NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

78

VALUE ENGINEERING IN PRECONSTRUCTION AND CONSTRUCTION

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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VALUE ENGINEERING IN PRECONSTRUCTION AND CONSTRUCTION

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C.

SEPTEMBER 1981

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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PREFACE

There exists a vast storehouse of information relating to nearly every subject of concern to highway administrators and engineers. Much of it resulted from research and much from successful application of the engineering ideas of men faced with problems in their day-to-day work. Because there has been a lack of systematic means for bringing such useful information together and making it available to the entire highway fraternity, the American Association of State Highway and Transportation officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize the useful knowledge from all possible sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series attempts to report on the various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which they are utilized in this fashion will quite logically be tempered by the breadth of the user's knowledge in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of special interest to design and construction engineers and others seeking information on the application of value engineering to highway projects. Past and present experiences with value engineering are reviewed, and guidelines are presented for application of this methodology during both preconstruction and construction stages.

Administrators, engineers, and researchers are faced continually with many highway problems on which much information already exists either in documented form or in terms of undocumented experience and practice. Unfortunately, this information often is fragmented, scattered, and unevaluated. As a consequence, full information on what has been learned about a problem frequently is not assembled in seeking a solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of synthesizing and reporting on common highway problems. Syntheses from this endeavor constitute an NCHRP report series that collects and assembles the various forms of information into single concise documents pertaining to specific highway problems or sets of closely related problems.

Value engineering is receiving increasingly more attention as a means of greater accomplishment within the limits of decreasing financial resources. The application of this methodology has resulted in significant savings for highway and transportation departments. This report of the Transportation Research Board reviews these successful experiences and presents guidelines for the application of value engineering during preconstruction and construction activities. Behavioral and organizational problems in the implementation of this methodology are discussed. The increased use of value engineering principles is recommended.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

VALUE ENGINEERING IN PRECONSTRUCTION AND CONSTRUCTION

SUMMARY

State highway and transportation agencies are confronted by many complex problems. Foremost among these is that during the past few years financial resources have become increasingly scarce in relation to existing and accruing needs. It is widely believed that this condition will persist through the decade of the 1980s and perhaps beyond.

The situation challenges all agencies to aggressively search for and implement ways of achieving more from available financial resources without reducing quality, reliability, or safety. Value engineering (VE) is emerging as an important management tool for dealing with the challenge. Although it is new to many state highway and transportation agencies, it has been successfully applied by several. Moreover, numerous government and private organizations have achieved significant savings through its application since it was introduced in the early 1950s.

The synthesis reviews results of VE applications to preconstruction operations in eight states and to construction operations in approximately the same number. In addition, the experiences of the U.S. Army Corps of Engineers (a mature program) are reviewed. The findings support the overall conclusion that the application of VE concepts, principles, and techniques in both of these major areas of operations is effective enough to warrant increased use by state highway and transportation agencies.

The best opportunities for initial application appear to exist in preconstruction, with emphasis on application to standard plans and specifications and on design criteria and guidelines. Although it can be expected that greater savings will be achieved by a VE program in these areas than through a value engineering incentive clause (VEIC) program for contractors, available data indicate that savings in the latter kind of program can be quite significant. Moreover, VEIC programs can be expected to yield ongoing benefits for a one-time sharing.

The synthesis findings indicate that problems in implementing and managing VE programs are more behavioral and organizational than technical. One reason is that there are widely varying perceptions among engineers as to what VE really is, and this has led to lack of interest and even resistance. It is commonly believed, for example, that VE is just a fancy name for traditional cost-cutting and that it is what is now being done as a matter of course in project and plan reviews. This is not so. VE is a formalized and powerful methodology quite different from traditional cost reduction and systems analysis, and it must be experienced to be fully appreciated.

Another problem encountered by departments is resistance to change. The value method is designed and calculated to generate recommended changes on a continuing basis, and it will fail if it does not do so and if changes are not implemented. Reviews of VE recommendations often are more of a defense of the reasoning behind the original product than a frank appraisal of the proposal to determine if it achieves the objectives at less cost.

The first and most important step in implementing a VE program is to gain the understanding and support of top management. This is needed initially to assure adequate funding for training and for creating positions; and more important, it is the most essential element required throughout the life of the program. Continu-

ing, active involvement of top management creates and maintains the positive attitudes that are necessary to implement cost-effective VE changes.

