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VALUE ENGINEERING

29 March 1963

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
(INSTALLATIONS AND LOGISTICS)
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Experience has demonstrated the effectiveness of Value Engineering in reducing cost without compromising the quality and reliability of defense hardware. This Handbook has been developed to aid Government activities and contractors in expanding and accelerating their Value Engineering programs to achieve meaningful cost reductions.

Value Engineering can be expected to realize its full potential only when it is related to management objectives. Accordingly, this Handbook is addressed to managers as well as to value engineers. It will have served its purpose if it energizes action by management to capitalize on Value Engineering concepts and techniques and at the same time provides guidance to specialists in applying Value Engineering procedures.

Value Engineering is maturing rapidly in terms of both perspective and methodology. This Handbook, an initial effort, will therefore be revised from time to time to incorporate new concepts and developments.

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PREFACE

The Departn of Defense is placing increased emphasis on the need for major cost reduction efforts by all who play a part in the Nation's defense effort. One of the important techniques designed to achieve such results is value engineering.

The existence of a well-managed, effective V.E. program is vitally important to contractor and Government alike. Suitable rewards are provided for those who achieve significant results. For defense contractors, the reward for effective value engineering efforts is increased profit on existing business and an improved competitive position in obtaining new business. For DOD industrial and procurement activities, the reward for effective value engineering efforts is an increased contribution toward cost reduction goals and an opportunity to demonstrate increased efficiency.

Suggestions for improvement of this handbook should be addressed to the Office of the Assistant Secretary of Defense (Installations and Logistics), Washington 25, D.C.

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Chapter I

VALUE ENGINEERING DEFINED

Introduction

No one can deny the need for more cost consciousness in the design, development, production and maintenance of national defense equipment. This need has been recognized for many years. However, the ever-increasing pace of technological advances has focused more direct attention on the problem. Value engineering has emerged in response to the recognition of the problem by the industrial complex. Department of Defense interest in value engineering results from an awareness of its potential contribution toward this needed cost effectiveness in the acquisition of defense materials.

In the broadest sense, the economics of national security relate to (1) the total resources available to the nation, and (2) the proportion of those resources allocated for national security purposes. Specific contributions to the first of these is somewhat outside the realm of value engineering. However, it can have a significant bearing upon the second—the proportion of our total resources allocated to defense. Value engineering, from the economic standpoint, contributes to the efficiency with which allocated resources are used. Value engineering can help make it possible to obtain maximum defense for a given amount of available resources. Conversely, it can help make it possible to achieve a required level of defense using a smaller portion of the nation's resources. Either way, its contribution can be real—and it is needed.

Value engineering must be carefully defined and clearly understood if it is to achieve its potential as a significant contributor to a more economic climate in defense procurement. This requires first an understanding of what constitutes value in defense products, followed by a clear exposition of what value engineering is and is not and how value engineering affects product value. This chapter is devoted to a discussion of these fundamental concepts.

Value

The value of a canteen of water to a thirsty man varies with the man's distance from a source of supply. The value of a ship's compass to its navigator is vastly different from its value to a housewife. The obvious logic of these statements illustrates that value is a variable.

Value, although it is a broad term, has been categorized so that it can be defined meaningfully. Four such categories are:

USE VALUE: Based on the properties and qualities of a product or material which accomplish a use, work or service.

COST VALUE: Based on the cost of a product, almost always expressed in money.

ESTEEM VALUE: Based on the properties, features or attractiveness involved in pride of ownership of the product.

EXCHANGE VALUE: Based on the properties or qualities which make the product exchangeable for something else.

The sum or total real value of a product probably embodies all of the preceding factors and more. For the vast majority of defense hardware, however, use value and cost value are virtually the only factors of significance. Fortunately, these two elements can be stated in fairly rigorous, precise terms. Use value can be stated in terms of operating requirements or functional characteristics; cost value, in terms of dollars. Since they are generally precise and measurable, they can be dealt with on a relatively objective basis.

It is important to note that even though cost and use value can be stated precisely, value is always relative, not absolute. Thus, high value in the defense environment is a function of both use and cost values and the relation between them. For example, an item with only an average use value and a below-average cost may have higher value than one which is above average in use value but is obtainable only at a very high cost. Analysis of such relationships is important in weapons system cost effectiveness studies, and resultant decisions leading to selection of a specific system, definition of its performance requirements and selection of specific contractors.

Once such a series of decisions is made, the use value of the system, in effect, is defined. Anything less than such established use value is unacceptable, more can be unnecessary and wasteful. For the Department of Defense, then use value becomes a constant. (In some cases, use value may be expressed as a limited range instead of a single parameter.) To achieve high value, emphasis is placed on defining precise use value (neither higher nor lower than required) and obtaining this use value at minimum cost. In other words, a high value defense product is one which provides exactly the required use (or performance) at the lowest possible cost.

Value Engineering

One very promising technique for obtaining high value products is through the process called "Value Engineering." For purposes of this Handbook, Value Engineering is defined as follows:

> **Value engineering is an organized effort directed at analyzing the function of defense hardware with the purpose of achieving the required function at the lowest overall cost.**

Although this definition varies from other definitions, it is one with which everyone connected with V.E. could agree at least in part.

There follows a further explanation of this definition to assure that all concerned with V.E. understand it.

A. *Defense Hardware*

Some practitioners of value engineering limit its application to hardware; others extend it to cover any and all cost reduction activities. For example, cases involving rearrangement of a cafeteria, reorganization of a telephone book, control of overtime and paperwork procedural analysis have been cited as examples of good V.E. practice. In a strict sense, it can be shown that such actions contain the major elements of V.E. because all were attempts to find lower cost methods of achieving a required function. Within the defense/industry complex, V.E. should be considered as being applicable only to defense hardware because: (1) value engineering's greatest immediate and long-term potential lies in hardware improvement: (2) other techniques exist, such as work measurement, data processing, procedure analysis, etc., which do not require as great a use of technical or engineering skills; and (3) only limited resources are available to do V.E.

B. *Required Function*

As used here, function is synonymous with performance (or with use value, as previously discussed). Required means that neither more nor less than what is actually needed and wanted is provided.

C. *Value Engineering Is an Organized Effort*

By organized effort is meant a methodology or set of procedures which draw together and utilize any and all techniques necessary to achieve the desired goal. It is not meant to imply that V.E. itself is a science or technology in the sense that physics and chemistry are considered such, but rather that it is a logical, organized method of applying these other technologies to the solution of the value problem.

The methodology of value engineering is treated in detail in the next chapter. As will be shown, the methodology, no matter where applied, contains the following seven elements: product selection, determination of function, information gathering, development of alternatives, cost analysis of alternatives, testing and verification of alternatives and proposal submission and follow-up.

The drawing together and utilization of the techniques necessary to achieve the desired goal also requires a formal, explicit organized effort to bring to bear on each specific value engineering task the required engineering, scientific and managerial abilities.

What Value Engineering Is Not

Thus far in this chapter value has been discussed and V.E. defined. However, this is not enough to reach a clear understanding of V.E. It is also necessary to spell out what V.E. is not.

Among the more serious misconceptions are five which merit consideration and clarification. Each of these are listed and discussed in turn below.

A. *"V.E. is nothing more than good old-fashioned cost cutting."*

To say this is to unduly simplify value engineering and, in fact, invite a connotation which fails to include crucially important elements of the process. In the minds of many individuals, cost-cutting means attacking things as they are to reduce their cost. Value engineering, on the other hand, is a more fundamental approach which takes nothing for granted and attacks everything about a product including the existence of the item itself, subject only to the restriction that the required function or performance must not be changed. The following example may make the distinction clear.

The cover for an electronic circuit is too expensive because it was designed in a hurry with the result that it was made largely by hand. Traditional cost-cutting would improve the design and look for better materials and processes to build it. Value engineering, by contrast, would first define the function of the cover—then look for alternative ways of [illegible] function. Perhaps the cover is supposedly necessary to prevent personnel from being shocked, but actually there are no dangerous voltages in the circuit. Thus, use of the V.E. approach eliminates the cover—does not redesign it. The basic function—safety—was met in the circuit design itself, thus the cover is superfluous. Value engineering leads to cost reduction—but is not what many people today mean by cost-cutting.

B. "*V.E. involves trade-offs, especially between cost and performance.*"

Trade-offs by definition and usage involve interrelated changes. Thus, reliability is reduced to bring cost down; missile-range capability is increased so cost goes up; delivery is expedited and cost goes up; etc.

By contrast, V.E. makes required function or performance a constant rather than a variable. In V.E. required function may not be reduced as a means of reducing cost. To say that V.E. involves trade-offs, then, is to deny the basic principle of value engineering—providing required function at lowest cost.

The required performance of components of certain product/systems may be derived from the performance of other components in the system. In this restricted context, value engineering may involve trade-offs to allow for use of standardized parts in the system, or to reduce the cost of integrating components into a system. But the required performance of the product/system itself would not be changed.

C. "*Value engineering is nothing more than good design engineering (or production engineering, or work simplification or operation analysis, etc.).*"

Value engineering can and does draw on all available techniques to help in defining function, developing alternatives and proving them. However, it does not follow that design techniques, when used in a V.E. study, are value engineering. The distinctive features are the objective, the method of approach and the criteria employed. Value engineering may in some instances require one set of disciplines and, in others, entirely different ones. To say that V.E. is any o[illegible]f these is an unjustified simplification.

D. "*Value engineering can and should be ap- plied before and during initial design efforts.*"

Value engineering, like original design efforts, looks for ways and means to satisfy functional requirements. In addition, value engineering considers the costs of providing function but, in the traditional sense, so does design engineering. Applying cost considerations before and during the initial design effort is actually good, cost-conscious, efficient design engineering practice. If such were the general rule, the need for a later look at the cost elements of a design would not be as great. Certainly efficient, cost-conscious design engineering which leads to the last word in product value is a desirable goal and if calling such an effort V.E. will help, so much the better. However, regardless of what it is called, it is a long way from being achieved. This is due to a variety of causes which include the intense pressures for performance, reliability and early delivery. There is also difficulty in achieving optimum value in the face of rapid technological change because of the lack of cost data, knowledge of product volume requirements at the time of conceptual design and the rapid rate of engineering change generation throughout the design cycle. Value engineering, as presented in this Handbook, is a technique which has evolved to assist in overcoming the admittedly high cost of achieving function in the face of these recognized obstacles.

Value engineering, then, especially in the defense effort, is considered to be something above and beyond the present status of original design practice. It is an adjunct to it—a method for giving cost and value consideration to products after the primary goal of designing a workable product as quickly as possible has been met.

This may seem to suggest that V.E. is not applicable during the design stage of an item. Such is not the case, however, and the problem is probably one of semantics, involving the meaning of the word design. In the broad sense, design means that period of effort between the establishment of initial concepts and the start of production. In the narrow, more precise and traditional sense, design means the initial creative process which translates concepts into sketches, drawings or blueprints and which is only the first step of the total process leading to production of an item. As a formalized function, V.E. is not directed to the initial creative process: it is directed at all that follows. It is in this sense that V.E. is said to be applicable to the design of a product.

E. "*Value engineering, when applied in the purchasing area, is different from V.E. applied in design or production.*"

This misconception has many variations, all on the central theme that V.E. varies with area of application. Actually, the basic elements of value engineering are the same, wherever applied.

Some practitioners seem to imply that value engineering (or value analysis) in purchasing consists of such actions as finding and developing alternate sources of supply, seeking out specialty vendors, using competitive bids to lower the cost of purchases, etc. These are all aspects of good purchasing practice - not value engineering. V.E. can be applied in purchasing, either directly by applying V.E. to purchased products or indirectly by requiring that vendors do the V.E. job. In addition, purchasing can supply help to the V.E. effort of other groups by suggesting alternatives and supplying price data, for example. Wherever applied, however, V.E. must not be confused with other necessary functions in product design, development, testing, production and purchasing.

Summary

Within the defense/industry complex, product value is determined by the interrelationship of function and cost. High value products are those that provide required use, at the lowest possible cost. Value engineering is a technique for achieving high value products. It is an organized effort directed to this end.

Value engineering is not just simple cost-cutting, does not lead to performance trade-offs, is not other types of engineering disciplines, is not applied during initial design efforts and is the same wherever applied.

In short, value engineering is a reappraisal of a product design both from a function and cost standpoint, done in order to assure maximum value using more recent knowledge of economic environment and requirements and with a basic objective different from that of the original design engineer. Where the design group is fundamentally concerned with the difficulties of achieving required function by some means or other, the value engineering group is concerned with achievement of this defined function at minimum cost.

Finally, V.E. is defined as follows:

> **Value engineering is an organized effort directed at analyzing the function of defense hardware with the purpose of achieving the required function at the lowest overall cost.**

Chapter II

METHODOLOGY

Introduction

Chapter I defined value engineering as "an organized effort directed at analyzing the function of defense hardware with the purpose of achieving the required function at the lowest overall cost." Further, to distinguish V.E. efforts from hardware design engineering, it was also pointed out that hardware design engineers are primarily motivated to achieve performance (functional) requirements in minimum time; whereas value engineers are primarily motivated by the goal of minimizing cost. Also, it was stated that value engineering efforts should be applied after the goals of hardware designers have been achieved, or at least achieved to the extent that designers will recommend that a prototype unit of hardware be produced for operational testing.

This chapter focuses on how value engineering is accomplished. The seven basic elements of value engineering methodology are first presented, followed by a general discussion of the methodology and detailed discussion of each element. A detailed case history and several additional examples are supplied as exhibits to this chapter to illustrate the application of the methodology.

Seven Basic Elements

There are seven basic elements* of the value engineering methodology. These elements are not always distinct and separate—in practice they often merge or overlap. The seven elements are:

1. *Product Selection*—The selection of the hardware system, subsystem or component to which V.E. efforts are to be applied;

2. *Determination of Function*—The analysis and definition of function(s) that must be performed by this hardware;

3. *Information Gathering*—The pulling together of all pertinent facts concerning the product: present cost, quality and reliability requirements, development history, etc.;

4. *Development of Alternatives*—The creation of ideas for alternatives to this established design;

5. *Cost Analysis of Alternatives*—The development of estimates of the cost of alternatives and the selection of one or more of the more economical alternatives for further testing of technical feasibility;

6. *Testing and Verification*—Proof that the alternative(s) will not jeopardize fulfillment of performance (functional) requirements; and

7. *Proposal Submission and Follow-up*—Preparation and submission of a formal V.E. change proposal.

To be an organized discipline, a value engineering effort should be comprised of all seven elements. In some procurement agencies or contracting firms, these elements of the V.E. job are "scattered" as "collateral" responsibilities assigned to design engineers, production engineers, purchasing specialists or engineering cost analysts, under the assumption that, collectively, value engineering efforts are being accomplished. However, under these circumstances, it is practically impossible to plan and control V.E. efforts; they are too diffused and too often given only lip-service. The premise upon which this Handbook is based is that value engineering is (or can be) an organized, effective discipline only when personnel devote their full time efforts to all seven elements of the V.E. job.

Another means of describing the substance of the seven elements is to point out that doing them provides answers to the following questions about a product:

- What is it?
- What does it do?
- What does it cost?

*Examples of the application of these seven elements are presented in Exhibits 1 through 7 of this chapter, pages 13 through 23. Exhibit 1 is a detailed case history of the application of V.E. methodology. Exhibits 2 through 7 are abbreviated illustrations applied to a variety of products

- What is it worth?
- What else might do the job?
- What do they cost?
- Which is the least expensive?
- Will it meet requirements?
- What is needed to implement?

Product Selection—Element One

The amount of resources which can be allocated to the value engineering function is limited. Therefore, it is of the utmost importance that these scarce resources be applied where there i high potential for cost reduction. In other words, value engineering should concentrate on products exhibiting high total costs in relation to function performed.

There are guidelines for selecting the products which seem to have the highest cost reduction potential. Because this element, Product Selection, of the value engineering methodology is so vital to the overall success of the V.E. program, and is sufficiently complex that it requires extended discussion, these guidelines are presented separately in Chapter III, Criteria for Applying Value Engineering. Thus, the emphasis of this chapter is on elements two through seven of the methodology.

Determination of Function—Element Two

By function is meant the purpose or objective of the hardware (subsystems or components) under consideration. In simple terms, functional requirements are those explicit performance characteristics that must be possessed by the hardware if it is "to work." They define the limits of what the hardware must be able to do in relation to the larger system of which it is a part. The method for doing this "work" is *only* implied by these performance requirements; it is the designer's job to make this method tangible and explicit. Thus, functional requirements are the ends that imply the means (i.e., the hardware design) to provide for these ends.

The definition of function in explicit quantitative terms is a difficult task. Many times there is a temptation to look at the product and say it defines required function. Actually, the designer often assumes that certain functions are required. Thus, many of the benefits of defining the function are obtained when the value engineer defines precisely which characteristics of the design are required. Often, components of the product (or the product itself) can be eliminated, and the entire assembly or system still will work satisfactorily. When this occurs, the ideal of value engineering has been achieved—elimination of an unnecessary component with a 100% cost reduction.

In attempting to define function, it is helpful to the value engineer to describe it in the form of two words: one verb and one noun. For example, in the case of a thermometer, the basic function is "register temperature." There are two reasons for so restricting the definition of function:

- The use of two words avoids the possibility of combining functions and attempting to define more than one simple function at a time; and
- The use of two simple words will achieve the lowest level of abstraction possible with words: the identification of the function should be as specific as possible.

The value engineer should be careful to identify all required functions, whether they are primary or secondary. For example, a light source also may be required to withstand severe environmental conditions or a handle also may be required to provide for locking. Accurate description of each required function in quantitative terms is a prerequisite for successful value engineering of the product.

Information Gathering—Element Three

Once having defined the function, the value engineer next embarks upon an intensive information gathering effort in two phases: (1) specific information about the product itself, such as cost of the present design, quality and reliability requirements, maintainability characteristics, volume to be produced, development history, etc.; and (2) general information concerning the technology of the product, including present state-of-the-art, vendor sources of supply for components of the item, processes to be employed in its manufacture, and establishment of contact with individuals in the organization who have technical knowledge of this type of product.

