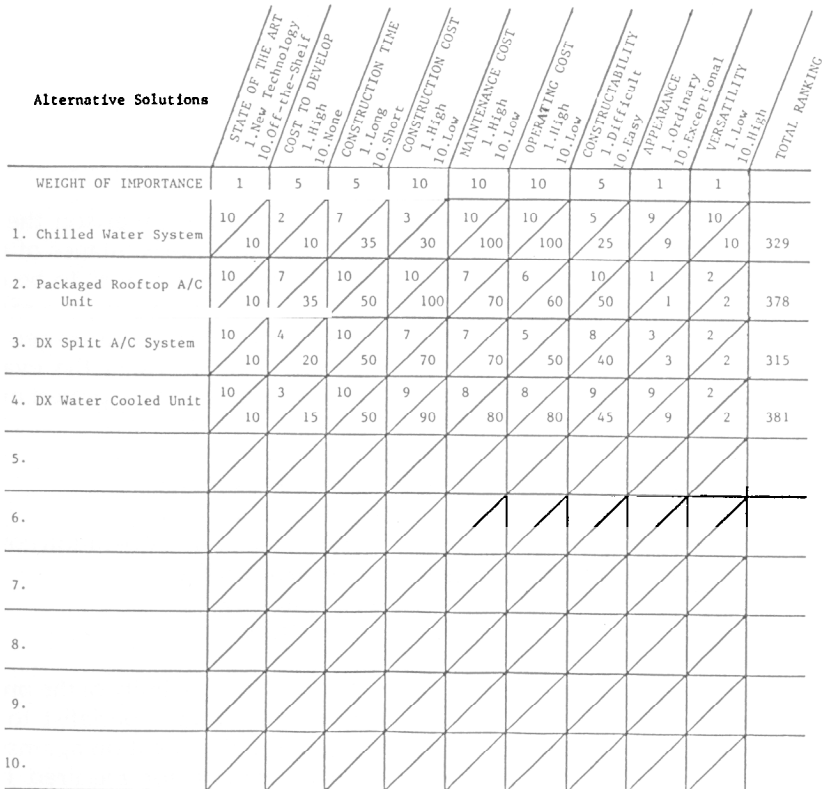


Figure 3. Evaluation Phase Feasibility Ranking

Project: Install Equipment
Function: Condition Air

Notes:
1. Each factor is assigned a weight of importance from 1(least Important) to 10 (most important).
2. Each alternative solution is assigned a value from 1 to 10 for each factor relative to the other alternative solutions.
3. The weighted values are summed across all factors to arrive at a total ranking for each alternative solution.

For example, chilled water – construction cost – alternative solution value of 3 – weighting factor of 10 – product of 30 points – etc.

a specific recommendation for implementation. Some considerations are:

- Ensure that user's needs are satisfied by the alternatives
- Determine technical adequacy
- Develop definitive costs and schedules for implementation of the alternatives.

B. Consult with specialists to verify feasibility of the alternatives and improve on ideas.

C. Sketch the proposed alternatives.

D. Detail all results and anticipate problems relative to implementation.

E. Prepare a written report which covers study results and recommendations:

- Identify the project
- Summarize the problem
- Before and after descriptions (include sketches)
- Cost of original design
- Cost estimate of alternatives
- Technical data to support alternatives
- Quantity requirements
- Cost of implementing changes
- Summary of potential savings
- List of actions necessary for implementation
- Acknowledgment of contributions
- Suggested implementation schedule
- List advantages and disadvantages
- Explain implementation problems

Here is a development and presentation phase checklist developed by Macedo, Dobrow and O'Rourke [1]:

A. Does each alternative meet performance requirements?

B. Are quality requirements met by each alternative?

C. Are reliability, maintainability and operational requirements met by each alternative?

D. Does each alternative prevent waste of labor, material or time?

E. Is each alternative compatible with the overall design?

F. Are safety requirements met by each alternative?

G. Have accurate cost estimates been developed for alternatives and the original design?

H. Does each alternative improve construction methods, operation or maintenance?

I. Has someone double-checked the quantities and costs used in the calculations?

J. Has all support data been documented?

K. Are the estimated savings correct?

L. Has the proposal been reviewed to make sure diminishing returns have not significantly reduced the potential savings?

Phase 5: Implementation

This is the final step in the value engineering study. In this phase the value engineer makes sure that the ideas developed and accepted during the value study are implemented. The value engineer prepares an implementation plan and then instructs the people responsible for carrying out the recommendations. The implementation plan is a list of procedures and milestones to be accomplished during the course of implementing the recommendations of the value study. It can be used by project managers as a control system

to verify that the recommendations are followed as specified in a timely manner.

People are more inclined to follow recommendations when they have a clear action plan to follow.

VALUE STUDY TEAM

A value engineering team follows the different phases of the job plan from conception to completion of the value study—information, creativity, evaluation, development and presentation, and implementation phases.

For best results a value engineering team generally consists of four to six people with expertise indifferent disciplines. Often an involvement of less than four persons will limit the amount of input into the study; whereas a very large team over six people may cause confusion and may become too cumbersome. The Society of American Value Engineers (S.A.V.E.), based in Northbrook, Illinois, has accreditation programs to certify individuals who have demonstrated their ability to organize and lead value studies within the guidelines established by S.A.V.E.

Certified value specialists, while professionals, are not mandatory for the process to function properly. However, the value study leader should be knowledgeable in function analysis techniques and F.A.S.T. diagraming, and should follow the value engineering job plan step-by-step.