Although top management support is essential, it is unlikely that a VE program will succeed if middle managers do not understand, believe in, and support it. These managers are directly responsible for initiating and carrying out VE studies and implementing recommended actions.

Implementation guidelines in preconstruction include the following:

- *Project selection.* Projects selected for a VE study should be in need of change and should provide an opportunity for savings sufficient to warrant the cost of the study.
- *Timing.* Generally, the earlier VE is applied the greater the potential for savings.
- *Participation.* When VE is applied in preconstruction areas, every effort should be made to involve construction, maintenance, and operations personnel in addition to design personnel. Decisions made in the early stages of project development have considerably more influence on life-cycle costs than those made in the construction and maintenance phases, and operations and maintenance costs typically account for a high percentage of life-cycle costs.
- *Standard plans and specifications and design criteria.* Serious consideration should be given to organizing and initiating a systematic and ongoing team effort to review and analyze all standard plans and specifications currently in use.
- *VE teams.* Most successful VE programs have used a team approach. The creative phase of the job plan calls for techniques that are likely to be more effective when a number of persons with diverse backgrounds and viewpoints work as a team.

Guidelines for VEIC programs focus on the agency's responsibilities to (a) create and maintain an effective and mutually beneficial program and (b) secure effective contractor participation. Guidelines include the following:

- *The VEIC clause.* The first step is ensuring that the clause encourages contractor participation. The sharing percentage must be equitable to both contractor and agency.
- *Securing contractor participation.* Experience indicates the necessity of educating contractors about VE methodology. The agency should do what it can to ensure an effective contractor orientation and education program.
- *Opportunities for participation.* Some agencies have found that there are greater benefits if VE is allowed on all projects on an across-the-board basis; others have restricted it to selected projects. Each agency must make the decision based on its particular circumstances. The key consideration is that contractors be provided with adequate opportunities to participate in the program.
- *Objective appraisal.* The agency must ensure that there is objective appraisal of contractor change proposals.
- *Expeditious processing of change proposals.* Once a project is let to contract, there are time limitations. The agency must ensure that contractor change proposals are processed expeditiously.

A VEIC program is more likely to achieve full potential benefits if it is just one part of a comprehensive VE program in the agency. It can be coordinated with other elements of that program in an atmosphere in which there is general interest in improving value/cost performance. Synergistic benefits can be expected.

CHAPTER ONE

INTRODUCTION

Value engineering (VE) is emerging as an important management tool to optimize expenditures for highway and transportation facilities. Numerous government and private organizations have realized significant savings since VE was first introduced in the early 1950s, and it appears that its application could be broadened by state highway and transportation agencies. This synthesis focuses on applications in preconstruction and construction. The basic objectives are:

1. To examine and broadly describe the VE process—its basic concepts, methods, and techniques;
2. To review approaches to its application in preconstruction and construction operations by American Association of State Highway and Transportation Officials (AASHTO) member agencies as well as results of such applications;
3. To suggest approaches to its implementation and use.

The synthesis is based on information and findings from two main sources: (a) extensive review of current literature and (b) interviews and discussions with a considerable number of officials of state highway agencies, transportation departments, and federal agencies, most of which have had experience with VE or are developing VE programs. In addition, an investigator attended the final half-day summary session of a 1-week VE workshop for one state agency, and one of the investigators participated in a 2-day VE conference sponsored by the Federal Highway Administration (FHWA).

HISTORICAL DEVELOPMENT

Value engineering evolved out of the necessity to find substitutions for scarce manufacturing materials during World War II. Harry Erlicker, a vice-president of the General Electric Company, observed that such substitutions frequently produced improved products at lower costs. He became convinced that significant benefits could be derived from an approach that sought to substitute intentionally. Consequently, in 1947 the company charged a creative staff engineer, Lawrence D. Miles, with the task of developing more effective ways to improve value.

During the next five years Miles and his group developed techniques and a rigorous methodology called value analysis (VA). In 1952 the first VA seminar/workshop was conducted for some 60 General Electric employees, most of whom returned to their positions as full-time value analysts and implemented VA programs. Subsequently more seminars were conducted, and they attracted representatives of government agencies and other companies. As engineers began to incorporate VA techniques into the mechanics of product design, the methodology of value engineering evolved and spread.