A. *Specific Information About the Product*

The value engineer should compile all information about the product under study, within the time constraints of the project and to the best of his ability. Particular emphasis must be placed upon getting accurate cost data on the item as presently designed. This will require contact with cost estimators, cost accountants, purchasing personnel and any others within the organization who may have cost data. Obviously, an accurate comparison of alternative costs with present costs requires precise cost data. No element of cost should be overlooked. Direct labor, material, and factory burden—all must be included, with a careful discrimination between the fixed, semi-variable and variable items of factory burden.

In addition to obtaining all available cost information, it is necessary to pull together all information about the performance of the item. All applicable specifications and standards must be analyzed to determine all requirements of the product. It will also be necessary to assemble all drawings, tech data sheets, tooling descriptions and any previously authorized engineering changes. The more knowledge the value engineer has concerning the product, the better job he will be able to do in determining if there is a less expensive way of achieving the required function.

B. *General Information About the Product*

More than just specific knowledge about the product is required if a thorough study is to be done. It is essential to possess, or have access to, all available information concerning the particular technology involved. Awareness of the latest developments in the field is required. A particularly good source of information is provided by specialty vendors, who supply components for the type of product under study. The value engineer should familiarize himself, to the maximum practical extent, with the various manufacturing processes that may be employed in the manufacture of the product. He should avail himself of any knowledge concerning the particular product area which may exist anywhere in the organization. The more information brought to bear on the problem, the more likely is the possibility of substantially reducing the cost of the product under study.

Development of Alternatives—Element Four

At this point, an intimate knowledge of the item under analysis has been developed and a basis for the most difficult and intangible portion of the process formulated. This is the creative portion of the value engineering activity and, depending upon the individual or individuals involved, may take many forms. The purpose is to generate ideas about the item's function and design and conceive of more economical and equally effective means of performing the same function. Analytical methods, iterative methods such as check lists and unstructured procedures such as brainstorming may also play a part in this process. Whatever methods are used, the basic purpose is to create a series of alternative designs, all of which will guarantee required function, and one of which will, hopefully, reduce cost. There follows an abbreviated check list, directed toward mechanical types of items, which provides a series of useful questions.

Typical Check List for Use in Developing Alternative Designs

General

- Can the design be changed to eliminate the part?
- Can the present design be purchased at lower cost?
- Can a standard part be used?
- Would an altered standard part be more economical?
- If the part is to improve appearance, is this justified?
- Is there a less costly part that will perform the same function?
- Can the design be changed to simplify the part?
- Will the design permit standard inspection equipment to be used?
- Can a part designed for other equipment be used?
- Can a less expensive material be used?
- Can the number of different materials be reduced?
- Are there newly developed materials that can be used?

Machining

- Are all machined surfaces necessary?
- Will a coarser finish be adequate?
- Does design permit the use of standard cutting tools?
- Are tolerances closer than they need be?
- Can another material be used that would be easier to machine?
- Can a fastener be used to eliminate tapping?
- Can weld nuts be used instead of a tapped hole?

Assembly

- Can two or more parts be combined in one?
- Can parts be made symmetrical?
- Is there a newly developed fastener to speed assembly?
- Are a minimum number of hardware sizes used?
- Are stock components called for where possible?
- Can roll pins be used to eliminate reaming?

Specifications and Standards

- Is there a standard part that can replace a manufactured item?
- Can an altered standard part be used instead of a special part?
- Can any specification be changed to effect a cost reduction?
- Can standard actuating devices be used, such as cylinders or gear motors?
- Is standard hardware used?
- Are all threads standard?
- Can standard cutting tools be used?
- Can standard gauges be used?
- Is material available with tolerance and finish that will eliminate machining?

Cost Analysis of Alternatives—Element Five

The various alternatives developed in the previous step of the V.E. process next are subjected to a test of their economic feasibility. That is, each alternative is costed, with the goal of finding the least costly, the next least costly, and so on until all alternatives are ranked according to cost. This, then, permits detailed technical (and economic) study of the alternatives on a priority basis, with the highest potential savings alternative first, to determine whether the alternative will lead to significant cost reduction. It may also cause further efforts at developing alternatives or may lead to a cancellation of the V.E. study, since it may show that no alternative is significantly less costly than the present method of meeting required function.

The costing of alternatives should take place in two broad steps. First, a gross cost estimate is made. Second, based on the gross estimate, more detailed and refined estimates are prepared.

A. *Gross Cost Estimating*

The purpose of the gross estimate is to arrive at quick indications of the relative worth of the alternatives as well as to rank them.

The gross estimate may be nothing more than an estimate based on comparing the elements, materials and processes of the alternative and the original (or present) method of providing function. Unless there are significant differences—fewer parts, easier to assemble, less expensive materials—the alternative probably is not significantly better than the original. Although it should not be discarded completely, it should be considered further only after gross costs of more promising alternatives have been estimated.

B. *Detailed Cost Estimating*

As previously described under element three, Information Gathering, the original (present) method of providing required function is costed as carefully and accurately as possible. Similar effort is required for each alternative method of providing required function which appears to have merit based on the gross evaluation of cost and technical feasibility.

The detailed costing proceeds step-wise, with each succeeding step being performed only if the preceding step shows that the alternative is still a good cost reduction candidate. Most of these steps are the responsibility of the value engineer or value team doing the V.E. study but, as will be shown in Chapter IV, sometimes a final decision about the cost and savings from a V.E. proposal cannot be determined until the formal proposal is reviewed by the customer.

Before listing each of these steps, it is important to re-emphasize that V.E. has as its primary goal the achievement of true cost reduction. Therefore, cost estimates must be as complete and accurate as possible. It is axiomatic that consistency in making measurements reduces errors in comparing them. Therefore, it is mandatory that whatever estimating approach an organization takes, it be consistently applied. More specifically, whatever method is used to cost the original or present method of providing required function also should be used in costing alternatives.

The steps in the detailed cost analysis are: (1) estimating the number of units to which the change will apply; (2) estimating the variable cost of manufacturing the alternative; (3) estimating the fixed costs of manufacturing the alternative; (4) estimating all of the costs necessary to implement the change into production; and (5) estimating the logistic costs of supporting and maintaining the alternative. A detailed description of each of these steps and of their use follows:

1. *Estimating the number of units to which the change will apply*

In terms of the number of units of product, a subcontractor or a prime contractor should measure the applicability of a V.E. change proposal to those units that will be produced after the change is implemented, as provided in the procurement contracts then in force. In these days of accelerated obsolescence and changing defense requirements, plans for future procurement contracts for additional units of product are very susceptible to cancellation. Therefore, to be realistic, the estimates of total savings from a V.E. change should apply to units produced under the contracts in force.

The estimate of the time required to implement the change should be as conservative as the estimate of the cost of implementing the change. It should reflect allowances for delays in the procedure for evaluating and authorizing the change proposal and delays in the planning and executing all the engineering, purchasing and manufacturing jobs that have to be done before units incorporating the V.E. change can be produced.

2. *Estimating the variable cost of the alternative*

This step is concerned with the determination of the variable portion of total unit cost; that is, those components of cost which can be identified with each unit or product, or are incurred in direct proportion to the number of units produced. Such costs fall into two categories:

- Direct labor and direct material normally measured and accounted for on the basis of the product or item in which they are consumed; and
- Variable items of burden such as inspection costs, test and shipping, and other items often included in burden. Some of these items may have to be estimated and others may be derived from existent standard costs or cost history.

Once the variable costs are determined, the balance of the cost estimating is directed at the definition of the various fixed costs which must be met if the alternative is to be adopted.

3. *Estimating the fixed costs of manufacturing the alternative product*

Care must be exercised in arriving at appropriate fixed costs to charge to the alternative method. The evaluation should reflect only those fixed manufacturing expenses that would be changed if the proposal were implemented. Often, accountants charge products with expenses of organizations, procedures and facilities that actually would not be affected if alternative methods were implemented. Those that are affected, however, must be covered. They would include such items as property taxes, heat, light, property insurance premiums, salaries paid to supervisory and technical personnel who plan and control the production activities and depreciation expenses for the building and equipment used to manufacture and maintain the equipment, again, if they change because of implementing the alternative method and only to the extent to which they will change.

4. *Estimating the costs of implementing the change into production*

These expenses are generally understood to cover the costs which the manufacturer incurs in getting the changes into production. Among them are the following: production engineering design; fabrication, installation and maintenance of new tools and equipment; development of new work methods needed to implement the change into the manufacturing process; training of personnel; expenses for the labor required to install or rearrange production and/or test equipment; and product design and test engineering work to alter existing product drawings, diagrams, test specifications, including the work of disseminating this information to all agencies affected.

5. *Estimating the logistic costs of supporting and maintaining the alternative method*

Although the group or person doing the V.E. job probably has limited knowledge of the logistic costs which would result from implementing the alternatives developed by his efforts, he nevertheless should identify and cover as many as possible. Among them are the following: adapting the V.E. change to products and support-material already in the field, disposing of stocks of spare parts already provisioned, adapting maintenance tools and test facilities (or providing new ones if necessary), costs of restocking spare and repair parts, preparation and publication of changes for operating, maintenance and supply manuals, and revision of training procedures and documents.

6. *Final use of the cost data*

Once the preceding costs, both fixed and variable, have been estimated as accurately and thoroughly as possible and the number of units to which the alternative method will apply has been estimated, the economic feasibility of the alternative method is easily determined. The difference in variable cost between the old method and the alternative is multiplied by the number of units. From these gross savings, all fixed costs must be deducted.

In addition to fixed costs discussed in the previous steps, costs of conducting the V.E. study, costs incurred in the management review of the V.E. proposal, costs of negotiating Contract Change Notices, and administrative handling expenses must also be deducted. Originators of proposals must develop for most of these latter areas a schedule of surcharges to be applied against each V.E. change proposal. Again, consistency in application is necessary.

If after deduction of all fixed costs from the gross savings, the net savings are substantial, the alternative method is economically feasible.

The cost data derived in analyzing an alternative can be used in other ways, such as calculating break-even point, figuring return on the V.E. investment and for future reference in preparing cost estimates for similar hardware items. Of course, its first use will be in preparing the formal V.E. change proposal, since this is the basic evidence supporting adoption of the alternative.

Testing and Verification—Element Six

All economically feasible alternatives developed in the V.E. study must be tested to ensure that they will provide required function. If they do not, they are rejected from further consideration unless modified to meet functional requirements.

In assessing technical feasibility, each required function is examined in turn. As previously described, primary and secondary functions are originally defined in terms of what the product or item must do, with what accuracy it must perform, how dependable the product must be and under what environmental conditions it must operate. In addition, required function may include elements related to operation and maintenance, such as safety, ease of repair and accessibility, etc.

The value engineer attempts to determine whether the alternative method meets each of these elements of required function.

The following general check list is recommended as a starting point in assessing the technical feasibility of an alternative method. The check list should be refined in detail every time that it is used, so that it includes each and every specific functional requirement of each category.

General Check List for Technical Feasibility

- Does the alternative provide necessary performance requirements?
- Are quality requirements met by the alternative?
- Are reliability requirements met by the alternative?
- Is the alternative compatible with the system of which it is a part?
- Are safety requirements met by the alternative?
- Does the alternative improve or at least not reduce maintainability characteristics of itself or the system of which it is a part?
- Does the alternative permit adequate provisioning, transporting and storing of necessary support material for the alternative or system of which it is a part?

In developing answers to the questions posed by the check list, the value engineering group may perform the testing and verification or they may call on specialists in their own organization, or consultants from other organizations. Library searching may be needed, detailed computer operations may be involved. Pilot tests may be required, or even full-scale field tests.

Depending on the nature of the alternative, it may vary from easy to assess to extremely difficult. Regardless of the relative ease or difficulty of assuring that the alternative will provide required function, it is the responsibility of the value engineer or V.E. team to establish conclusively that functional requirements are met.

Proposal Submission and Follow-up—Element Seven

Once the V.E. team or value engineer has assured himself that an alternative is economically and technically feasible, and is the best alternative of all developed, a formal proposal is prepared recommending adoption and implementation of the alternative.

The preparer of the proposal should be guided by considering the procedures used by others in evaluating it. Specifically, he should view his proposal as others will view it. If the report does not communicate effectively, the whole study is in jeopardy.

In addition, consider the man, or the group of men, that will read the report. They are busy; they want the facts quickly and concisely. Yet, the report must tell them all they want to know about something with which they are not familiar. Before and after must be clearly explained. The before must be briefly reviewed. The after must be justified. Precise costs of both must be cited. In short, the entire V.E. study must be summarized concisely and accurately.

A standard form should be used wherever possible, supplemented with graphic material as required. Exhibit 8 illustrates such a form. A standard form is recognized, and its purpose is immediately understood; it can be circulated, reproduced and reviewed with more efficiency. In large organizations where many studies are undertaken, a standard form can also be for filing and reference. If a form is not available, however, or if a more lengthy report is desired, there are a number of suggestions which may help to prepare proposals which communicate effectively. These suggestions are as follows:

- The title should briefly refer to the item and the study. It should be followed by a summary of the problem and a "nutshell" description of the proposed solution.
- Clarify what the item is, what it does, what assembly it is in—and similar facts to outline your subject.
- Indicate why it was selected for study, i.e., what aroused your suspicions about its poor value. Also show why savings are likely, pointing out for example, that so many thousands of them are used each year, etc.
- Reveal the alternative and provide a short description of its salient features.
- As accurately as possible, indicate in detail the savings that will result.
- Summarize the pattern of study, referring to the sources of your data. Mention which vendors or articles led to your selection of alternatives.
- Couch explanations according to the training and experience level of the reader. Reports that are reviewed at a lower level usually involve proving the engineering feasibility of the change with extreme technical detail. Technicians and engineers want such facts; they need them to approve your conclusions. At higher administrative levels, the technical details can be summarized while the financial benefits must be emphasized. Long-range effects on policies, procurement and applications are more significant at the higher levels of decision making.
- Where it is appropriate, mention the names and contributions of other individuals in the organization. If the study has the approval of other authorities, cite this as an indication of broad organizational support.
- Design the report to secure approval; anticipate objections and provide the answers. Remember—if the reader has to stop to get more information, the report may be dead.
- The use of supplementary material depends on the nature of the report. If it is long and complex, simple charts, figures and tables may be far more effective than pages of hard-to-read values, dates and statistics. Illustrations and photos are always a welcome relief from pages of text. A table of contents is a requirement when the report is long.

By following the preceding suggestions, proposals will be prepared which facilitate prompt, accurate evaluation based primarily on the merits of the proposal—a desirable goal for the V.E. effort.

Once the proposal is submitted, it must be followed up periodically in order to monitor its progress. (A sample form to facilitate this follow-up is included as Exhibit 9.) The responsible value engineer should regularly make a check of who has the proposal and what its current status is.

Occasionally, there are delays in initiating evaluation action on the proposal. In this case, polite reminders to the responsible authority may be necessary. Follow-up notes should:

1. Offer help, if any further clarification of the proposal is required; and

2. Stress that delay in project acceptance will result in a loss of savings, especially on current programs.

As might be suspected, the preceding is meant to imply that the value engineer or V.E. group should never let a V.E. effort die because of inaction at the evaluation stage. Instead, the evaluation action should be carefully followed and gently "needled" as necessary until final action, in the form of approval or disapproval, and implementation once approved, has been completed.

Summary

There are seven basic elements of value engineering methodology: (1) Product Selection; (2) Determination of Function; (3) Information Gathering; (4) Development of Alternatives; (5) Cost Analysis of Alternatives; (6) Testing and Verification; and (7) Proposal Submission and Follow-up. To be an organized discipline, a value engineering effort should be comprised of all seven elements.

Application of the methodology will answer the following questions about the product: (1) What is it?; (2) What does it do?; (3) What does it cost?; (4) What is it worth?; (5) What else might do the job?; (6) What do they cost?; (7) Which is least expensive?; (8) Will it meet requirements?; and (9) What is needed to implement?

A clear determination of function is a prerequisite to a successful value engineering analysis. Following the determination of function, the value engineer must then gather all pertinent information pertaining to the product and to the technology in general with particular emphasis on a complete cost breakdown. The next step is to develop alternative means of achieving the required function. The alternatives must then be costed in detail and the least expensive, technically feasible method selected. The selected method must then be subjected to testing and verification to ensure that it does, in fact, achieve the required performance. The next steps in the process are to summarize the results of the study, submit them in the form of a value engineering change proposal and follow-up on the proposal to the point of either implementation of the change or rejection of the proposal.

Exhibit 1

CASE HISTORY

Product Selection

The item selected for analysis is a Signal Data Converter Chassis Assembly, which is a major component of an air-borne navigational system. The Signal Data Converter acts as the brain of the doppler navigation system. Essentially, it is a high-speed computer which converts the input electrical signals from the receiver-transmitter for input to the direction-velocity indicator, to which it is coupled.

The item was selected for initial review on the basis that it was a high-cost, complex product. The initial analysis indicated that five major components of the total assembly should be subjected to a detailed V.E. study.

Determination of Function

The five major components of the Signal Data Converter that were selected for detailed study, with a description of their primary function, are listed below:

- *Chassis Subassembly*—provide a mounting surface and housing for the electronic modules (not under study), interconnect board subassembly and associated wiring.
- *Top Cover*—serves as a shield against atmospheric contamination and mechanical damage during and after installation.
- *Bottom Cover*—provide a protective shield for the interconnect board subassembly.
- *Interconnect Board Subassembly*—provide circuit continuity within the Signal Data Converter.
- *Handle*—permits removal of the Signal Data Converter from its mounting rack.

Information Gathering

The Signal Data Converter is a "make" item. Prototype fabrication and testing have been completed; fabrication of an additional two hundred deliverable items to the prototype design is planned to start in eight weeks—no production problems are anticipated.

The chassis subassembly is a sheet metal fabricated box with the bottom open. Twenty electronic modules are mounted on the chassis which also houses the interconnect circuit board and harness assembly, providing continuity between the Signal Data Converter and other related units of the system. The present cost of the chassis subassembly is $99. The top "deck" is punched to accept the rectangular connectors to which the electronic modules are mounted. Four holes are punched into the front panel for conventional round connectors. There are thirty-two anchor nuts riveted in the chassis for mounting the bottom and top covers. There are two locating holes in the rear panel. The electronic modules (20) are located on the top of the assembly by locating holes, color coding and part numbers stenciled in place. The interconnect board subassembly is mounted inside the chassis.