For example, consider the construction of a building addition to accommodate a new or expanded manufacturing process. The specialist does not necessarily have to know all details of the project; but should have a general understanding of facility design, construction, operation and maintenance principles. The value study team should be multidisciplined—probably consisting of members representing the owner and user of the facility, construction manager, specialty contractors, designers and engineers, maintenance and operating personnel.

VALUE STUDY TIME REQUIREMENTS

The Society of American Value Engineers suggests a dedication of 40 hours for the value engineering team to proceed through the different phases of the job plan. However, it may not be necessary for all the members to participate for the entire 40 hours.

A value engineering study can be performed during any phase of the project life cycle. However, the greatest return on the value engineering investment can be expected when the value study is initiated during the planning and programming phase of a project, where the ability to impact costs is greatest, since the process determines scope rather than details of the project.

The greatest opportunity to impact life cycle costs of a project occurs during the programming and conceptual design stages. Therefore, it is extremely important to allocate sufficient time and money for the planning and programming of projects. The project manager should advise the building project owner to include funds for a formal value study during the initial phases of the project. (See Figure 4.)

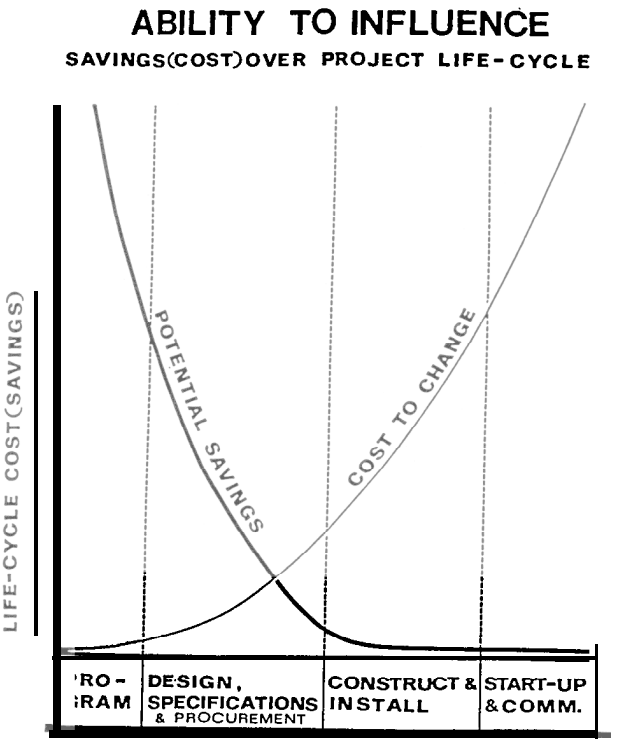


Figure 4. Ability to Influence

The ability to impact project costs diminishes with time-from 100 percent during the pre-design, planning and programming phase to perhaps 5 percent at the start of construction or installation. Ironically, the planning and early design phase has the greatest impact on total project cost, yet generally represents a very small percent of the total project cost.

Application of value engineering is not limited to building construction. The technique can easily be applied to manufacturing and service industries, production processes, building operation and maintenance and even administrative and service functions. To illustrate: those persons responsible for building operations and maintenance should employ value engineering techniques as a tool for utility reduction/cost savings; and for development of building performance standards. Existing facilities may become obsolete with time and may have outlived functional usefulness. Project managers in the building industry should provide value studies on the major building systems to insure that projects are designed and constructed and operated in the most economical way, taking into consideration life cycle costs.

SUMMARY

Value engineering is a function-oriented mulitdisciplinary team approach for planning projects and eliminating unnecessary costs without sacrificing total performance and quality.

The value engineering approach provides a vehicle for helping to reduce or eliminate unnecessary project costs that are frequently caused by the following problems:

- Poor definition of the problem
- Failure to generate alternative solutions to the problem

- Poor communications
- Lack of information
- Shortage of time
- Lack of motivation
- Poorly defined owner's or user's requirements

The objectives of the value engineering study are:

- To make sure that the owner's project requirements are defined and met in a cost effective manner.
- To provide savings of at least 15 to 20 percent on the project cost by eliminating unnecessary costs.

Value engineering is a powerful project planning, programming and estimating tool to meet owner's needs and wants. It provides an effective method of defining the problem to be solved and a system for achieving the best value for meeting owner requirements through the use of function analysis. The completed value study identifies the owner's project requirements and establishes the costs to meet them. The University of Wisconsin-Madison and several other universities offer programs in value engineering for people who are interested in learning the system. The project manager and owner can be comfortable that designers and other people responsible for implementing the project plan are starting out with the right information when a value engineering study is completed during the planning phase of a project.

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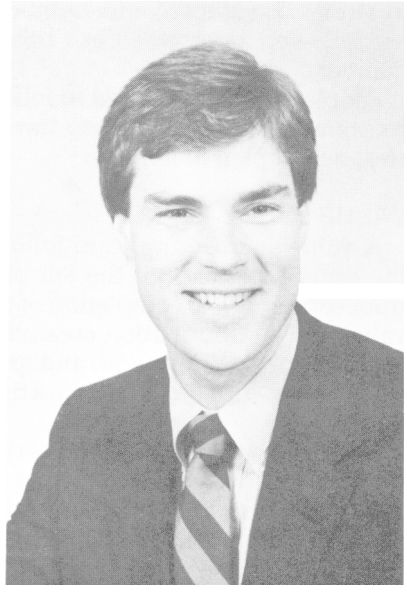

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