The first federal agency to adopt the value method and formalize a value program was the Department of the Navy, Naval Ship Systems Command (formerly the Bureau of Ships) in 1954. This agency coined the term *value engineering* (VE), which incorporated the same basic concepts and methodology as VA. The list of federal agencies that have subsequently adopted VE and implemented ongoing programs is a long one. It includes the U.S. Army Corps of Engineers, General Services Administration, Bureau of Reclamation, Veterans Administration, and U.S. Air Force, among others. Former Secretary of Defense Robert S. McNamara's emphasis on cost reduction was a big factor in initiating VA in the U.S. Department of Defense. One objective of the program was to create a staff that would have the sole responsibility of achieving maximum product value, the goal being to save at least $10 for every $1 spent (*1*).

VALUE ENGINEERING IN TRANSPORTATION

During the late 1960s and early 1970s, rapidly escalating construction and maintenance costs, "leveling off" of revenues, and mounting backlogs of needs led to an increased interest in VE by state and federal transportation agencies. The California Department of Transportation initiated a formal VE program in 1969, spurred by the wide publicity VE was receiving and the passage of legislation that required cost-reduction incentive clauses in highway contracts. By 1976 at least eight agencies had established active VE programs (*1*).

At the federal level, Congress became interested in VE applications to highway projects during the late 1960s. Following a series of hearings, Congress inserted a provision in the 1970 Highway Act that permitted the secretary of transportation to require value engineering, or other cost-reduction analyses, on any proposed federal-aid highway projects on any federal-aid system. Subsequently (in 1975) the FHWA created an organizational unit, headed by a value engineer, to spearhead that agency's efforts to stimulate interest in VE within itself and among AASHTO member departments. The FHWA (*2*) stated:

> It is our intent to provide a high level of support to those highway agencies that are willing to maintain a responsive Value Engineering program. We will continue to encourage those agencies not fully aware of the potential of Value Engineering and, through the National Highway Institute, we will continue to furnish opportunities for training in the technique.
>
> Our goal is to obtain recognition of the benefits to be derived from a Value Engineering program in each state highway or transportation agency and the development of a capability for its practice.

The FHWA's initial efforts were those employed by all organizations in the beginning: VE workshop training and dissemination of VE information. During fiscal year 1976, 12 VE workshops were sponsored and conducted in as many locations. They were attended by 146 FHWA employees, 139

state employees representing 38 different AASHTO member departments, and 27 others representing various federal, state, and city organizations. Although the primary purpose was training, participants studied live projects, and potential savings amounted to more than $14 million (*2*).

The FHWA's supportive efforts have accelerated since 1976. Through 1980, 54 training workshops (including those mentioned above) had been sponsored and/or conducted for some 40 different AASHTO member departments. Approximately 1,600 engineers and technicians have received basic VE training.

Miles's value analysis approach was rapidly accepted, adopted, and applied after its introduction in the early 1950s. As stated in a recent publication (*3*), "The concepts and techniques of VA have spread throughout the world in both industry and government. It has grown and been widely accepted because it gets results. It provides a modern day, organized, systematic approach to the problem of reducing costs."

All indications are that a rapidly increasing number of state highway and transportation agencies are becoming convinced that VE can be of substantial benefit in meeting challenges posed by rising costs and diminishing financial resources. This interest is spurred not only by the desire of highway and transportation engineers to provide transportation economically, but also by the fact that declining revenues and high inflation have combined to severely limit funds available to meet construction and maintenance needs. Also, state legislatures are requiring greater assurance that all agencies are optimizing expenditures of limited funds.

CHAPTER TWO

A PERSPECTIVE OF VALUE ENGINEERING

Review of current trade journal articles and discussions with transportation officials, contractors, and others indicate that there are varying perceptions as to what value engineering really is. This chapter is devoted to a broad description of fundamental concepts of the value method and key elements in the methodology. The aim is to show how VE is different from traditional cost-reduction approaches.

DEFINITION OF VALUE ENGINEERING

The Society of American Value Engineers, in the current AASHTO-AGC-ARTBA *Guidelines (4),* defines VE as "the systematic application of recognized techniques which identify the function of a product or service, establish a value for that function, and provide the necessary function reliably at the least overall cost."