The top cover serves as a shield against atmosphere contamination and mechanical damage. It does not provide a pressure seal. The cover is beaded for structural rigidity. Twelve metalcals are bonded to the inside of the cover on which are inscribed circuit diagrams of the electronic modules for maintenance purposes. Doublers are riveted to the cover flanges to increase structural integrity of the cover under vibration. The present cost of the top cover is $85.

The bottom cover is made from 0.040 aluminum sheet flanged on the long dimension and attached to the chassis by sixteen screws. It has three beads in the transverse direction equally spaced from fore to aft. The present cost of this component is $15.

The interconnect board subassembly consists of a printed circuit board and an electronic harness.

The present cost of the subassembly is $485. It is mounted in the chassis so that the twenty module connectors are attached to the top of the chassis and the four conventional connectors are attached to the front panel. The harness is made separately and is mounted on the printed circuit board. The ends of the harness are soldered to terminals and eyelets of the board at approximately one hundred and fifty (150) points. The handle is mounted to the front panel and costs $15 (a separate latching hook is also mounted on the front panel, and costs $0.81).

In addition to gathering data on the specific components under study, the V.E. team contacted numerous specialty vendors who had experience in manufacturing similar items. The team also conducted considerable research into the general technology of mounting and housing this type of equipment.

Development of Alternatives

All ideas were recorded which could produce the items in some other manner than presently done, or change existing processes and materials.

For the chassis subassembly:

- Make a casting which would include bosses for attaching points including latching hooks and handle which are mounted at final assembly of the Signal Data Converter. All cut-outs and holes could also be incorporated in the casting.
- Use channel section runners on the side. Eliminate the back panel, retain the front panel and rivet a top plate to the front panel and channel sections.
- Investigate specialty suppliers for procurement of chassis which would meet the requirements.

The top cover was reviewed as follows:

- Make the cover out of fibreglass in the present configuration.
- Procure a cover along with the chassis subassembly from a specialty vendor.
- Procure a cover that would not have flanges, but would slide down the side of the chassis and be attached to the chassis at the sides, eliminating the flanges and reinforcing doublers.

The bottom cover was analyzed as follows:

- Eliminate it.
- Remove flanges and mount to bottom of chassis.
- Reduce the number of mounting points from sixteen to twelve.
- Eliminate the beading.
- Eliminate the counter sinks.
- Eliminate painting operation.

The interconnect board subassembly was reviewed as follows:

- Point-to-point wiring.
- Harnessing without a printed circuit board.
- Use contour (flat) cabling in conjunction with the printed circuit board.

The handle was analyzed as follows:

- Use two hooks at each end of front panel.
- Use a hook in the center of the front panel.
- Put a coil spring on the locating pins to eject the Signal Data Converter two inches from its rack.
- Put a leafspring across the back panel for ejection purposes.
- Combine handle function with that of the latching function.

Cost Analysis of Alternatives

A thorough cost analysis of all the proposed alternatives was conducted. The least expensive technically feasible alternatives which were selected are listed below with a comparison of their cost with the present cost.

- *Chassis Subassembly*—procure basic chassis from a specialty supplier and perform the remaining operations inhouse.
  New cost $24.84—present cost $99.
- *Top Cover*—fabricate from fiberglass (molded construction).
  New cost $37.44—present cost $85.
- *Bottom Cover*—redesign to flat sheet and mount to bottom of chassis.
  New cost $1.32—present cost $15.
- *Interconnect Board Subassembly*—procure from a specialty supplier. Design to incorporate principles of contour cabling.
  New cost $300—present cost $485.
- *Handle*—eliminate and combine function with latching hook mounted during final assembly.

New cost $0.74—present cost (handle and latching hook) $15.31.

Summary

Original Cost	$690. 31	
New Cost	364. 34	
	$334. 97	Unit cost Reduction

Testing and Verification

Each of the proposed alternatives were checked with the responsible design groups for their preliminary evaluation. Several of the alternatives were given preliminary approval by the designers almost immediately. Several others were scheduled for testing to ensure that their incorporation would not sacrifice any required performance of the Signal Data Converter. All alternatives passed their qualifying tests and were accepted for inclusion in the formal V.E. Change Proposal.

Proposal Submission and Follow-up

The formal V.E. Change Proposal was submitted to the Project Manager having cognizance of the Signal Data Converter. The proposal pointed out that implementation of the recommended changes would reduce the unit price by $334.97 or 47.9%. The recommended changes could be implemented on all two hundred (200) units, thereby producing a gross saving of $66,994. Costs of implementing were estimated to be no more than $12,000, which therefore would provide a net saving of approximately $55,000.

Besides achieving required function at lower cost, the total assembly would be simplified, thereby improving maintainability and reliability. Furthermore, the overall weight of the end item would be reduced.

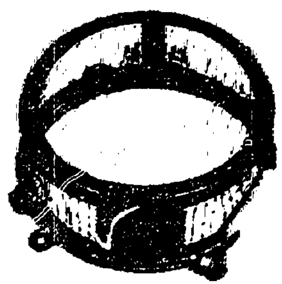
Attached to the proposal were the comments of the designers who had been asked for a preliminary evaluation and the test reports on those components which were subjected to a testing program.

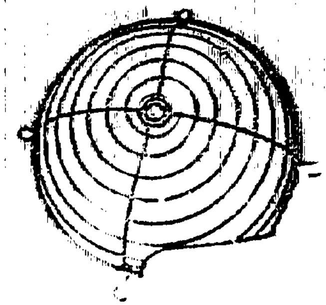
One member of the V.E. team was assigned responsibility for follow-up on the proposal. He was available to any of the evaluators should they require any additional information and was utilized on several occasions. Once the proposal was approved, he provided assistance to the various design and production departments in its implementation. Actual implementation, in this case, proved to be routine and no major difficulties were encountered.

SCREEN ASSEMBLY, OIL COOLER FAN
UH-1B, UH-1D HELICOPTER

Exhibit 2

BEFORE **AFTER**





SELECTION:
EXCESSIVE COST; INFORMAL DESIGN REVIEW.

FUNCTION:
PROTECT FAN.

INFORMATION:
ALUMINUM SHEET, ROYALITE STRIPS, SCREEN WIRE; FORMED; RIVETED; PAINTED; $89.75 EACH.

ALTERNATIVE:
WELDED STAINLESS STEEL WIRE FORM ASSEMBLY.

COST OF ALTERNATIVE:
$1.95 EACH.

TESTING:
GROUND RUN EVALUATION.

PROPOSAL:
SUBMITTED, APPROVED INTERNALLY; ACCEPTED; COST REDUCTION $87.80 (98% SAVING) EACH; NET TOTAL SAVINGS TO DATE: $34,500.

RATE GYRO MOUNTING BRACKET
SubROC MISSILE

BEFORE

AFTER

SELECTION:

ONE OF SEVERAL HIGH COST MECHANICAL PARTS IN MISSILE.

FUNCTION:

MOUNT GYRO.

INFORMATION:

MACHINED FROM FLAT ALUMINUM ALLOY STOCK; $68.13 EACH; THREE PER MISSILE.

ALTERNATIVE:

ALUMINUM CASTING WITH STRAPS TO HOLD GYRO.

COST OF ALTERNATIVE:

$5.56 EACH.

TESTING:

BENCH TEST; FLIGHT TEST.

PROPOSAL:

SUBMITTED, APPROVED; COST REDUCTION $62.57 EACH (91% SAVING); $181.71 SAVED PER MISSILE.

Exhibit 3

DUST COVERS FOR ELECTRICAL RECEPTACLES MINUTEMAN LAUNCH CONTROL SYSTEM

SELECTION:

HIGH COST ITEM.

FUNCTION:

PROTECTS RECEPTACLES.

INFORMATION:

METAL ALLOY; MACHINED; THREADED AND KNURLED; INTERNAL NON-CONDUCTOR; CHAIN ATTACHED; COST $4.50 TO $10.05 DEPENDING ON SIZE.

BEFORE

AFTER

ALTERNATIVE:

PLASTIC CAP.

COST OF ALTERNATIVE:

FROM LESS THAN $ .02 TO LESS THAN $ .03 DEPENDING ON SIZE.

TESTING:

ACTUAL USE TEST

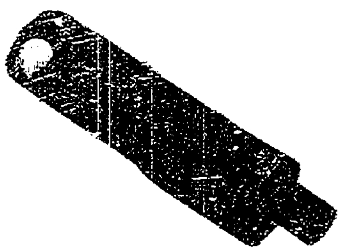
PROPOSAL:

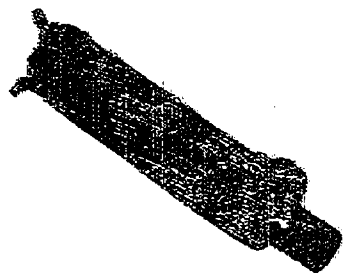
PROPOSAL SUBMITTED, APPROVED INTERNALLY. AVERAGE COST REDUCTION PER UNIT $5.98, A 99% SAVING. TOTAL NET SAVING ON 80,000 UNITS - $478,400. PLANNED FOR APPLICATION TO OTHER WEAPONS SYSTEMS.

Exhibit 4

VENTURI ASSEMBLY
ARMY ROCKET

BEFORE | **AFTER**





SELECTION:
WORK PROJECT FOR TRAINING COURSE; HIGH COST OF ITEM.

FUNCTION:
GENERATE PRESSURE

INFORMATION:
MACHINED FROM HEAT RESISTANT ALLOY; WELDED ASSEMBLY; MYLAR SEALING DISC; COST $89.11 EACH. (QUANTITY - 100 UNITS).

ALTERNATIVE:
WELDED WIRE ASSEMBLY CEMENTED TO FORMED SCREEN AND TAPER-DRILLED CRES TUBE AND WASHER.

COST OF ALTERNATIVE:
$7.55
(QUANTITY - 100 UNITS)

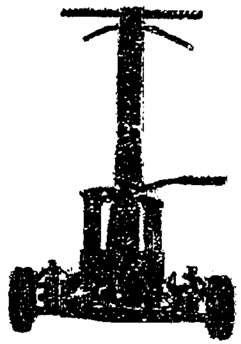
TESTING:
CONTRACTOR DESIGN REVIEW

PROPOSAL:
SUBMITTED, APPROVED INTERNALLY FOR FUTURE PRODUCTION; $81.56 UNIT COST REDUCTION (91%). TOTAL NET SAVING OF $7006.00 ON QUANTITY OF 100 AFTER DEDUCTING $1905.00 IMPLEMENTATION COST.

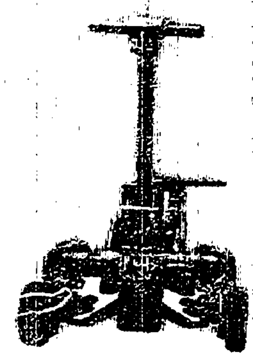
Exhibit 5

ASROC HAND LIFT TRUCK

BEFORE



AFTER



SELECTION:

EXAMINATION INDICATED COST EXCESSIVE FOR FUNCTION REQUIRED.

FUNCTION:

TRANSPORT ROCKETS.

INFORMATION:

HYDRAULIC LIFTING MECHANISM; CONE-TYPE BRAKES; 460 PARTS; COST $2,480 EACH; 400 UNITS PLANNED PROCUREMENT.

ALTERNATIVE:

MECHANICAL LIFTING MECHANISM; DISK-TYPE BRAKES.

COST OF ALTERNATIVE:

$758

TESTING

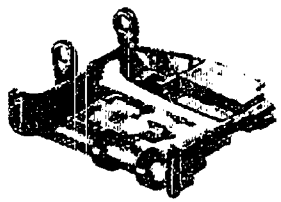
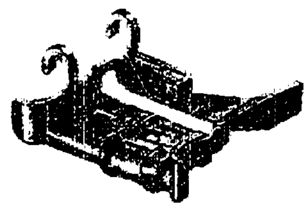
LABORATORY TESTS AND FLEET SERVICE TESTS.

PROPOSAL:

SUBMITTED, APPROVED, COST REDUCTION $1,722 (69% SAVING) EACH; TOTAL NET SAVING ON 400 UNITS: $688,800; WILL BE APPLIED TO ASROC-TERRIER PROGRAM LATER.

Exhibit 6

CARTRIDGE, FEED TRAY
M-60 MACHINE GUN

BEFORE	AFTER
	

SELECTION:

HIGH SAVINGS POTENTIAL BASED ON PRELIMINARY COMPONENT ANALYSIS.

FUNCTION:

FEED CARTRIDGES.

INFORMATION:

WELD PARTS INTO ONE SUBASSEMBLY; ASSEMBLE 10 PARTS INTO PAWL ASSEMBLY; $38.70 EACH.

ALTERNATIVE:

FEED TRAY INVESTMENT CAST; REDESIGNED PAWL ASSEMBLY.

COST OF ALTERNATIVE:

$7.33 EACH.

TESTING:

LIVE FIRING AND LIFE TESTS.

PROPOSAL:

SUBMITTED, APPROVED; COST REDUCTION $31.37 EACH (80% SAVING); TOTAL NET SAVINGS ON 5,000 GUNS - $150,000; 15 PARTS ELIMINATED.

Exhibit 7

Exhibit 8

VALUE ENGINEERING PROPOSAL

Part No.	Name		Project No. Proposal No. Section
Qty. per Device	Function Verb	Noun	Date

PRESENT (show sketches)	PROPOSED (show sketches)

NON-RECURRING COSTS (est.)		
	Hrs.	$
Design		
Drafting		
Evaluation		
Model Shop		
Publicat'ns		
Tech Lab		
Tooling		
Misc.		
Total		

	Direct Material	Direct Labor	Variable Portions of Burden	Total Variable Cost Per Piece
Present Cost				
Proposed Cost (est.)				

Net Savings:

1. Difference Var. Cost, Proposed vs. Present: ________
2. Total No. Pieces ________
3. Total Gross Savings (1x2) ________
4. Less: Non-recur. Costs ________
5. Net Savings ________

Proposed By:

____

____

____

____

____

____

Product Line ________
Proj. Name ________
Proj. No.

Design Engr. ________
Prod. Engr.

VALUE ENGINEERING PROJECT STATUS

Proposal No.	Station No.		Feasibility, Man-power, Funding Consent Report		Delayed for Further Study		Redesign to Start	Evaluation to Start	Evaluation Completed	Customer Approval	Production Effectivity	E.C.O. Issued	Final Report			Cost Data			
																	Non-Recurring Cost	Net Savings per Unit	Ratio Savings/ Cost
		S														Est.			
		P														Imp.			
		A																	
		S														Est.			
		P														Imp.			
		A																	
		S														Est.			
		P														Imp.			
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		A																	
		S														Est.			
		P														Imp.			
		A																	

S—SCHEDULE DATE **P**—PROMISE DATE **A**—ACTUAL DATE

Exhibit 9

Chapter III

CRITERIA FOR APPLYING VALUE ENGINEERING

Introduction

Chapters I and II were devoted to what value engineering is and how value engineering concepts are applied. This chapter discusses criteria for deciding when, where and to what extent value engineering concepts should be applied.

Value engineering resources should be allocated and scheduled so that maximum improvement in total hardware value is assured with the least effort expended in the time available.

Both value engineers and managers of value engineering programs must have criteria for making these decisions. The value engineer or his manager may know very well how to use all the V.E. techniques, but to use them successfully requires criteria to decide when, where and to what extent they should be applied. The individual value engineer (or a V.E. team) relates these issues to items of hardware so he can decide how to manage his own time and efforts. The manager of a V.E. program relates these issues to plan, organize, measure and control the efforts by several value engineers (or several V.E. teams) to be assigned to more than one hardware project. Thus, the questions of how, when, where and to what extent V.E. should be applied are answered by the value engineer and by the manager of all the value engineers. This chapter is addressed to both points of view.

When To Apply Value Engineering

As defined earlier, V.E. is a technique which may be applied to a product at any time after initial design effort is completed. For a product already in production, then, V.E. should be applied as early as possible. For an item or product in development, V.E. should be applied before production but after initial design.

The actual point of application selected is based on two factors. The first is a matter of obtaining the most savings from V.E. This would argue for applying V.E. as early as possible in the life cycle of a product for two reasons: (1) the more units of production to which cost reduction changes apply, the greater the total savings generated by the change; and (2) the earlier the change, especially if it can be made before production begins, the lower the implementation costs, both from the standpoint of modifications to production lines, tooling, procedures, etc., and from the standpoint of changes to logistic and support elements such as spares, manuals, maintenance facilities, etc.

Too early an application, however, is not desirable because if V.E. is applied, say immediately after the first design attempt, it may well prove to be wasted effort if the first designs are subsequently modified or changed. It should be noted that in many cases the likelihood of change is quite large, especially in weapon system development because of the complexity and technical novelty of the designs, because of system integration problems and, most of all, because of the dynamic technologies involved.

From the standpoint of achieving maximum efficiency, then, it would seem that V.E. should be applied sometime before production begins, but after initial designs are completed. The most important breakpoint, in any case, is the start of actual production runs.

The second factor affecting the timing of V.E. action is related to the ease or difficulty of actually accomplishing V.E. Although V.E. can be applied to completed designs, it has been found that the process is easier to do if the product actually exists in physical form. In addition, it has been found that the evaluation process is easier if the product is already in existence, because costs are easier to gather and estimate. These considerations would argue for the introduction of V.E. downstream in a product's life cycle.

Resolution of the seeming conflict between the two factors just developed can be made by selecting a point in the product's development which satisfies both as much as possible without sacrificing savings potential. On this basis, the application of V.E. at a point between initial design and production is suggested, with the actual selection of the specific point a function of the product, the organization's already established procedures, existing control points and the manufacturing or development process itself.

Most of the preceding discussion about when to apply V.E. applies primarily to new development programs. It is not suggested that the use of V.E. be limited only to such programs, however. Many products already in use never were value engineered and possibly can benefit from value engineering when they are reprocured. In addition, products which were value engineered initially may benefit from subsequent value engineering at reprocurement, if advances in technology have led to developments which could significantly lower costs while retaining essential function. The important point to recognize is that value engineering applied to these products will not be as efficient and fruitful as it would have been if applied to them in their initial development stage. The reason is that many otherwise worth-while changes will not be approved because the costs of implementation and the costs of changing logistic support are greater than the gross savings entailed in the V.E. proposal. Even those that are approved will result in less total savings because of these same costs and because they apply to less units than if applied earlier. Therefore, V.E. should always be applied as early as possible after initial design.