Ebisch (*5*), commenting on the definition, points out some of the existing problems of understanding the term *value engineering:*

> The meaning of [the definition] is quite revolutionary. Unfortunately, it is a revolution which works very subtly within a complicated process. A one-sentence definition of value engineering, therefore, can easily sound like fancy language for what every good designer should do as a matter of course. . . . The problem is that value engineering is commonly believed to be the same as cost reduction or systems analysis. Simple definitions are unsatisfying because true value engineering is a formalized and powerful methodology *that must be experienced to be fully appreciated.* [Emphasis added.]

Existence of such misconceptions as those pointed out by Ebisch led the AASHTO-AGC-ARTBA Joint Committee Task Force to include this statement in the *Guidelines (4)* to emphasize what VE is not: "Value engineering is not just 'good engineering.' It is not a suggestion program and it is not routine project or plan review. It is not typical cost reduction in that it does not 'cheapen' the product or service nor does it 'cut corners.'"

The misconception that VE is the same as other approaches to cost reduction, or that it is what is already being performed as a matter of course in project or plan reviews, has undoubtedly contributed to the lack of interest in or even resistance to its use. To perceive it this way is to overlook the facts that it adds significantly to other approaches and that documented results have consistently been better than those achieved by traditional approaches. Probably the most successful way to change these misconceptions is, as Ebisch points out, to enable engineers to experience the methodology. All indications are that a very high percentage of those who participate in a 1-week workshop in which the VE process is applied to live projects are convinced of its merits.

Terminology

The value method developed by Miles has been accepted by many different kinds of organizations and has been applied to many different kinds of problems. Many terms that identify particular applications have come into being and are in common usage. For example:

- *Value analysis.* The application of value principles in

environments other than engineering and to items already in production.

- *Value management.* The concept that value principles are a management tool applicable to a variety of problems and functions, including cost, and can include cost-awareness programs.
- *Value assurance.* The application of VE during initial creative phases (such as design or procedure preparation) to ensure a high value when put into production or service.
- *Value improvement.* The application of value principles and techniques to already existing items to create higher value—an after-the-fact approach.

There is a consistent set of concepts, principles, and methods in all the above terms. Whatever the process is called, the value method forces thinking and action in an *organized and creative approach designed to optimize the difference between cost of making the product and cost of satisfying the user.*

VE methodology incorporates three features that make it quite different from traditional approaches to cost reduction: a user-oriented function approach, a problem-oriented job plan, and creative problem-solving methods. These features are described below.

USER-ORIENTED FUNCTION APPROACH

The key feature of VE, and the one that most distinguishes it from other approaches, is the user-oriented function approach. The overall aim is to strip the project or item under study to its bare essentials to define and evaluate its function. The approach requires that the following questions be answered: What is it? What does it do? What must it do? How long must it do it? What is it worth? What does it cost? What else will perform the function? What does that cost?

Function Analysis and Evaluation

Once it is decided to make a VE study of a product or service, the first step is to analyze and evaluate the function the item performs. This begins with determining users' actual needs—those performance qualities, traits, or characteristics that the item must possess if it is to be useful and efficient and provide good value at the lowest cost and highest level of usefulness.

The users' needs are the objectives, and the design specifies the means by which the objectives will be satisfied. By starting with a definition of users' needs rather than with the product itself, one avoids the temptation to look at the item and conclude that the function it performs is the required one. It also provides a basis for determining if the function is actually necessary or if it can be eliminated. Most traditional approaches start by accepting the product and then proceed to seek ways to make it at less cost.

A rule in VE is that the basic function be expressed in only two words: a verb and its noun object. The verb identifies the item's required action—for example, transport, shield, inform, or instruct. It answers the question: What does it do? The noun identifies what is acted upon—for example, trucks, vehicles, drivers, or tires. It answers the question: What does it do it to? The noun must be measurable, or at least understood in measurable terms, because a value will be assigned to it later; that is, cost will be related to function.

Inherent in the process of VE is the principle of full retention of all necessary use and esteem features of the item under study. Value work must be done without reducing necessary quality or features that the user is willing to purchase. For these reasons, VE recognizes two types of functions: use and esteem. *Use functions* are often referred to as work functions and relate directly to the utilitarian purpose of the item and its use value. *Esteem functions* are often referred to as aesthetic functions and relate to a user's desire to accept an item at a cost in excess of bare utilitarian value.

In a VE study these two functions are classified as either basic or secondary. A *basic function* is a performance feature considered essential by the user. It reflects the primary reason for the item's existence and/or the reason the user is willing to accept it. It answers the question: What must it do? It satisfies needs, not desires. A *secondary function* is a performance feature not considered essential. It answers the question: What else does it do?

Worth, Cost, and Value of Functions

VE function evaluation methodology requires that the worth, cost, and value of performing be determined. *Worth* is the least expenditure required to provide the functions needed by users. It concerns only the necessary function(s) and not the present design of the item. *Cost* is the total magnitude of funds required to obtain and use the specified and desired functions. The total costs of ownership of a facility by the typical state highway or transportation agency are the total life-cycle costs, as shown in Figure 1. It should be recognized that application of VE requires consideration of time factors and may well lead to changes in the distribution of costs.

Allocating cost and worth to function enables the *value* of the function to be judged. It permits comparing and ranking the values for the functions being performed by the item under study. The ranking technique used is calculation of a value index; that is, the ratio of the cost divided by the worth of each function. The value index serves three purposes. First, it assists in the determination of whether to proceed with the study. It should proceed only if poor value—indicated when the value index is greater than 1—exists. Good value is indicated when the index is 1. Second, it identifies areas where the cost/worth ratio is greatest. Generally these areas will have the greatest cost savings potential and are the best parts of the problem to select for VE study. Third, it

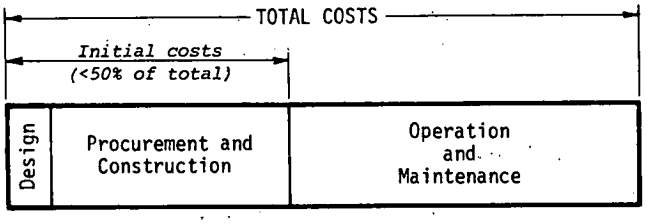

FIGURE 1 Life-cycle cost distribution.

provides a factor for measuring the effectiveness of VE efforts. Did the cost/worth ratio approach unity after the VE effort?

Value may be increased in three ways: (a) by improving the usefulness of a facility with no change in cost; (b) by retaining the usefulness with a decrease in cost; and (c) by combining improved usefulness with a decrease in cost. The time factor must be considered in all three cases, because lengthening or shortening the life cycle affects costs and cost distribution. Optimum value is achieved when all criteria of usefulness are met at the lowest overall cost.

PROBLEM-ORIENTED JOB PLAN

The questions asked in function analysis and evaluation are simple and straightforward, but the answers can become complicated. The job plan is the methodology used to organize the function approach.

The literature describes a number of versions of the VE job plan. Some sources list five steps, and others list up to eight. The number of steps into which a VE study is divided is less important than the use of an organized and systematic approach. The eight-phase plan shown in Figure 2 illustrates the methodology.

Phase 1: Information

The objective in this phase is to rigorously review all pertinent data about the item under study to obtain a thorough understanding of it. The key questions are: What is it? What does it cost?

In addition to specific knowledge of the item, it is important to have all available information about the technologies involved and to be familiar with the latest pertinent technical developments. The more information available, the more likely a substantial cost reduction.

Phase 2: Functional

Phase 2 is the point at which function analysis and evaluation is performed. The objective in the phase is to identify, define, and classify the item's functions in order to allocate costs to them and judge their value. Key questions are: What does it do? What must it do? What is it worth? As an aid in this phase, the VE team should use the functional analysis system technique, a diagramming technique that shows the logical relationships of the functions of an item, system, or procedure.

Calculation of the value index for each function identifies the parts of the item that have the greatest potential for cost reduction. The scope of the remaining study effort can then be defined.

Phase 3: Creative

The objective in this phase is to generate numerous alternative means for accomplishing the functions selected as having the greatest potential for cost reduction. The key question is: What else will perform the function? The greater the number and quality of alternatives, the greater the possibility of an effective solution.