Criteria for Selecting Items for Study

For the same amount of V.E. time and effort, the benefits that can be achieved from analyzing one item seldom are the same as the improvement that can be achieved from analyzing another item. This is significant to the manager of V.E. and to the value engineer. A preliminary analysis of all subsystems of an overall weapon system enables the manager to select subsystems according to cost reduction opportunities. A preliminary analysis of all parts enables the value engineer to select and rank the parts according to their potential value improvement. This section suggests criteria for this preliminary analysis.

A. *Value Standards*

Value standards are of two types: theoretical standards, based on a mathematical expression of the product's function, and historical standards, which are based purely on historical cost data on the same or related products.

The theoretical standards require further explanation. They are based on establishing the scientific or physical equations which define the product's function, then calculating through a series of steps what the minimum possible cost of the function could be. For example, the required function might be electric power transmission. One element of cost in transmitting electricity is the cost of line losses. Part of the line loss is related to the current carried and the resistance of the line (wire). Resistance is related to the material or composition of the wire, its diameter and its length. The diameter and length of wire is directly related to the weight of the wire, and the weight of the wire and its composition is related to the price of the wire. Thus, the power loss is ultimately related to the cost of the wire. By making appropriate calculations, the power loss can be balanced against material cost and lead to an electric power transmission value standard. Actual calculations for this function, it should be pointed out, are more complex and involve a number of additional factors.

Several points concerning this type of value standard should be noted.

First, the standard is derived from physical laws or formulas and is based on the inherent physical and chemical properties of materials or systems.

Second, the theoretical standard eventually must include costs—and these are always historical. In the example given, the costs include the cost of electricity and the costs of the wire. Usually, long-term average costs are used but, even so, such costs can change over a period of time.

Third, the standards are always based on the present state of scientific knowledge and, thus, are subject to change over a period of time.

Fourth, it appears that these value standards are more precise and meaningful than those based purely on the traditional or historical cost of a given product.

Finally, it must be recognized that theoretical value standards are quite difficult to compute and, for this reason, are available only for very limited product areas. Furthermore, many of the existing standards of this type are considered to be trade secrets and, therefore, not generally available.

Historical value standards, on the other hand, are comparatively much easier to develop and are more generally available than theoretical value standards. Essentially, they are based on a presumption that products which have been in existence for some time, especially if they are highly competitive products, are produced efficiently and sold at a reasonable price. In other words, it assumes that their cost is a good indicator of their real value.

Value standards of either type are an effective tool for selecting items to be subjected to value engineering. In the preliminary review of a number of products or a number of components of one product for purposes of determining the area of greatest potential return form value engineering, the actual or estimated cost of the various functions are compared with the standard for those functions. If the item's cost greatly exceeds the value indicated by the standard, it should be considered an appropriate candidate for value engineering.

Even on new weapon systems, many of the subsystems or components have been used in previous systems. Therefore, historical cost data is probably available for these items and should be used as a rough "value standard" in determining whether the items are likely prospects for value enginering.

B. *Relative Cost Ranking*

In the absence of value standards, the estimated cost of the parts or subsystems can be ranked from highest to lowest in terms of dollars per unit of the product and total dollars per product. Generally, potential value improvement is greatest on those components of highest unit or total costs.

Sources of information and techniques for estimating costs were discussed in Chapter II. These estimates need be accurate only in a relative sense for the purpose of ranking each component according to its approximate percentage of an estimated total cost of the product or system (the total cost might be assigned an index of one thousand (1000); each part may then be assigned a relative cost index which is a percentage of one thousand (1000)).

The estimated costs to be considered should include the direct costs of producing the part (including special tools, facilities, etc.) and the costs of supporting the product (i.e., supplying and maintaining the product) throughout its expected useful life. Since some parts may be subjected to wear more than others, they will have to be produced in larger quantities per unit of product and replaced more often than others.

In short, product cost criteria should reflect the value engineer's judgment of expected costs of production and logistics support, expressed in rough, relative terms for each component of the product. Two "relative cost indices" can be assigned to each component, one for relative production cost and the other for relative support cost.

The basic cost factor used in determining relative priorities can be further refined by applying the following additional measurement criteria:

- *Complexity of the product*—generally, the more complex the product, the more opportunity there is for improved value.
- *State of development of the state-of-the-art*—those product designs that are pushing the state-of-the -art normally will offer substantial potential for value engineering.
- *Degree of time compression in the development cycle*—a product which has had an accelerated development program usually contains elements of overdesign.

All three of the above criteria are directly related to cost although not all high cost items have these characteristics. However, high cost items characterized by one or more of these attributes are likely prospects for the application of value engineering.

C. *Correlation of Resources to Task*

The term "value engineering resources" refers to the kinds of facilities and know-how possessed by a value engineer and his organization. For example, one value engineer may possess knowledge and experience in "engineering the value" of electrical-mechanical systems; another value engineer may have concentrated most of his knowledge and experiences in improving the value of electronic circuits. Now, suppose the product-design to be value engineered contained two subsystems, one electrical-mechanical and the other electronic. In this case, the probability of maximizing improvement in the value of this product is greater if the knowledge and experience of each value engineer are matched with the two subsystems.

This example is so obvious that it may seem trivial. On the other hand, the pressures of getting the job done often militate against taking the time to classify and match the value engineering resources available with the value engineering job to be done. These resources are scarce. In the defense-product business, product functions and designs are growing more and more complex. It is easy for value engineering to become an indiscriminate "nit-picking activity." The most successful value engineering manager is the one who can match his available resources (talents, skills, know-how) with the total job to be done. Thus, this criterion for where to apply V.E. techniques has to do with a "qualitative analysis" of available resources and the V.E. job to be done. There is, therefore, a higher correlation between the available V.E. resources for some parts of the total V.E. job to be done than for others.

Engineering talent and experiences can be classified in many different ways. For purposes of correlating value engineering talent with portions of the total V.E. job to be done, some ways are better than others. For instance, it may be more useful to know whether an engineer has had most of his experience with specific kinds of materials and energy systems than to know whether he has had most of his experience with design, test or maintenance engineering activities.

Those categories which best describe knowledge and professional V.E. competence available would be checked and matched with an analysis of the performance and design specifications for the product. Results of this sort of "input-output" analysis would assist in selecting those portions of the total V.E. job that would probably yield the greatest value improvement.

The Use of PERT/Cost Networks To Develop Criteria for Value Engineering Applications

A PERT/Cost network is a diagrammatic model of all the sequential activities required to design and develop a product, with each activity specified by its beginning and ending events and by the estimates of its time and cost to complete. Figure 1 illustrates a PERT/Cost network. Where a PERT/Cost network exists, it can be a useful tool for determining areas of V.E. application.

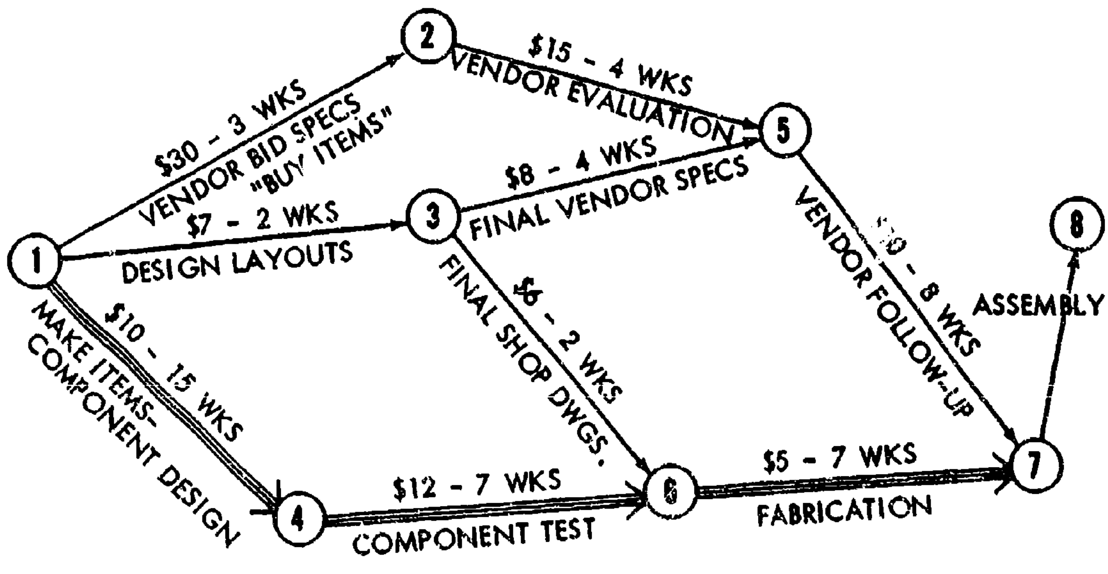


Figure 1 - A PERT/Cost network showing the sequence of planned events for the project and the estimated cost and time of each activity planned for the project. (Critical path is designated by heavy arrows connecting events 1 - 4 - 6 - 7).

PERT/Cost networks are used to plan and control development projects. As actual activities and events occur, their time and cost are compared with those that were planned and the network of remaining activities is revised accordingly. Thus, PERT/Cost networks show explicitly the estimated sequence, timing and cost of all the activities required to develop a product, according to a design concept that has been selected. Of course, the validity and reliability of these estimates are probably the most valid and reliable ones obtainable if they are derived by those persons authorized and responsible for performing the activities.

To the value engineer, perhaps the outstanding advantages of PERT/Cost networks are the conciseness and completeness with which they indicate details of where and when value engineering efforts should be applied in a particular hardware development project.

Two features of a PERT/Cost network that make this possible are:

- They show what product components and processing activities are expected to require the greatest cost and/or time relative to all others in the project.
- They portray the schedule for accomplishing these product components and their associated activities.

These two features permit the value engineer to respectively:

- Focus on those components and activities for which V. E. changes probably will result in the most significant value improvements.
- Develop a schedule for the application of value engineering effort.

Changes in the PERT/Cost network may result from value engineering effort. As value engineering change proposals are likely to alter the hardware designs, they also alter the type, sequence, time and cost of the activities whose purpose is to produce the design. However, as time passes, PERT/Cost networks are modified and updated in accordance with restrictions and progress actually experienced with the development project. Thus, V.E. efforts should be integrated with the information system supporting PERT/Cost networks whenever and wherever they are used.

Criteria for Deciding the Extent of Value Engineering Efforts

Value engineering efforts can be measured in terms of the number of value engineering man hours expended. A value engineer or his manager must decide where, when and to which components of the hardware project he will focus his efforts. He must also decide how much time and money he expects to spend on a particular value engineering job.

Experience has shown that the value of almost any product can be improved, i.e., its cost can be reduced without impairing its functional capabilities. Experience has also shown that value engineering efforts to achieve these improvements can be costly and time-consuming in themselves. There is a point of diminishing return per additional hour of time spent on a value engineering job.

The value engineer performs two functions. First, he applies value (cost) criteria to the functional specifications and the product design. Second, he proposes design changes that will reduce its cost without impairing its performance capabilities. Neither of these functions is routine. Usually, rigorous and relevant value criteria are not easily available to the value engineer. He must spend time extrapolating or interpolating them from whatever cost data are available. He may spend even more time searching for a less costly design alternative and proving that it will not impair product function. Budgeting the time and cost of value engineering efforts is like budgeting for product research efforts. Both kinds of effort may be more time-consuming and costly than gains they achieve for a particular project.

Initially, the total V.E. job to be done should be broken down into components that are classified, (1) by the functions required to be performed, (2) by the relative total cost of each component (in comparison with value standards if available) designed to perform the functions, and (3) by the kinds of V.E. talent and experience available to be applied to a job. Perhaps the manager of value engineering in a corporation breaks down his job in components which may consist of several major equipment end items, each of which is the job for a value engineering team. In turn, the V.E. team would break down its job into smaller sets of components, each set comprising the job for a single value engineer to tackle. Thus, there is almost always a set of components to which V.E. techniques should be applied. Each component within the set should be ranked according to a preliminary quantitative estimate of the cost-reduction opportunity that could be realised by spending more value engineering effort time and money. To control expenditures of this additional V.E. effort, the following rule can be used by the manager or the individual value engineer: if one dollar of additional V.E. effort applied to a component is likely to yield at least $10 of savings in the current project, then expend the additional effort. Otherwise, shift the V.E. effort to another component of the overall V.E. job to be done.

Thus, the V.E. manager and the individual value engineer should constantly assess the value of expending their own resources.

Summary

As an organized (i.e., specialized) function, value engineering accomplishes essentially two things: (1) it challenges the feasibility of an existing design by invoking cost criteria; (2) it originates design alternatives that will not jeopardize function, but will reduce future costs (production, operating and maintenance) of the hardware.

Value engineering resources and talents are scarce commodities. Criteria are needed for managers and value engineers to decide where, when and to which components of a hardware project existing resources and talents should be applied.

The urgency of need for accelerated improvement in the performance of most defense products means that in design evaluations, cost criteria are not usually invoked as early or as rigorously as performance criteria. It is not usually advisable to apply value engineering techniques until after there is reasonable assurance that some design will meet performance specifications. Until this assurance is obtained, value engineers have little to challenge or offer by way of an alternative. Thus, value engineering techniques can be applied too early in the life of a product. On the other hand, V.E. techniques can be applied too late to achieve maximum cost reduction. Generally, V.E. should be applied initially after the laboratory (or "breadboard") model has been tested and approved and before production has commenced.

Criteria for focusing V.E. efforts stem from three sources: (1) comparing actual or estimated costs with value standards; (2) a relative ranking of the costs of the items being considered; and (3) a classification and matching of V.E. resources with the total job to be done.

PERT/Cost networks are useful for guiding V.E. efforts because they contain explicit estimates of the types, sequence, time and cost of activities required to produce prototype models of a product design.

The extent of V.E. efforts can be measured in terms of hours or dollars of effort expended. A reasonable guide for budgeting additional V.E. efforts is to continue allocating more funds and manpower to value engineering as long as the expected gains equal or exceed ten times the cost of the added V.E. efforts.

Chapter IV

MANAGEMENT REVIEW AND ACTION

Introduction

Preceding chapters have described the steps required to select a product for value engineering, to make a V.E. study of the selected product and to prepare change proposals based on the results of the study. The completed proposals must then be reviewed and evaluated by originator and customer management.

For V.E. proposals, the reviewing or checking element of the engineering change procedure concentrates on two basic factors: first, does the proposed change provide a product which meets required performance capabilities and, second, does the change reduce total future costs. "Will it work?" and "How much will it save?" are two questions of fundamental importance. Answering these questions initially is the responsibility of the originator and is an integral part of the V.E. methodology presented in Chapter II. Assuring that they have been answered completely and correctly is the responsibility of reviewing authorities.

This chapter discusses the responsibility of originator and customer reviewing authorities and presents some of the factors they must consider during review of V.E. change proposals. Although the material in this chapter is primarily intended for reviewing personnel, the content should be carefully studied by originators, since a thorough knowledge of how a proposal is evaluated will have a salutary effect on the thoroughness and completeness of proposal preparation.

The DOD Engineering Change Procedure

Since most V.E. proposals involve engineering changes, the usual method for processing and evaluating them is through the engineering change procedure. The Department of Defense recognizes that deficiencies exist in the engineering change procedures currently in use, the most serious being the lengthy delays which often occur between preparation of a proposal and final action on it. Nonetheless, these deficiencies are not so serious that they prevent the successful processing of value engineering proposals, provided these proposals are adequately prepared and aggressively followed up by the originator. The problem of timely processing of engineering changes is currently being studied. Some useful improvements already developed include:

- Giving proper priority to cost reduction changes.
- Using a sound processing scheduling system.
- Modifying the change process by such methods as using concurrent flow, setting time limits, assigning specific responsibilities and using modern data handling techniques.
- Preparing clear and accurate change proposals.
- Reviewing these proposals prior to submission to ensure that they are complete, correct, of significant value and readily subject to customer review.

Additional improvements will be forthcoming as these studies progress.

Who Reviews V.E. Change Proposals

It is the job of the value engineering specialists who originate change proposals to gather and organize the facts and do the testing necessary to prove, to their satisfaction, technical and economic feasibility. This is an integral part of the methodology of V.E. as discussed in Chapter II. This effort culminates in the preparation of a formal V.E. change proposal, or abandonment of the study.

Management review of a change proposal at the originating activity level may take many forms but, in general, all are similar in function. The usual procedure is to route the proposal to the technical staff with design and/or production responsibility for the product affected by the change. These specialists in turn may request the opinions of other technical staffs before endorsing or rejecting the proposal. If the technical staffs agree that the proposal is technically feasible, it is sent to financial control personnel (cost analysts and cost estimators), who may or may not modify the estimates of savings that were prepared by the originators. Next, the project manager, if satisfied that the proposal is valid, authorizes its submission to the customer (Department of Defense).

The customer subjects the proposal to review by its technical staff; a design configuration control group, if necessary; by cost analysts; and, finally, by the program manager. The skills required in reviewing V.E. proposal often involve a combination of those possessed by design engineers, production engineers, maintenance engineers, logistics specialists, cost accountants, estimators and analysts. In addition, to be effective, the review procedure requires skills in communicating, understanding and bridging all these specialized fields.

Review for Technical Feasibility

There is no standard method for reviewing the technical feasibility aspects of all V.E. change proposals. Decisions may be made quickly and easily on some because of the nature of the proposal or by reference to well-known, similar products or designs that support the change. Other proposals may require full-scale operational tests to satisfy the customer that they are technically feasible.

In formulating a proposal, the originator, if he does a complete job, investigates technical feasibility from several points of view. At the minimum, he satisfies himself that:

- Function has not been sacrificed.
- Reliability requirements are met.
- Quality requirements can be maintained.
- The changed component or part is compatible with the system.
- Safety has not been prejudiced.
- Maintainability has not been sacrificed.

Obviously the reviewing authority cannot repeat all the technical analyses performed by the originator. Rather, he assures himself that approved, sound testing methods and reliable, approved data and engineering techniques were used by the originator during the process of formulating the proposal.

Finally, the review of technical feasibility includes consideration of its applicability to other products and/or specifications and standards. Even if the proposed change proves not feasible for the product intended, review authorities might determine that it could be used for other products. The point is that proposals can be useful to other product design and development engineering projects—especially if the originators' evaluations are rigorous and conclusive. The extent to which a proposal is applicable to other products also affects the reviewing authorities' consideration of its economic feasibility.

Review for Economic Feasibility

The review for economic feasibility usually is more rigorous than for technical feasibility, because the reviewer has more complete knowledge of the economic than of the technical factors. The originator, building a component or system to a specification, is in a better position than the reviewer to prove technical feasibility. However, the originator seldom, if ever, has complete knowledge of such economic factors as:

- Number of units to which the change may ultimately be applied.
- Applicability of the proposal to other products.
- Loss from disposal (other than at originating activity) of material made obsolete by the change.
- Cost of negotiating a Contract Change Notice.
- Cost of preparing and distributing technical documentation to all affected parties.
- Cost of reviewing proposal at customer level.

The first three of these factors can be determined with reasonable accuracy, at relatively little cost or effort. The others cannot, and in the absence of specific, readily available cost data, must be covered by some form of surcharge.

A. *Factors Readily Determinable with Reasonable Accuracy*

1. *Number of Units to Which Change will Apply*

In terms of the number of units of a product, the originator measures the applicability of a V.E. change proposal to those units that will be produced after the change is implemented, as provided in his procurement contract then in force. Plans for future procurement contracts are susceptible to cancellation. Therefore, to be realistic, the estimates of total savings from a V.E. change should apply to units produced under the contract currently in force.

The customer reviewing authority does not necessarily have to be as constrained. He should use all knowledge available to help him make a judgment as to the most likely number of units to which a change will be applied.

2. *Applicability to Other Products*

While the originator should include in his proposal any known applicability to other products, the customer has a greater capability for identifying this. The reviewer should ensure that his review procedure provides for this. In those cases where it is determined that a V.E. proposal is applicable to other products, the total net savings from such application must be determined. This requires the reviewer to subject the additional possible application to the same rigorous cost analysis that is spelled out in Chapter II.

3. *Loss from Disposal of Material*

The proposed change may make obsolete certain spare parts that have already been provisioned in inventories at the time the change is implemented. The value of these spare parts is reduced, perhaps to nothing. There may even be a significant additional expense to dispose of these obsolete parts.

The loss of material made obsolete by a V.E. change may be significant to the savings calculations, although strictly speaking, they generally should not be counted as part of the non-recurring expenses of making a V.E. change. The cost of providing this material has already been incurred in the past; what is done now cannot change the past. It is not realistic to penalize future realizable savings by expenses that were incurred in the past. As a practical matter, however, the expense from not using, and perhaps disposing of parts already bought for building the product or provisioning it in the field, may be included as a non-recurring cost of a V.E. change—especially if the parts could be used if the change were not made.

B. *Use of Surcharges*

All the costs that must be considered by review authorities cannot be developed or estimated easily or with a high degree of accuracy. Included in these costs are those of (1) negotiating a Contract Change Notice, (2) preparing and distributing technical documentation and (3) reviewing the proposal at the customer level. In these cases, it is necessary that reviewing activities develop and apply surcharges to each V.E. change proposal. Development of these surcharges will not be an easy task because of the lack of cost data. Until such time as cost data is available, these surcharges will have to be established somewhat arbitrarily. It is important that these surcharges, once established, be made known to originators of V.E. change proposals and that reviewers make their application a matter of record in each proposal they review.

Summary

The engineering change procedure is the most frequently used method for evaluating and controlling V.E. changes. Although deficiencies exist in current change procedures, active steps are being taken to correct them. Primary responsibility for demonstrating that a V.E. change proposal is technically and economically feasible rests with the originator. Management review, however, assures that the originator has completely and correctly demonstrated total feasibility.

The originator usually is in a better position to determine technical feasibility than the reviewer. Thus, the reviewer attempts to assure that the proper techniques were used by the originator in demonstrating technical feasibility—he usually does not repeat, for instance, the testing program. On the other hand, the review authority usually is in a better position to determine total net savings, i.e., the economic feasibility, because as the customer he has knowledge of economic factors not available to the originator. These factors must all be considered during the review of proposals.

It is important for the originator to fully understand the processes which the reviewing authority uses in evaluating proposals. Such an understanding will enable the originator to improve the quality of V.E. proposals submitted for review. Patterning the originating activity review procedure after the customer review procedure contributes to the effi iency with which V.E. change proposals can be processed.

Chapter V

ORGANIZATION

Introduction

Preceding chapters have covered the definition, philosophy, methodology and application criteria of value engineering as well as the evaluation and review processes necessary to bring it to fruition. The methods of organizing the value engineering function are equally important. Full benefits of the V.E. program cannot be achieved without a well-planned, sound organization.

An effective organization consists of more than a number of neat black boxes and lines on a chart. It is a living organism made up of people whose efforts are directed toward a common objective. In the final analysis, the success or failure of an organization depends on the quality of people selected to staff it. The selection and training of qualified personnel and the motivational influences required to stimulate them are the subjects of other chapters of this Handbook. However, the basic requirement for well-qualified people should be kept firmly in mind when considering the organizational aspects of a V.E. program.

Two Types of V.E. Functions

There are two functions which must be considered in structuring an organization to do V.E.—the coordinating or planning function and the operating function. In smaller activities these two functions may be performed by the same group, yet the functions remain separate and distinct.

The coordinating function is principally characterized by its assistance to those who perform the V.E. analysis, while the operating function is concerned with the actual performance of V.E. Each of these functions is discussed below.

A. *The Coordinating Function*

The coordinating function is concerned with overall program control, assignment of savings targets and the allocation of resources necessary to meet these targets, determination of priorities, measurement of progress both quantitatively and qualitatively and development of policy and procedures for the application of value engineering.

A typical list of responsibilities assigned to the coordinating function follows:

- Program control throughout the organization. This includes selection of product areas to be subjected to study, assignment of savings targets to each of the units within the activity, allocation of resources necessary to meet these targets, development of reporting systems to measure progress toward these goals and performance of periodic informal reviews to qualitatively evaluate the various elements of the program.
- Development and supervision of the V.E. training program in cooperation with the training department.
- Continuous review and follow-up on all V.E. changes in process, both within the organization and at the customer level.
- Provision of technical guidance to operating V.E. units, including dissemination of information concerning new technological advances which possibly can be of use in the V.E. effort.
- Management of a publicity program directed to top management and to all personnel who are or should be concerned with product value, informing them of the results of the V.E. effort.
- Accumulation of cost data, both internally and from outside sources, in order to support the development of valid value standards.

B. *The Operating Function*

The operating V.E. function is concerned with the actual performance of value engineering. The prime responsibility of this group is to conduct V.E. studies and generate V.E. change proposals. This function is carried out by value engineers or by other personnel trained in the value engineering technique. Succeeding sections of this chapter discuss a number of ways of organizing the application of the value engineering technique, regardless of when or where it is applied. The basic technique, as set forth in Chapter II, remains the same.

Additionally, the operating function usually has the responsibility for ensuring that any V.E. proposal is carried through to completion, i.e., either implementation or rejection. In other words, it is the operating function that is responsible for "closing the loop" on the V.E. process, although in some organizations the coordinating function shares the responsibility for "closing the loop."

Key Variables Affecting Organization Structure

There is no one magic pattern which represents the optimum organizational structure for performing the value engineering function. A basic distinction must be made between producing activities and procuring activities since their approach to V.E. is different due to their basic purposes. Even within these broad groupings, which are discussed separately in succeeding sections of this chapter, organizational patterns vary from activity to activity depending upon several key variables, such as size of the operation, the product mix involved and the existing organizational structure of the activity.

The size of the activity will determine the number of levels in the V.E. organizational structure. For example, in a small company the V.E. function may be organized in only one unit or even in one man, embodying both the coordinating and operating functions. On the other hand, in a very large company there may be a corporate director of V.E., division managers of V.E. and plant managers of V.E., all performing only the coordinating function. In addition, there may be a number of operating V.E. units in each of the major departments of each plant.

The type of product produced by the activity greatly affects the type of V.E. organization. For example, a company specializing in research and development on advanced aerospace equipment obviously will be heavily engineering oriented and the principal focus for V.E., therefore, will fall within the engineering department. On the other hand, a manufacturing company primarily engaged in the production of standardized military items which are procured in large quantities on a recurring basis tends to concentrate V.E. effort in the production department. Another company that subcontracts a great portion of the total dollar value of their contracts might well place primary emphasis on V.E. in the purchasing department.

In order to inject a new management tool into a going operation with the least possible confusion, it is desirable to utilize to the maximum possible extent the existing organizational structure. There is an organizational similarity between V.E. and other disciplines such as reliability, quality control and maintainability. V.E. might be fitted into an organization in the same manner as these other disciplines.

V.E. Organization in the Producing Activity

A. *The Coordinating Function*

The specific location of this function varies from organization to organization due to the several variables already mentioned. Because of their natural tie-in, however, many companies have integrated the value engineering staff activity with quality control, reliability and maintainability and grouped these functions under the general heading of product assurance. This is a reasonable and logical way to organize the V.E. coordinating function, particularly in engineering-oriented organizations.

The coordinating function is not limited to a particular level of an organization. For example, it may be required at two or more levels in a large company; in small operations only a single level may be required. However, it is important in any size organization that the highest level coordinating function represent a clear focus of responsibility for the overall performance of the value engineering effort. It also is important that this function report to an executive with the power to cut across departmental or divisional lines, since there will normally be V.E. activities in two or more departments, such as engineering, purchasing, production, etc.

B. *The Operating Function*

The operating function of value engineering can be organized in a number of ways depending upon the size, product mix and existing structure of the company. In practice, however, most of the patterns fall into three categories:

1. *Inter-functional Project Teams*

"Ad hoc" teams of specialists including full-time value engineers are assigned to perform value engineering on specific components, subsystems or end items. Normally the team is comprised of representatives from various departments, i.e., design, production engineering, purchasing, industrial engineering, manufacturing, etc. The complexity of the hardware and its cost will determine the intensity of anaylsis undertaken by the project team. The team may work on a full or part-time basis and may be established for a short term (two weeks) or for a long period of time (six months). The team approach can be used in any stage of the project cycle but, in practice, it more frequently is used downstream rather than in the design stage. This method of organizing the operating function has the advantage of bringing together a number of diverse yet complementary talents which provide a multi-disciplined approach to the problem. The disadvantage of this approach is that it does not provide for the development of a continuing capability in depth since project teams are normally disbanded after the completion of their task.

2. *Project Value Engineers*

In this approach a value engineer is assigned to a particular project to do V.E. from design through production. In this case, the value engineer normally has a high technical capability in the product area to which he is assigned. He is responsible for ensuring that optimum value is built into the product at every stage in its development. This method of organizing the V.E. effort has the advantage of providing a continuity of value engineering analysis through all design and production decision points. Its disadvantage is that the number of projects which can be value engineered is limited by the number of professional value engineers on the staff.

3. *Procedural Review Points*

Under this method a value engineer participates in all committee decisions at the established review points such as design reviews, make-or-buy reviews, systems integration, drawing release points, etc. The value engineer in this case is responsible for ensuring that value considerations are given proper weight at each of these decision points. This approach permits the value engineering staff to subject more projects to V.E. analysis. It usually is linked with widespread training programs which attempt to train all personnel concerned with product value to perform V.E. as part of their every day job. The role of the professional value engineer at the review points is principally one of determining whether value has been properly considered in the product's development and production. The disadvantage of this system is that it does not encourage any intensive, in-depth value engineering studies.

There are many variations on the above three methods of organizing at the operating level. The three general patterns mentioned above obviously are not mutually exclusive. Many organizations use combinations of the above—some even use all three at the same activity. The determination of the correct one to be applied at any given activity is a function of the variables referred to earlier (size, product mix, existing organization structure.)

The type of V.E. training program used by the activity can have an effect on the type of organization selected. For example, as cited above, an activity that has put a large number of people through a seminar training program could decide to select alternative 3 (above) and use a few value engineers only as monitors to ensure that value has been built into the product.

V.E. Organization in DOD Procuring Activities

Many of the comments made in the preceding section covering V.E. organization in industrial activities, both private and Government, also are pertinent to a discussion of organization for V.E. in DOD non-industrial activities. For example, even in non-industrial activities the coordinating and operating functions remain distinct and identifiable. Generally speaking, the higher levels in the DOD are concerned with the coordinating function while the operating function is found principally at the field activity level. The basic difference, however, between producing and procuring activities is that the latter place primary emphasis on evaluation of proposals and on pre-procurement purification of specifications rather than on detailed V.E. studies.

There are, however, some significant differences in the environment of field activities which need to be clarified. The prime responsibility of the V.E. unit in these activities is to provide assistance to technical staffs in evaluating V.E. change proposals submitted by contractors. Generally, V.E. studies performed by a procuring activity are secondary in importance and are limited to a study of the specifications contained in procurement packages. The V.E. units at any procuring activity also provide guidance to contracting officers concerning the type of V.E. incentive clause to be included in contracts. Although assistance in evaluating contractor proposals and guidance to contracting officers is also a responsibility of V.E. units at the command and technical bureau level in DOD, their primary responsibility is overall program control.

As stated earlier, there is no one correct way to organize the V.E. effort in procuring activities. As a rule of thumb, however, it can be stated that V.E. has some close kinship with the disciplines of quality control, reliability and maintainability and, therefore, should wherever possible be organized similarly to these functions.

Determination of the Level of Effort

Over a period of time the level of V.E. effort to be applied will be determined by the ratio of net savings achieved to costs incurred. Generally speaking, this ratio should exceed 10 to 1; in other words, for every dollar spent for value engineering, the activity should recover ten or more dolars. This ratio of return may not be possible, however, where the total effort is applied to development programs which include only the production of a few end items. Returns of as low as 2 to 1 may be worth while in such instances.

It is a more difficult matter, however, to determine how much to invest initially in a V.E. program. The level of effort is a variable depending upon whether it is a producing or procuring activity, the size of the organization, the products handled, etc. Experience to date indicates that a budget of from 1/10 of 1% to 1/2 of 1% of total annual dollar volume is an appropriate level for producing activities. For procuring activities, a level of effort approximately one-half of the range for producing activities is considered reasonable but may vary considerably depending upon the degree of inhouse specification analysis undertaken by the procuring activity. These figures are presented only as guidelines and should not be taken as inflexible limitations.

The structure of the V.E. organization also will be a determining factor in the level of effort to be applied. The overriding consideration is a reasonable return on the funds invested. Understaffing the V.E. function does not permit maximum utilization of the technique; overstaffing leads to a lowered savings to cost ratio and damages the program by subjecting it to charges of "empire building."

Illustrative Examples

The following examples of organizing for the V.E. function are intended as illustrations of the concepts presented in this chapter. They are not intended for use as "preferred" models.

Example 1—Defense contractor A is a prime producer in the aerospace industry and has an annual dollar volume of five hundred (500) million dollars in military contracts, many of which are research and development projects. The company has two major divisions, the aeronautical division and the missile and space division which are separated geographically. The prime responsibility for the V.E. effort in this company is lodged in a corporate director of value engineering who is concerned with the overall program control, policy guidance and direction of the company-wide V.E. training program. Each of the two divisions has a division coordinator of value engineering reporting to the vice presidents for engineering. Each of these managers has several full-time value engineers on their staffs to assist the manager in determining priorities of projects to be subjected to value engineering, allocating resources to these projects, setting targets for expected results and measuring progress toward these objectives. Within the engineering, production and purchasing departments of each division there are a number of value engineers who are assigned to specific projects. Once assigned, a value engineer remains with the project throughout its life in the company, performing V.E. on the hardware at preselected points in the product cycle. To the extent possible, the studies are timed to coincide with already established review points such as design reviews, make-or-buy decisions, drawing releases, etc. (See organization chart, Exhibit 1.)

Example 2—Defense contractor B is a manufacturer of ordnance items for the military. All manufacturing is done at one plant which has an annual volume of twenty (20) million dollars. All of its military contracts are for the production of relatively stable items which are re-procured on an annual basis. This contractor has only one full-time value engineer who reports to the manager of industrial engineering, who in turn reports to the vice president of manufacturing. The value engineer performs both the coordinating and operating functions. He selects his own projects after conferring with the managers of industrial engineering, production and production engineering. He conducts many of these projects himself but, in some cases, participates in a team effort with representatives of the production engineering department and various shop departments. (See Exhibit 2.)

Example 3—Shipyard C has a staff of four full-time value engineers reporting to the chief design engineer, who reports to the Planning Officer, who in turn reports to the shipyard commander. The value engineering department carries out both the coordinating and operating function. Most of their projects, however, result from suggestions generated in other departments of the yard or, in some cases, from other shipyards. Their principal effort is directed toward, first, screening these suggestions to select out those which look the most promising and then, second, carrying out V.E. studies on the priority projects. In performing the actual analysis, they often draw heavily upon personnel in other departments of the yard. (See Exhibit 3.)

Example 4—Procuring activity D is responsible for the procurement of aeronautical spare parts for one of the military services. It has a manager of value engineering, reporting to the director of procurement, who is responsible for the coordination of V.E. activities in each of the procurement divisions of the directorate. Value engineers in each of the procurement divisions perform value engineering studies on priority items selected by the manager of value engineering prior to their procurement by the various contracting officers. The V.E. studies principally consist of a detailed analysis of the specifications contained in the procurement packages. In addition to performing V.E. studies of the type mentioned above, the value engineering staffs of the divisions often are called upon to assist the technical staffs of each procurement division in evaluating value engineering change proposals submitted by contractors. See Exhibit 4.)

Summary

A sound organizational structure is an essential requirement of an effective value engineering program. There are two functions to consider; the coordinating and the operating functions. The former is concerned with assisting those who perform V.E. while the latter is directed toward the actual performance of V.E. There is no one correct way to organize the V.E. effort. The specific structure selected depends on a number of key variables; size of the activity, product mix, existing organization and whether the activity is a producer or procurer of hardware. In producing activities, emphasis is placed on performing V.E. analyses. In procuring activities, the major effort is directed to evaluating and processing V.E. change proposals submitted by the producers of hardware. In addition, procuring activities may establish an "inhouse" V.E. effort concentrating on pre-procurement analysis of specifications. The level of effort will eventually be determined by actual return on investment but initially, for producing activities, the cost of the V.E. program should range between $\frac{1}{10}$ of 1% to $\frac{1}{2}$ of 1% of the total annual dollar volume of the activity. For procuring activities, it should be approximately one-half of this figure but may deviate considerably from this range depending upon the degree of inhouse specification analysis undertaken. The overriding consideration is the attainment of a reasonable return (10 to 1 or more except on certain types of development programs) on the funds invested in the value engineering effort.