The most common creative technique used in VE is that of brainstorming, a group problem-solving technique based on the stimulation of one person's mind by another's. In a typical brainstorming session a group of four to six people sit around a conference table and spontaneously generate ideas to solve a specific problem. A freewheeling atmosphere is desired during brainstorming, and criticism of ideas is not allowed. The effort is to depart from habitual, ordinary patterns and typical solutions.

It is in this phase that the item or function is challenged. Only after determining that the function must remain should those making the study seek alternative ways to perform the same function at the lowest cost.

Phase 4: Judicial

The objective in this phase is to select the most promising ideas from those generated in the creative phase. The key question is: Will each idea perform the function?

The initial step is to develop a set of broad evaluation criteria against which to judge the ideas. Factors typically considered are the state of the art of the idea, the cost to develop the idea, the probability of implementation, the time needed for implementation, and the potential benefit. Final selection is made after comparing alternatives using weighted evaluations and cost evaluations.

Phase 5: Development

The objective in this phase is to develop fully the selected idea(s) and present management with specific recommendations for change. Several questions should be addressed: Will it work? Will it meet all the requirements? What are the implementation problems? What are the costs? What are the savings?

The VE team must be certain that the facts gathered support the recommendations. The team should also develop specific alternatives and realistic cost analyses for these alternatives as well as for the recommended solutions.

An important objective of this phase is to develop a *realistic* implementation plan. It should answer the following questions: How should it be implemented? What must be changed, and in what sequence? Who should do it? How long should it take? Is a deadline required? What is the implementation cost? What are the consequences of delay?

Phase 6: Presentation

The objective in this phase is to prepare and present the best alternatives to those with the authority and responsibility to approve the VE proposal. The key questions are: What is recommended? Who has to approve it?

It should be recognized that a VE study proposal is almost always a challenge to the status quo: it is a recommendation for change. Those presenting the recommendation should

therefore devote considerable effort to developing good presentation strategies.

Phase 7: Implementation

The objective in this phase is for management to ensure that approved VE recommendations are converted into actions. Until this is done, savings to offset the cost of the study will not be realized. There are three major objectives of this phase: (a) to provide assistance, clear up misconceptions, and resolve problems; (b) to minimize delays; and (c) to ensure that approved recommendations are not altered to such a degree that they lose their cost-effectiveness or the basis for their original selection.

It is management's responsibility to ensure that implementation is achieved. Whoever has the authority to approve and order implementation should (a) assign an individual to direct the process and meet all deadline dates and (b) establish a feedback system.

Phase 8: Follow-up

The objectives in this phase are to (a) compare results achieved with those planned and expected, (b) ensure that