DEFENSE CONTRACTOR "A"
VALUE ENGINEERING ORGANIZATION CHART

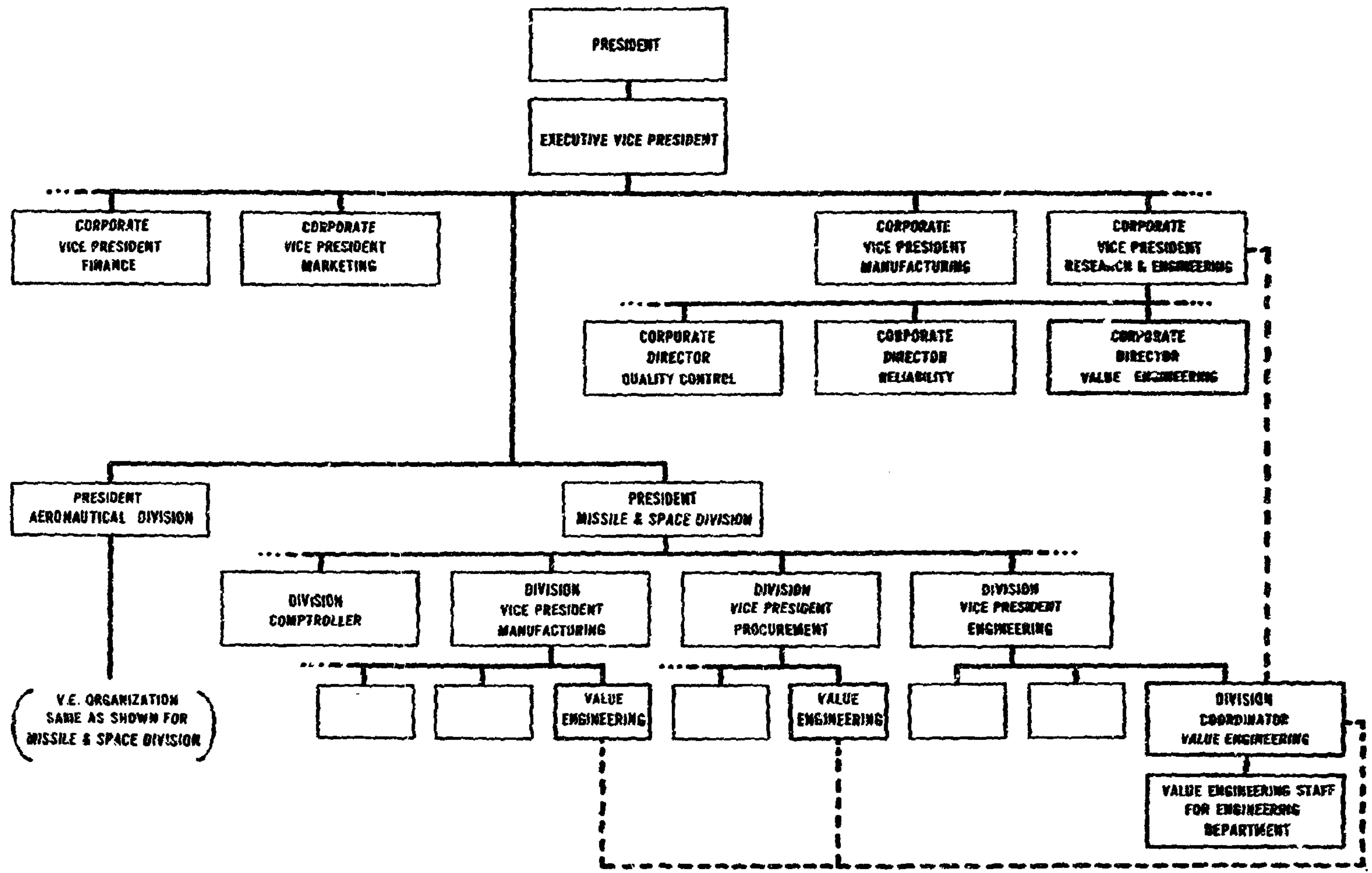


Exhibit 1

DEFENSE CONTRACTOR "B"
VALUE ENGINEERING ORGANIZATION CHART

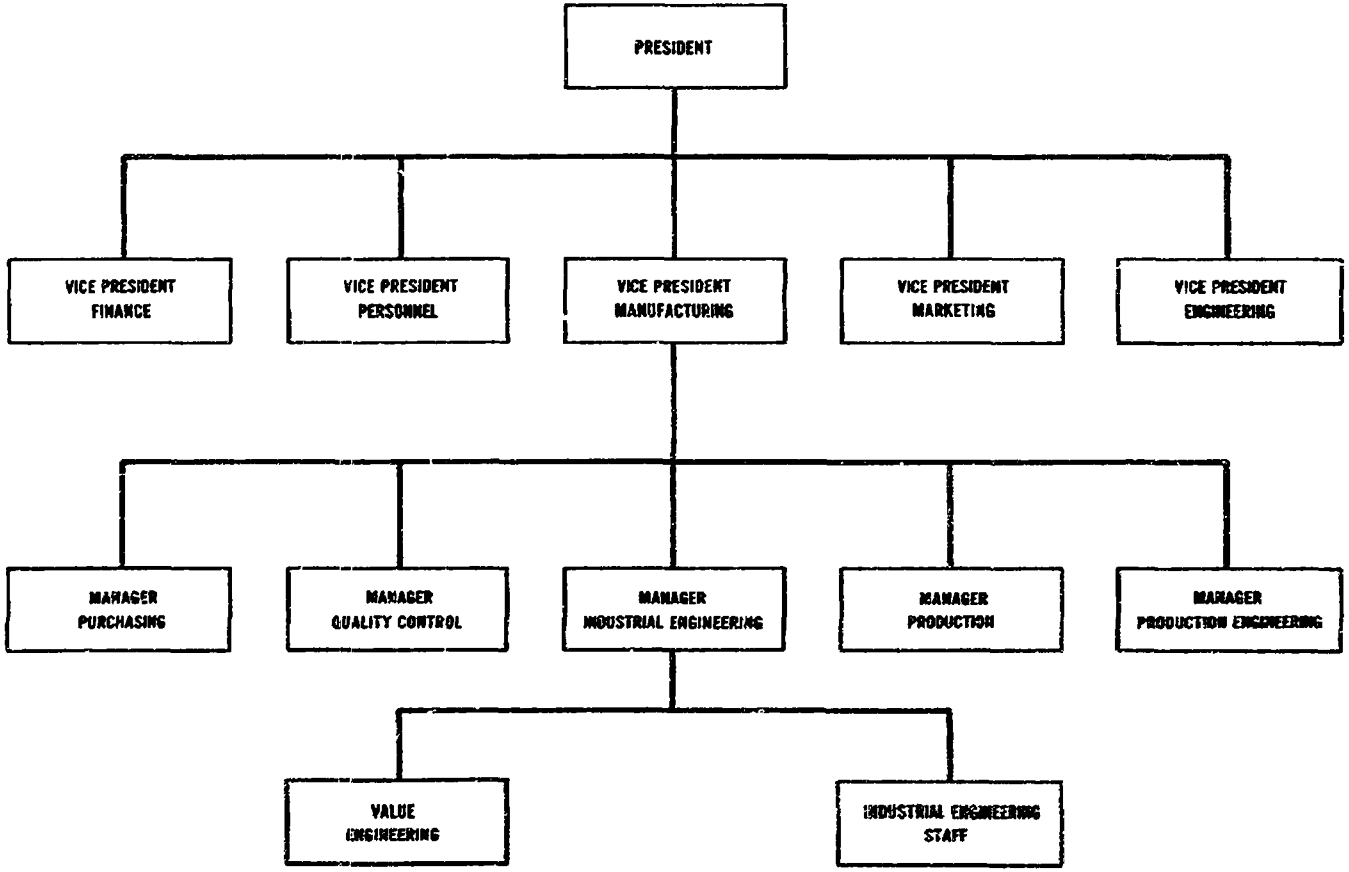


Exhibit 2

SHIPYARD "C"
VALUE ENGINEERING ORGANIZATION CHART

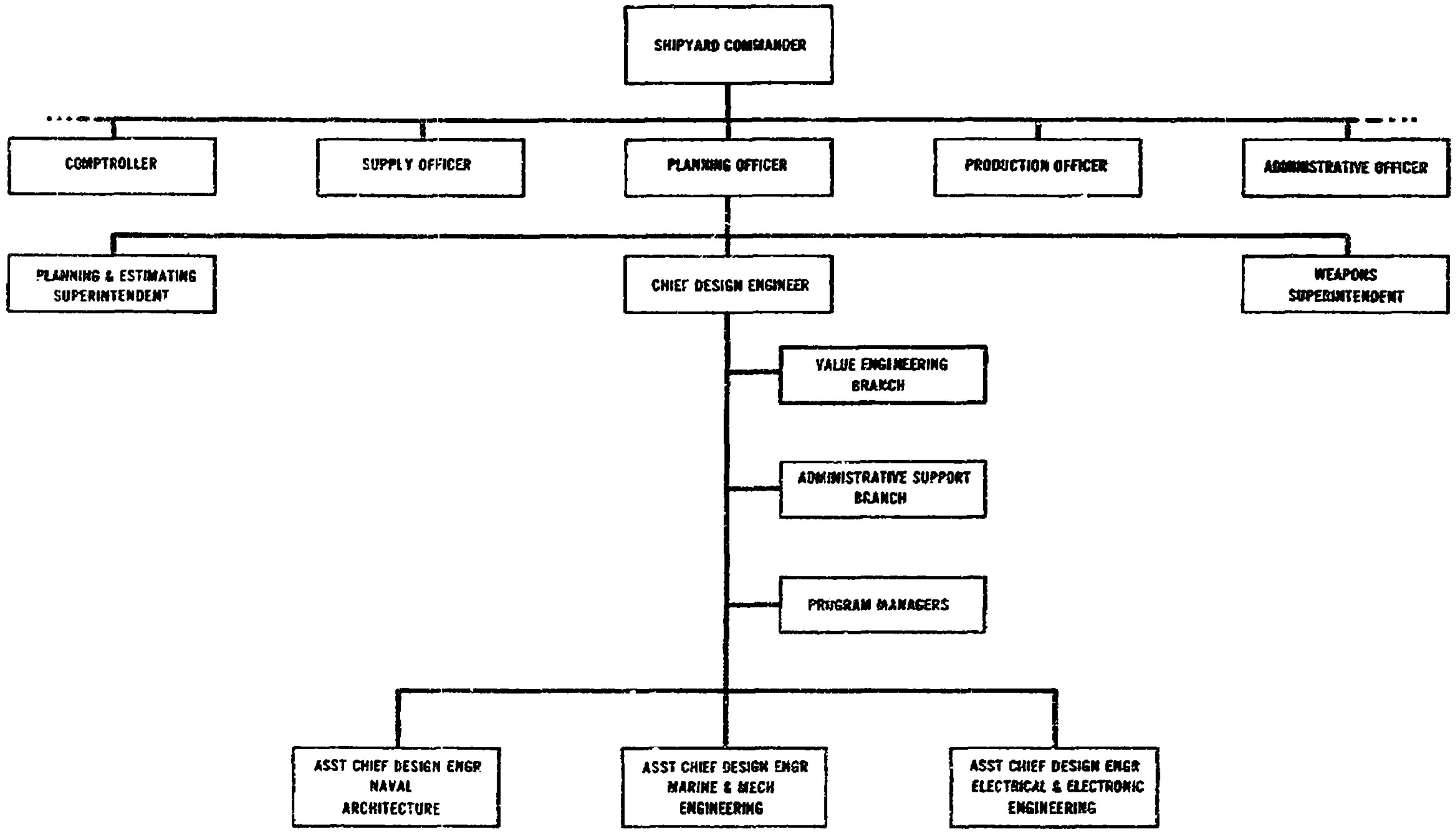
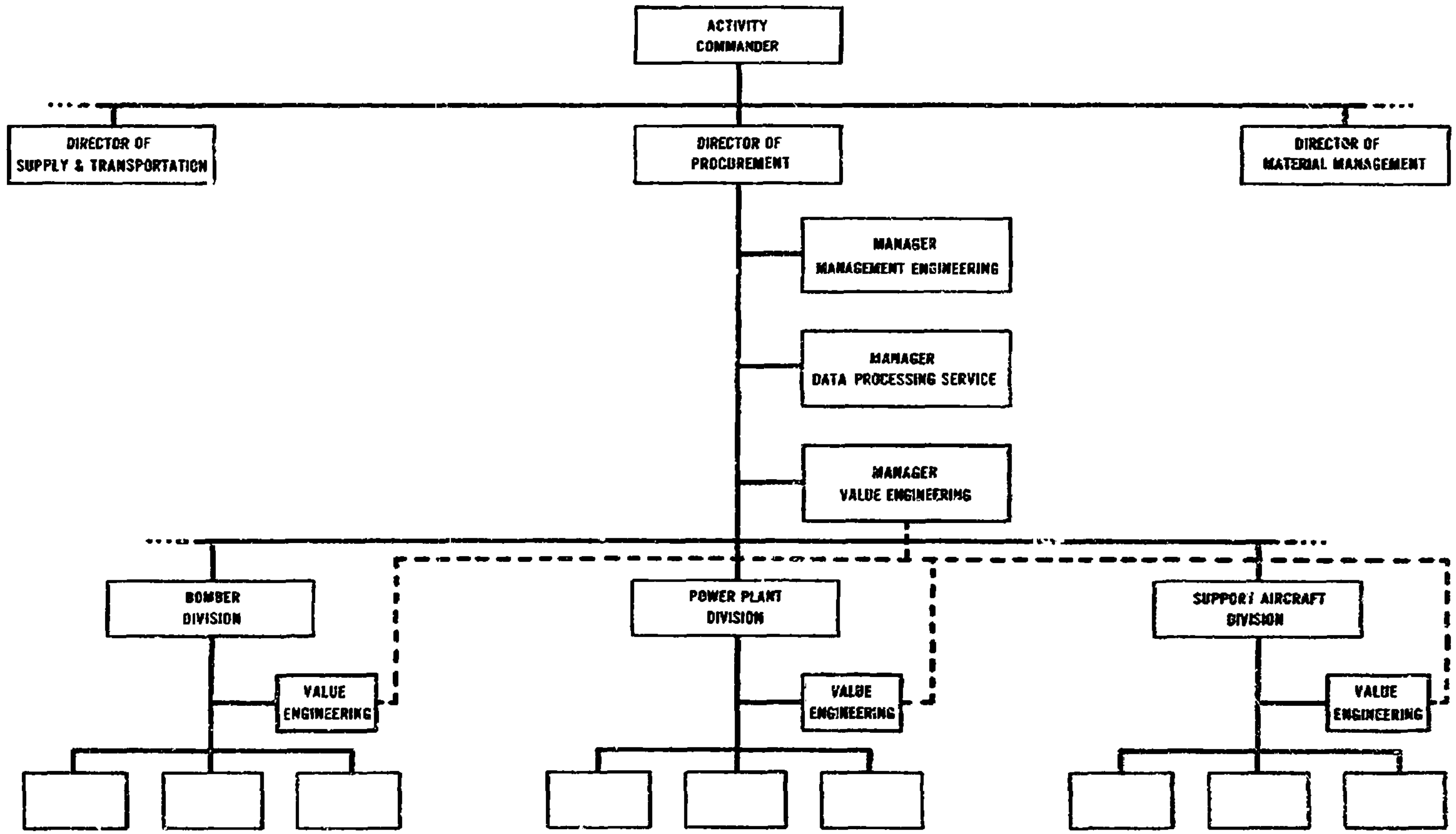


Exhibit 3

Exhibit 4

PROCURING ACTIVITY "D"
VALUE ENGINEERING ORGANIZATION CHART



BRANCHES ORGANIZED BY SPECIFIC AIRCRAFT OR ENGINES

Chapter VI

TRAINING

Introduction

Man are not born with the specific skills that society requires, but must develop them. Consequently, carefully formulated programs for training personnel are essential to any new and emerging program. Increased emphasis on value engineering training is mandatory if the full potential of V.E. is to be realized.

A planned program of value engineering training in appropriate DOD/Industry organizations is required. Only in this way will the skilled manpower become available to do the value engineering job. A corollary benefit will accrue. Any planned program of training demonstrates an organization's interest in the development of its personnel. Thus, training programs are an effective integration of the interests of both management and employe[illegible]

In discussing v[illegible] engineering training, a distinction must be made between the full-time value engineering specialist, i.e., the "professional" value engineer, and other operating personnel. With respect to the specialist, training programs generally assume that formal academic training in an engineering or related discipline has been completed. Closely supervised on-the-job training and rotational work assignments are the most frequently used techniques for training the V.E. specialist. The objective is a fully-qualified value engineer capable of holding his own in a formal value engineering job environment. The V.E. training for other operating personnel can be accomplished through indoctrination lectures and participation in workshop seminars. The objective of this training is to give the individual a basic understanding of the goals of V.E. and to present to him some specific V.E. techniques for use in his work.

This chapter presents some of the techniques that have been used successfully in value engineering training. Workshop seminars and indoctrination lectures for training operating personnel are discussed. The contribution of formal institution training, on-the-job training and rotational work assignments to the development of full-time value engineers is outlined. Attention also is called to a few miscellaneous training techniques that have been found useful.

Obviously, these training techniques are not mutually exclusive, nor will every organization need to employ all types of value engineering training at one time. Decisions as to what types are appropriate and who is to be trained depend in part upon the size of the organization and the scope of its activities.

Techniques for Training Operating Personnel

A. *The Workshop Seminar*

1. *Purpose*

Workshop seminars are the main source of formal value engineering training for operating personnel. Because workshop seminars identify individuals with special aptitude for value engineering, they also can be considered as one of the first steps in developing qualified full-time value engineers. Incorporation of the "learn by doing" technique in the form of project work demonstrates the feasibility of value engineering methodology.

The broad objectives of workshop seminars are to:

- Educate personnel in the methodology of value engineering.
- Demonstrate by personal participation that the methodology is effective as a routine discipline for cost reduction.
- Improve communication between all groups concerned with product value.

- Identify personnel who have talent for value engineering.
- Develop raw data for actual V.E. change proposals.

2. *Characteristics*

The particular arrangement and curriculum for workshop seminars will vary according to the organization's products, major business, size and structure. However, certain definable attributes of the workshop seminar are considered fundamental. Each of these are discussed in the following paragraphs.

a. *Priority of Attendance*

Conflict between the pressures of daily task accomplishment and seminar attendance must be resolved prior to student selection. Stress should be placed on the need for regular attendance.

b. *Duration and Session Schedule*

A range of forty to eighty hours is suggested. The time should be divided about fifty-fifty between lecture and project work. Half-day and full-day sessions have been found to work well; less than half-day sessions have been found inadequate. In any event, the total calendar time between the first session and the last session should range from two to four weeks. Less than two weeks may not provide sufficient time for the attendees to obtain suitable cost data on their projects, especially if outside vendor quotations are required.

c. *Number of Participants*

Class size will vary according to the organizational needs and the availability of experienced personnel to serve as team project leaders. Past practice indicates the optimum group to be about forty persons. However, satisfactory results have been obtained with groups of one hundred. The larger group obviously requires more careful planning of project work and vendor coordination.

Attendees for each seminar should be drawn from the various line and staff groups. The following groups should be represented at each seminar: engineering (design, project, specification, test), purchasing, manufacturing, reliability, finance and quality. One or more personnel from contracts, sales/marketing, industrial relations and [illegible] ther f[illegible]tion which has interfaces with va[illegible] [illegible]siderations sho[illegible]ld be scheduled to attend the first seminar. They then can serve as the value engineering training contact within their respective areas.

The interfaces between Government agencies and contractors can be improved through the workshop seminar. Significant communication improvements have been achieved by inviting subcontractors, contractors or Government agency representatives to attend.

d. *Team Organization and Responsibility*

Seminar attendees are assigned to teams of from four to eight for the project portion (see e. below). A team of six or seven permits more complete workshop coverage of advanced value engineering methodology such as the development of value standards or a cost target plan for the project.

Each team is held responsible for the preparation of a report which describes its application of the lecture theory to their workshop project. Upon completion of the seminar, these reports normally are submitted to the value engineering line organization for possible implementation.

Many workshop seminars devote their last few hours to oral presentations by a few or by all teams. Team members are called upon to present conclusions and recommendations resulting from their study project.

e. *Workshop Projects*

Projects are an essential element of the workshop seminars. The participants, working in teams, apply the value engineering methodology to a piece of hardware. This exercise frequently results in significant cost reduction [illegible]osals, thereby proving to the individual that [illegible]an improve product value and that the value engineering methodology does work. Although seminar project work is an exercise, it must offer a real opportunity for the team's efforts to be realized. Every attempt should be made to select a "live" project, with actual savings potential.

The following features are desirable for workshop projects:

- Prejudged as susceptible to cost improvement.
- Assembly of from five to fifty individual parts or details.
- Hardware sample and/or mockup is available.
- Drawings, specs, layouts are available.
- Total cost per program is large enough to achieve measurable reduction.

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- Performs a distinct function by itself.
- Responsible designer or equivalent agrees to its use.
- Unclassified.

Projects should be selected at least two to four weeks in advance of the seminar. One project per team and a few spares should be prepared. A distribution of projects among electronic, mechanical, hydraulic, etc., is usually desirable. It is not necessary for the attendees to have specialty knowledge concerning the equipment to be value engineered.

A data package must be prepared for each seminar project. A data package check list is included as Exhibit 1 to this chapter. In addition, ground rules to guide the team should be provided for each project. These should specify the anticipated quantity to be used in calculating alternate costs, learning curve factors and a policy for computing the cost of making changes.

f. *Seminar Leadership*

Three types of leadership personnel are usually involved in a value engineering seminar: lecturers, guest speakers and project leaders. The lecturers provide the theory and background of the value engineering methodology and creative problem-solving. Guest speakers are used, as needed, to cover the areas of inhouse disciplines which touch on value considerations. These include purchasing, cost accounting, contract administration and estimating. Project leaders provide guidance and stimulation during the project work portion of the seminar. Ordinarily, project leaders work with from one to three teams.

The lecturers must combine an understanding of their topic with the ability to communicate. They do not need to be actively working as full time value engineers, but it is desirable that they have previously attended a seminar. At least one of the lecturers should be a value engineer. Guest speakers should be experts in their respective fields. Project leaders must have previous value engineering experience. They should be able to keep the team energized toward the seminar goal. The value engineering staff is the best source of project leaders.

g. *Curriculum*

A seminar lecture schedule should be prepared in advance. The curriculum should cover all aspects of the value engineering methodology as discussed in Chapter II. Lectures should be given on the details of internal procedures that bear upon the value program. This includes topics such as: internal cost procedures, contractual aspects of value engineering, relationship of value engineering to reliability, quality control and purchasing services, etc. A typical workshop seminar curriculum is presented as Exhibit 2 to this chapter.

h. *Vendor Participation*

To acquaint participants with the suppliers' role, a limited number of vendors may be invited to participate in the seminar. Vendors should be invited to send two representatives, one technical and one cost estimating, with a small display of their product or process. Vendors should be selected appropriate to the workshop projects. A portion of the project time (one day) can be designated for team members to discuss their projects with vendors.

B. *Indoctrination Lectures*

This type of training encompasses familiarization sessions of from one to eight hours duration. These sessions introduce the fundamentals, goals and operation of the value engineering program. They are intended for audiences other than those expected to attend workship seminars.

Indoctrination lectures are appropriate for personnel whose primary responsibility does not warrant attendance at a full-scale workshop seminar, such as: middle management executives, senior staff personnel, planning personnel, draftsmen, laboratory technicians and newly-hired personnel.

The specific content of indoctrination lectures must be tailored to the audience. However, certain basic features are common. They are:

- Concepts of value.
- Principles of value engineering methodology.
- Criteria for application.
- Organization and operation of the value engineering program.
- Contractual aspects.
- Case histories.
- Relationship and contribution of the audience to the value enginering program.

The effort to plan and present indoctrination lectures should not interfere with nor jeopardize the workshop seminar effort. However, they should be accomplished as soon as feasible after implementation of the workship program. This type of training activity is normally performed by staff value engineers.

Selecting and Training Value Engineers

A. *Selection Criteria*

Most practicing value engineers have an academic degree in one of the engineering or related disciplines, or they have the equivalent in years of experience in these fields. No formal academic training exists for value engineering, per se. While attempts are being made to develop value engineering courses for inclusion in engineering curricula, it is not likely that value engineering will be recognized as a major subject for academic study, as is electrical, mechanical, industrial or civil engineering. Thus, value engineers must be developed by DOD and industry.

For value engineering trainees, it is reasonable to require academic training in related fields. It would be difficult for someone without this academic background to enter the field and develop at a reasonable pace.

To be successf. . value engineer must be respected for his professional competence, but equally as important, he must have the tact and diplomacy to sell himself and his ideas. An effective value engineering program depends on the skill and persuasiveness of the value engineer in establishing close working relationships with all personnel concerned with product value. Thus, it is imperative that personality traits be strongly emphasized in the selection of value engineering trainees.

As previously discussed, the workship seminar can serve as a screening device in the selection of value engineering trainees. The seminars provide an opportunity for an individual to display value talents and to be observed for evidence of desired personality traits. In addition, workshop seminars give the potential value engineer an opportunity to get a taste of value work before he is committed to it. The interests of cost effectiveness are served by using the workship seminar as a "test bed" before proceeding with on-the-job training.

B. *On-the-Job Training*

On-the-job training is the practical school in which a value engineering trainee learns approved methods of work. He deals with the tools of his trade under the tutelage of qualified value engineers. He is given the opportunity to learn how to apply basic skills to specific and productive work assignments. Perhaps as important as the training received is the satisfaction gained from being productive while in a training status.

C. *Rotational Job Assignments*

Such training frequently is used in conjunction with on-the-job training. It requires the "trainee" value engineer to be assigned to various operational areas for limited periods of time. These areas may include manufacturing, cost estimating, methods engineering, design engineering, etc. Exposure to these other environments serves to broaden the individual's perspective and, in so doing, leads to an improved understanding of the complex nature of product value.

Other Training Techniques

Many organizations choose to train personnel for V.E. through less formal methods than those previously discussed. Many organizations supporting formal training programs supplement them with informal training devices. Some of these informal training approaches are discussed below.

A. *Handbooks and Manuals*

Handbooks and manuals are means of bringing about a climate of cost awareness throughout the organization. These documents can be value engineering oriented in the sense that they define "how to do" value engineering, or they can provide cost data relating to trade-off possibilities between materials, manufacturing processes and related information, or both.

B. *Bulletins and Newsletters*

A value engineering newsletter or bulletin, distributed periodically, could contain a section devoted to value engineering methodology.

C. *Technical Meetings*

Value engineering films or speakers from other facilities may be presented at inhouse colloquia.

D. *Displays*

Case histories annotated to indicate the value engineering method may be placed at strategic locations throughout the organization.

Implementation of Training

A. *Training Responsibilties*

Value engineering training requires participation by many organization elements. Coordination by a central source is desirable to avoid conflict, duplication and dilution of the primary effort. A value engineering training coordinator should be designated to act as the focal point for integration of the total effort. Each functional department should designate one person as responsible for coordinating its participation with the training coordinator.

Most large-scale Department of Defense and industrial activities have training staffs, usually as a part of personnel or industrial relations departments. While the primary responsibility for value engineering training (as with all training) must rest with the line organization, the staff training personnel play a key role. Their assistance to line personnel includes: coordinating individual speciality training, such as value engineering, with the activity's overall training program; developing training devices; providing and scheduling the use of training facilities; training of instructors in the techniques of training, i.e., "teaching the teachers how to teach;" and many other types of assistance that only professional training people can provide.

B. *Training Plan*

A training plan should be prepared as a portion of the overall value engineering program plan. In addition to those elements normally contained in program plans, it should delineate:

- Annual training schedule for the overall organization and for each major functional division.
- Assessment procedure to evaluate training effectiveness.
- A method for developing an inhouse training capability (if none exists and the size of the organization warrants).

C. *Training Capability Development*

The establishment of inhouse training capability must reflect the needs of the organization. Therefore, it is necessary that the personnel responsible for this task be familiar with value engineering and with the overall company or agency operation. Where no value engineering program exists, the inhouse training capability may be achieved by obtaining initial training outside the organization. Some sources of value engineering training are:

- Consulting organizations with value engineering training capability.
- Professional societies (Society of American Value Engineers).
- Colleges/universities (UCLA, Northeastern University, Boston College).
- Large defense contractors.
- Department of Defense agencies, shipyards, arsenals.

Upon completion of this outside training, a Value Engineering Training Plan can be formulated which incorporates the organization's specific requirements. The next step would be to schedule the first inhouse workshop seminar utilizing the services of one or more of the sources listed above. In subsequent seminars, responsibility gradually would be shifted to inhouse personnel, ultimately culminating in a complete inhouse value engineering training capability.

Summary

Training is an important element of a comprehensive value engineering program and requires proper emphasis if V.E. is to reach its full potential. A planned training program is needed to provide the necessary skilled manpower to do the V.E. job.

A distinction must be made between training full-time value engineers and training other operating personnel. The training program for value engineers is necessarily more detailed and includes on-the-job training as well as formal instruction. Rotational assignments are often used to improve the value engineer's understanding of the complex nature of product value.

The workshop seminars can serve as a first step in training value engineers and are a major source of V.E. training for other operating personnel. Indoctrination activities are an appropriate training device for personnel not directly involved in the performance of value engineering. Other, less formal, training techniques employed are manuals and handbooks, bulletins and newsletters, technical meetings and displays.

Responsibility for the training program should be assigned to a V.E. training coordinator. He should develop and implement a total training plan. The plan may include the development of an inhouse training capability if the size of the organization justifies such an effort.

Exhibit 1

DATA PACKAGE FOR WORKSHOP PROJECTS

This is not intended as an exhaustive listing of important considerations, but is intended to serve as a guide.

Drawings, Layouts or Sketches
- Next Assembly
- Assembly
- Detail Parts
- Schematics

Cost (Actual and/or Anticipated)
- Tooling
- Raw Material
- Outside Purchased Parts, Tooling
- Inspection
- Fabrication
- Assembly
- Any Other Significant Elements

Manufacturing Planning and Status
- Tooling Description
- Handling Equipment
- Planning Sheets
- Scrap Loss
- Lot Size
- Packing and Shipping

Contact Points (Name, Location, Telephone)
- Responsible Designer
- Responsible Buyer
- Responsible Cost Analyst
- Responsible Contract Administrator
- Specialty Consultants
  - Theory
  - Fabrication
  - Quality
  - Field Services

Specifications (Performance, Model, Process)
- Customer
- Internal
- Subcontractor

Design Criteria and Status
- Intended Function
- Weight
- Reliability
- Known Problem Areas
- Design History
- Fabrication History
- Procurement History
- Associated Documentation
  - Manuals
  - Handbooks
  - Reports

Contract Data
- Incentives
- Quantity Required
- Anticipated Future Quantity

Purchasing Data
- Responsible Buyer
- Participating Vendors

Photographs

Exhibit 2

TYPICAL VALUE ENGINEERING WORKSHOP SEMINAR CURRICULUM

Session I

10 minutes	Keynote
20 minutes	Value Engineering's History, Concepts, Philosophy
20 minutes	General Orientation of Value Engineering Techniques
20 minutes	The Importance of Evaluating our Habits and Attitudes
10 minutes	Recognition of "Roadblocks" and Overcoming Them
15 minutes	What Value Engineering Can Do for this Division or Operation
10 minutes	Break
15 minutes	Selection of Product for Study
15 minutes	Get All the Facts
15 minutes	Determine Costs
30 minutes	Determine the Function
30 minutes	Functional Workshop
1 hour, 15 min.	Lunch
15 minutes	Put a $ on the Specifications and Requirements
30 minutes	Functional Workshop
3 hours, 30 min.	Project Work (Gather Project Information)

Session II

Project Work (Gather Project Information) Correlate Project Information and Determine Project Function

Session III

15 minutes	Developing Alternatives
30 minutes	Creativity
30 minutes	Creative Workshop
15 minutes	Blast and Create
15 minutes	Break
2 hours	Creative Workshop (on Operation Projects)
1 hour, 15 min.	Lunch
1 hour, 45 min.	Project Work (Creative Session on Project)
2 hours	Determine Function and Create

Session IV

30 minutes	Recap on Information Gathering and Development of Alternative Phases
3 hours, 15 min.	Project Work (Correlate Information From Functional and Creative Efforts)
1 hour, 15 min.	Lunch

Session V

30 minutes	Every Idea Can Be Developed
15 minutes	The Importance of Testing and Verification
15 minutes	How To Refine Ideas
15 minutes	Put a $ on Each Idea
15 minutes	Evaluate the Function
15 minutes	Evaluate by Comparison
15 minutes	Break
1 hour, 45 min.	Project Work—Evaluate Ideas
1 hour, 15 min.	Lunch
15 minutes	The Use of Specialty Vendors
15 minutes	Consult Vendors
15 minutes	Use Specialty Products, Processes and Materials
15 minutes	Use Company and Industrial Specialists
15 minutes	Use Company and Industrial Standards
15 minutes	Break
2 hours, 15 min.	Project Work (Investigation of Project Ideas)

Session VI

60 minutes	Introduction of Specialty Suppliers
15 minutes	Vendor Display Time
15 minutes	Break
2 hours	Project Work
1 hour, 15 min.	Lunch
60 minutes	Introduction of Specialty Suppliers
15 minutes	Vendor Display Time
15 minutes	Break
2 hours, 15 min.	Project Work

Session VII

Project Work

Session VIII

Project Work

Session IX

3 hours, 45 min.	Project Work
1 hour, 15 min.	Lunch
15 minutes	Developing the Proposal
15 minutes	Motivate Positive Action
	Project Work

Session X

3 hours, 45 min.	Project Work
1 hour, 15 min.	Lunch
30 minutes	Value Engineering—a New Tool for Everyone To Use
1 hour, 45 min.	Project Work (Wrap-up)
	Management Presentation

Chapter VII

MOTIVATION AND INCENTIVES

Introduction

In the commercial market costs rarely play second fiddle to delivery schedules and product performance. In the defense industry concern about military effectiveness and desire to buy time tend to overwhelm pressures to cut costs. Everyone in the DOD/Industry complex accepts the principle that costs should be held down. The rewards for reducing costs (or penalities for not reducing costs) are not, however, as tangible in the military products business as they are in the commercial products business. Thus, there is a need for special motivating actions to reduce costs of military products—actions by both Government and contractor personnel.

It has been stated in previous chapters that organized value engineering programs are an important means for achieving cost reduction because they focus on the cost of achieving required function. But an organized value engineering program may still fail unless there is a tangible reward for implementing valid V.E. change proposals.

This chapter discusses concepts and techniques for motivating V.E. programs in the DOD/Industry complex.

Motivation Within DOD

Within the Department of Defense there are two composite groups concerned with V.E. One group consists of people: the management, technical, procurement and fiscal staffs associated with the various procurement or industrial activities, who provide the environment for the V.E. effort, make the final evaluation of V.E. proposals and, in some cases, perform the value engineering studies. The other group is made up of the organizations concerned with product value, such as arsenals, shipyards and procurement activities.

A. *Personnel*

One of the strongest motivating influences on personnel is the knowledge that their management supports the program and is closely following its progress. Evidence of management interest can be shown in a number of ways such as issuance of a management policy statement on the subject, appearance at V.E. training sessions as guest speakers and participation in award ceremonies recognizing individual and group contributions to the program.

Outside of special awards, it is not possible to provide direct financial incentives for Government personnel in the Department of Defense as a means of motivating superior effort in value engineering. Nevertheless, shipyard or arsenal commanding officers, procurement managers and system directors presently are evaluated on the efficiency of their organizations. Historically, the emphasis on the cost elements of their activities has not been as strong as it is in private industry. There are ways and means, however, such as fitness reports, evaluations for promotion and public recognition, to focus attention on the financial aspect of performance. The Department of Defense cannot be operated or judged in the same profit-oriented manner as private industry. Notwithstanding that, a specific re-emphasis of the importance of cost considerations should be made, especially as value engineering contributes to them. Value engineering effort and effectiveness should become an element of career and promotion evaluation for all Department of Defense personnel connected with V.E.

B. *Organizations*

For the Department of Defense as a whole, and for major organizations within it, certain actions can be taken to motivate cost reduction efforts, including value engineering. Those actions involve the establishment and enforcement of basic cost reduction policies, such as the current

DOD Cost Reduction Program. The Office of the Secretary of Defense provides policy for the Department of Defense as a whole. The policies must be implemented by each Service, command and activity in a manner which clearly sets targets, establishes methods for evaluating progress against the targets and provides means for assigning specific responsibilities for the actions required to meet the targets. The specific implementing policies and directives must be tailored to the needs and procedures of each organization.

Motivation in Industry

When dealing with the problem of motivating defense industry, it is again necessary, as in the case of DOD, to distinguish between those motivating forces aimed at persons and those directed toward organizations. A discussion of the motivating techniques directed at each of these groups is presented below.

A. *Personnel*

Within industry there are two categories of personnel concerned with value engineering activities. One group consists of those people who do the actual value engineering work. The other group includes the peripheral groups which provide service or evaluation assistance to the V.E. group, as well as management which provides overall direction and policy for the V.E. function.

For both these groups, the same motivating techniques described for use in the Department of Defense apply equally well. Since private industry has more flexibility than the Department of Defense in matters of promotion, evaluation, raises, career enhancement, etc., the techniques can be more easily applied. In addition, industry can use such techniques as financial awards and bonuses as well as incentive plans based directly on performance. Industry should take advantage of its greater flexibility in motivating superior performance by those persons or groups connected with or responsible for V.E.

B. *Companies and Organizations*

For industry as a whole, and specific companies or organizations within industry, there are several motivating forces prompting the use of value engineering, all related directly or indirectly to increased earnings and profits. One of those factors is the part which V.E. can play in improving a company's future competitive position, ultimately leading to increased business and higher profits.

Another of the motivating forces behind value engineering is a company's desire to show the customer (DOD) that active, fruitful efforts are being made to reduce costs and increase the value of defense products. Although cost reduction always has been important to defense contractors, it is even more so today in view of the specific continuing requirements for efficiency demanded by DOD.

In addition to increasing a company's ability to compete effectively for new business and satisfying the customer, value engineering provides another important benefit: increased profit on future and existing business through financial incentives provided for successful V.E. efforts. The formal and legal approach to those financial incentives is contained in Section I, Part 17, of the Armed Services Procurement Regulations. Since the ASPR provisions serve as the basis of all V.E. efforts connected with defense hardware, a discussion of the basic concepts underlying them is presented in this Handbook.

Financial Incentives Provided in ASPR

To ensure a clearer and more complete understanding of the ASPR financial incentives for value engineering it is necessary, before discussing the incentives themselves, to discuss briefly the ASPR definition of value engineering, the type of V.E. effort to which ASPR is directed and the part which V.E. is considered to play in contract performance.

In this Handbook, value engineering is described and defined rigorously with primary emphasis on how it is performed. In ASPR, however, the definition of value engineering is based more on the kinds of results to be obtained from it and descripitions of some of the areas where it can be applied. Although a comparison may indicate differences between the two definitions, careful study will show that there is no conflict between them. The reason that any difference exists is because the ASPR definition is intended for contractual use, while the Handbook definition is intended for the use of those engaged in doing or managing value engineering.

It is also important to note that the V.E. effort contemplated by the ASPR is that which leads to changes *requiring Government approval*. It goes without saying that V.E. changes not requiring approval are highly profitable to contractors. In commercial work and on some types of fixed price Government contracts, the contractor usually keeps 100% of the savings. This Handbook is directed to all V.E. efforts, but primarily to efforts leading to changes which require DOD approval.

The use of V.E. by a contractor is considered to be an effort additional to what is ordinarily required of him because V.E., as far as the ASPR is concerned, is intended to lead to changes in what the customer (DOD) originally specified as required in a given product, system or item. In other words, V.E. challenges existing products, designs and specifications with the goal of finding and eliminating unnecessary cost. This concept, as well as those already presented above, plays an important part in the ASPR incentive provisions.

Although a number of different techniques have been used to provide contractors with financial motivation for doing value engineering, the current approaches essentially fall into two categories. One is through the provision of incentives based on actual results achieved from voluntary contractor V.E. programs. The second is through the inclusion in some contracts of specific program requirements for V.E., with direct DOD funding and such control and monitoring as is ordinarily required to ensure compliance with contract requirements. Each of those approaches is discussed below.

A. *Incentive Provisions*

The incentive method specified in ASPR for motivating cost reduction through value engineering is to allow contractors to share in V.E. savings. Sharing of savings is a basic element of the incentive concept because it ties results and reward together.

Other important elements of the incentive concept are the risk which the contractor takes in doing value engineering and the amount of profit which the contractor can earn by investing his available resources in cost reduction techniques. Those elements are compensated for in the incentive approach to value engineering by adjusting the ratio by which contractor and government share in savings. Thus, depending on the circumstances, the saving-sharing ratio will vary from contract to contract.

The principle of tying reward to risk through sharing savings is the same principle as the one applied to the cost element of contract performance in the various incentive contracts currently being used by the Department of Defense. Application of the principle to V.E. should present no new problems to those presently engaged in defense business.

The risk and alternative investment concepts, although they may be similar in some respects to present incentive contracts, nevertheless are unique when applied to value engineering. The risk element is heavily influenced by the fact that value engineering proposals are subject to government approval before they can be implemented. Thus, a contractor performing value engineering is not completely in control of the results of his efforts. The risk of disapproval is taken into account when setting the saving-sharing ratio.

The alternative investment concept is based on an awareness that contractors constantly choose among alternative investment opportunities. A contractor will tend to channel his resources of time, money, and manpower into those areas or projects which return the greatest profit to him. In the cost reduction areas, for example, value engineering is but one of a number of useful tools available to a contractor. Since V.E. can benefit many DOD projects other than the specific contract to which it is originally applied, it is desirable for DOD to encourage contractors to select V.E. efforts in preference to other efforts with only limited cost reduction application. Again, as in the case of the risk element, the saving-sharing ratio is adjusted toward that end.

Specific details and guidelines are contained in the ASPR for determining what saving-sharing ratio to use for each type of contract and under what conditions.

B. *Program Requirements*

Under certain conditions, it will be in the best interest of the government to make value engineering a required contractor action rather than making the use of V.E. optional as in the case of the incentive provision approach discussed above. ASPR recognizes the need for required V.E. programs under some contracts and provides methods for including them in the contracts. The approach is to describe the type of program desired, sometimes including specifications, and then to require that the contractor establish and maintain the described program at a measured level of effort. As would be expected, the quality and quantity of results produced by the program will be followed closely by the DOD contract administrators.

The situations which might call for use of the required program approach to value engineering usually involve either or both of the following circumstances:

First, in a development contract the nature of the contract may be such that it is desirable to apply V.E. to the product or system immediately after initial design efforts. In some cases of this type, detailed cost data are not available promptly enough to permit an accurate determination of the savings produced by the V.E. effort. Under these circumstances, opportunities for saving-sharing by the contractor may be severely limited, and the incentive for doing V.E. on a voluntary basis virtually non-existent. The required program may be the only practical way to obtain V.E. efforts of the type and level desired.

Second, a contract may of itself offer little opportunity for sufficient savings generation to motivate contractor V.E. efforts. For example, the contract may be too small or of too short duration to permit the development, evaluation and implementation of V.E. proposals. The government may, however, be aware of other similar contracts in planning or in being which could benefit indirectly from V.E. performed in the contract. In such a case, use of the required program approach would be the only way to obtain the desired V.E. effort.

Summary

Provision of effective motivating forces for the V. E. effort requires the use of techniques directed at the personnel involved in the effort and at the organizations of which they are members, for both the Department of Defense and industry. For personnel in DOD the two main sources of motivation are: (1) management's overt demonstration of support for the program; and (2) the consideration in the evaluation of individual performance, of contribution to product value. For DOD groups and organizations, establishment of basic cost reduction policies, together with the setting of specific targets for cost reduction, serve as the primary means of motivating superior performance, especially when coupled with reporting systems to measure progress.

For personnel in industry, the same techniques applied to DOD personnel can be used, plus additional devices such as awards and bonuses.

For companies as a whole the desire to improve competitive position and achieve customer satisfaction serve in part to motivate the performance of value engineering. In addition, financial incentives are used to spur extra effort. Such incentives are described in ASPR, and consist of two approaches:

- Incentive provisions which provide for sharing between the Department of Defense and the contractor of savings generated by V. E. efforts performed voluntarily by the contractor.
- Required program efforts of DOD-specified scope, level and type.

Each approach has its merits depending upon the specific situation to which it is applied.

PROGRAM CONTROL

Chapter VIII

Introduction

Any management program, if it is to be successful and attain its full potential, requires close control and monitorship by those responsible for achieving its objectives. This is particularly true of value engineering because of the critical need to allocate scarce technical talents in a manner which maximizes the return on their use.

Three basic devices are required to control a value engineering program: the establishment of target savings, a reporting system and an audit system. Each of these control devices is discussed in this chapter. Collectively they provide a means to accurately measure the progress of the program and a method of directing value engineering efforts toward a maximum contribution to product value.

Savings Targets

In order to obtain maximum savings from the value engineering of military hardware, it is important to establish realistic savi[illegible] goals. These goals identify performance targets for those engaged in the V.E. effort. They provide an added impetus to the V.E. group to concentrate their efforts on projects promising the greatest dollar return per man hour of V.E. effort.

It is desirable to break down targets as much as possible so that each level of V.E. effort has a specific goal. Since the basic objective of V.E. is to reduce costs, targets should always be expressed in terms of dollars. Wherever possible, target breakdowns should be established on individual projects and even on pieces of hardware.

Targets should be set at reasonable levels; "reasonable" in this context means that the target should not be set so high as to be unattainable nor should it be so low as to require little effort to exceed it. The target level should be attainable only by a superior effort.

It is difficult to provide precise instructions on the setting of targets because several key variables affect the level of savings that can be achieved through value engineering (see Chapter V). However, two "rules of thumb" can be stated.

First, although many examples of net savings to cost ratios of fifteen to one and higher can be documented, a reasonable ratio of return is generally held to be ten to one (except for development programs calling for only limited production of end items: see page 36). Therefore, one method of establishing a savings target is to compute the anticipated cost of the V.E. effort and multiply it by ten to establish a savings target. A second method of computing a target figure is to assume an average level of cost reduction through value engineering on the entire product mix. To clarify this latter method, assume a product composed of ten parts or components. Since it normally will not be possible to subject all ten components to a detailed V.E. analysis, the application of a priority selection system will indicate the three or four items that are to be analyzed in depth (see Chapter III). Although 20%, 30% or even 40% reduction in cost of a component often is achieved through V.E., the total cost of the end product obviously is not reduced this much. An across the board figure of 5% total cost reduction is reasonable, and targets can be established on this basis.

Targets should not be est[illegible]hed and then forgotten. They must be given continued publicity. Progress toward the targets must be measured on a continuing basis. Measurement of progress is accomplished through another program control device, the reporting system.

Reporting System

The reporting systems described in this chapter are those required for effective program control. They can provide the input data to the DOD Cost

Reduction Program, which requires the reporting of value engineering savings in addition to savings achieved in many other cost reduction areas. The program control reporting system is necessarily more detailed than the DOD Cost Reduction Program system because the former is one of the tools by which a V.E. program is directly managed while the latter is designed to report end results. The two reporting systems are complementary, not duplicative.

Listed below are items of information which normally would be included in a V.E. program control reporting system within a contractor or Government industrial activity. At higher reporting levels, not all items would appear and of those that do appear many would be summarized rather than reported in detail.

- Identification of the preparing unit.
- Date the report was prepared.
- Time period covered by the report.
- Number of V.E. projects currently under study.
- Estimated potential dollar savings on projects under study.
- Number of V.E. proposals currently under evaluation, either inhouse or by customer.
- Estimated dollar savings on proposals under evaluation, if approved.
- Breakdown of "age" of proposals under evaluation—0 to 90 days, 90 to 180 days, over 180 days.
- Number of V.E. projects approved and implemented—the reporting period and year to date.
- Dollar savings of approved and implemented projects (only net savings should be reported)—for the reporting period to date and also further broken down by the savings to be accomplished in the current year and in future years.
- Number of personnel engaged more than half time in V.E. work.
- Total cost of V.E. program, last twelve months.
- Ratio of savings to cost of program, last twelve months.
- Individual listing of projects approved by customer during current reporting period, including brief description, cost of the project and net savings attained.

In addition to reporting the items listed above concerning its own inhouse V.E. program, DOD procuring activities should report the following data on contractor V.E. programs.

- Number of active contracts containing V.E. provisions broken down by type of provisions required funded effort or savings sharing approaches).
- Dollar value of active contracts containing V.E. provisions broken down by type of provision (as above).
- Number of V.E. proposals approved for implementation this month and year to date.
- Dollar savings (DOD net portion only) on approved V.E. changes implemented—this reporting period and year to date and also further broken down by the savings to be accomplished in the current year and in future years.
- Number of V.E. change proposals currently under evaluation.
- Estimated dollar savings on proposals under evaluation if approved.
- Breakdown of "age" of proposals under evaluation—0 to 90 days, 90 to 180 days, over 180 days.
- List of proposals approved during current reporting period, including brief description of proposal, DOD net savings anticipated, contractor share of savings (if any) and applicability of change elsewhere, if feasible.

For most activities, the above data can be arranged on a single sheet of standard size paper using the reverse side for the individual item listings.

Audit System

The reporting system provides a quantitative measurement of the V.E. program. Adequate program control also requires a qualitative evaluation of the V.E. effort. This can be accomplished best by an on-site audit.

V.E. audits can be of several varieties; internally within DOD or within contractor establishments and also by DOD of contractor operations. Regardless of the type, the substance of the audit should be the same. It should include an examination of the organization, staffing, procedures and budgets of the V.E. function. In addition to evaluating the general effectiveness and technical competence of the V.E. units, the audit team should make whatever inquiries are appropriate to determine the level of acceptance of the V.E. function throughout the organization. Furthermore, the audit team should perform a detailed analysis of reported V.E. savings to verify their validity.

In order to minimize the cost of V.E. audits, they should be integrated into already established audit functions. In addition to minimizing costs, this approach avoids the creation of an additional irritant to operating personnel.

The frequency of audits depends upon available manpower resources. Generally throughout industry and Government, a scarcity of qualified auditing personnel results in a less frequent auditing cycle than is desirable. Since the V.E. audit normally will be integrated into an established audit function, it follows that they probably will not be done as often as they should. Once a year is a reasonable cycle; however, it may be difficult to achieve this in actual practice.

To provide more specific guidance on the nature of the V.E. audit, a list of representative questions to be asked by the audit team is included as Exhibit 1 to this chapter.

Summary

Maintaining an effective value engineering program requires continuous monitoring and control. Three basic control devices are essential. Setting savings targets provides an incentive for performance and assists in determining priorities and allocating resources. Targets must not be set too high or too low but rather at levels which can be achieved by a superior performance. Precise rules for setting target levels do not apply across the board because of differences in product mix, V.E. capability, size of the organization, etc. Broad targets, however, can often be set by (1) multiplying the cost of the V.E. effort by ten, or (2) taking 5% of the total product dollar volume. The reporting system measures progress toward the targets and provides a quantitative measurement of the program. A well-designed reporting system should be concise, responsive, accurate and timely. Summary reports should be employed for higher-level use. The concept of "reporting by exception" should be utilized wherever appropriate. The audit system provides an on-site qualitative measurement of the V.E. program as well as a verification of reported savings. V.E. audits should be integrated with existing audit functions to minimize cost. Audits should be on a annual basis, but this requirement may have to be relaxed because of heavy workloads. The use of the three control devices will assist management to obtain maximum return on its value engineering investment.

Exhibit 1

LIST OF REPRESENTATIVE QUESTIONS TO BE ASKED BY V.E. AUDIT TEAMS

1. Does the organization have a policy statement regarding value engineering?

2. Are implementation procedures published and in use?

3. Does management exhibit a consistent and continuing interest in the program?

4. Are specific actions taken to "close the loop" after value engineering proposals have been generated?

5. Does the organization select its value engineering projects on a systematic basis?

6. What is the average savings-to-cost ratio achieved by the value engineering program?

7. Is the value engineering effort organized in an effective manner?

8. Is the value engineering program adequately staffed?

9. Is management setting realistic targets for the value engineering effort?

10. Does the V.E. reporting system accurately report the progress of the program?

11. Are there periodic audits of the value engineering function?

12. Is there a formal procedure for documenting and auditing savings resulting from value engineering efforts?

13. Is management providing adequate incentives for the performance of value engineering?

14. Are internal reviews of value engineering change proposals sufficiently detailed and analytical so as to ensure a high percentage of acceptance of proposals by the customer?

15. Are V.E. proposals given proper attention by project supervision?

16. Does the organization use the purchasing agents' talents and experience in design reviews, hardware analysis, seminars, and task forces?

17. Does value engineering work with the material department to search for and disseminate information on new materials, processes, components, and specialty suppliers?

18. Are value check lists included in all applicable RFQ's? With what results?

19. How often do the heads of value engineering activities attend value-oriented military and industrial conferences and meetings outside the organization?

20. Does management support a value engineering training program?

21. What is the duration of formal training seminars?

22. What is the general reaction, comment, and criticism elicited from participants at the conclusion of the seminar?

23. How suitable are the projects selected for seminar training?

24. What is the spectrum of projects selected for seminars?

25. Have accurate costs of parts, processes, materials, labor, and all other charges been obtained for seminar projects?

26. Have worthwhile seminar proposals been implemented?

27. Has proper funding been received for personnel time and facilities for seminar training?

28. On what basis are full-time value engineers selected?

29. Are house organs and bulletin boards used to publicize the program and its accomplishments?

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