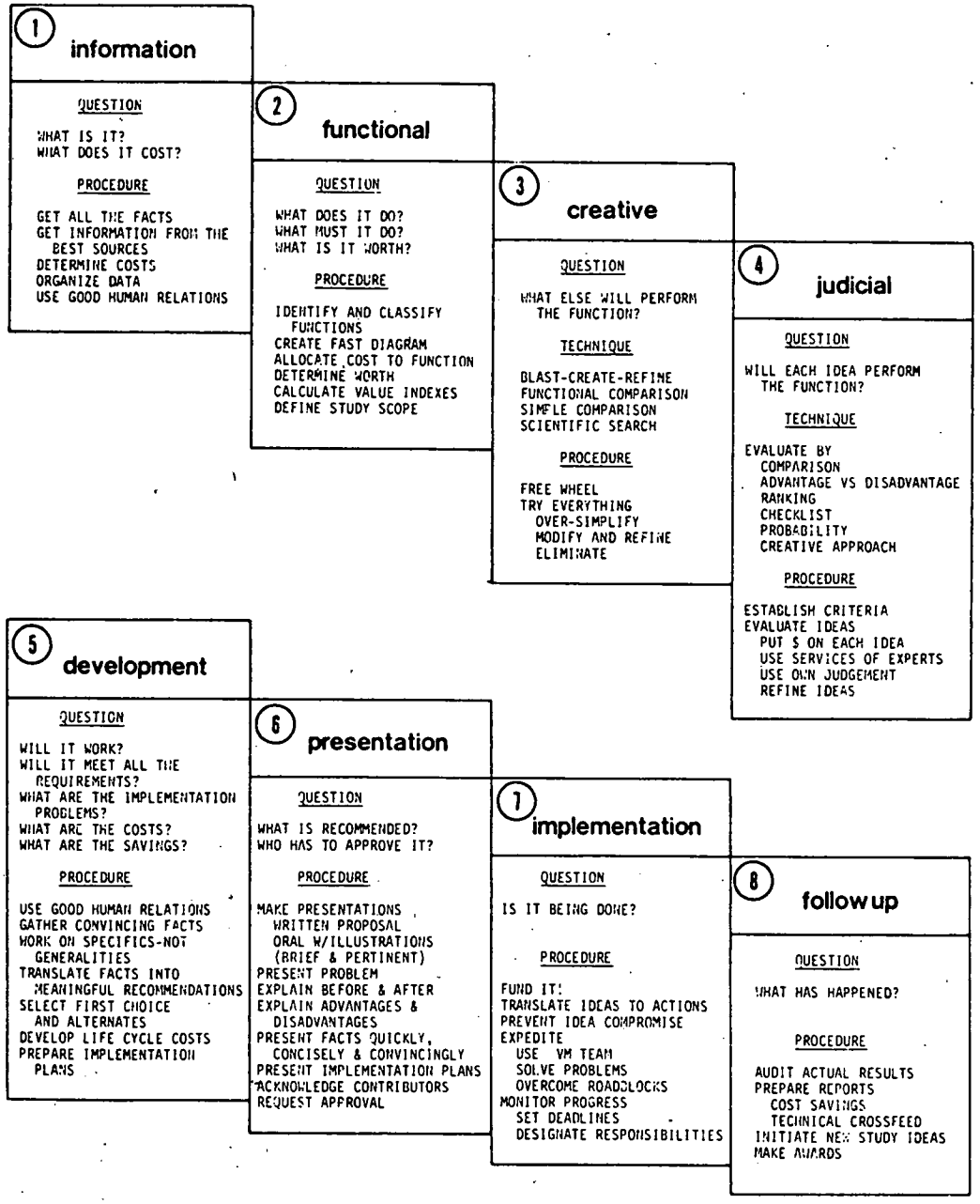

FIGURE 2 VE job plan (6).

management receives results of evaluations and reports of cost achievements, (c) evaluate the conduct of the project to identify problems that arose and recommend corrective action for the next project, and (d) assure that all who contributed significantly to the study and results are appropriately recognized.

Questions that should be answered in this phase include the following: Did the idea work? Did the organization save money? Would you do it again? Could it benefit others? Have the results been properly reported? Should any awards be made?

CREATIVE PROBLEM-SOLVING METHODS

Many of the misconceptions about the nature of the value method result from a tendency to view it as simply another name for traditional cost-cutting techniques. It should be viewed more broadly as a problem-solving process that expands traditional problem-solving approaches. That expansion is achieved by incorporating the two new techniques described above: a user-oriented function approach and a problem-oriented job plan. Both these features represent significant departures from the traditional cost-reduction approaches.

All descriptions of the value method emphasize that it is creative, and creative thinking is stimulated by the phased structure of the job plan. The kind of thinking desired in the process is not bound by existing ways of doing things; rather, the process encourages disciplined innovation. By its very nature, the process typically leads to recommendations for change that challenge the status quo; thus the emphasis is on good human relations in all phases of the job plan. Overcoming resistance to change may require more effort than the study itself.

Two general observations about the value method are appropriate here. Both are from a human behavorial viewpoint.

First, the value method is a logical one and is certainly consistent with the scientific method that is basic to scientific training. This is probably the main reason that a high percentage of engineers and technicians who go through a training process using real projects for subjects of study are enthusiastic about it. They achieve results from a meaningful application of the scientific method in which they are trained.

Second, the creative thinking phase in the VE job plan has the great virtue of stimulating and releasing people's creative talents. Unfortunately, typical project or plan review processes, although systematic and organized, tend to become routine and perfunctory, stifling creative talents.

What is most needed for a successful VE program in any organization is a positive management environment—an environment conducive to creativity, innovation, and positive change. The VE process and methodology can create this kind of environment.

CHAPTER THREE

VALUE ENGINEERING IN PRECONSTRUCTION

VE implementation approaches among the states vary somewhat in terms of approach, scope, and organization. Typically the approach in preconstruction has been to apply value methodology to existing design standards and specifications and to large projects. Although some programs have been more effective than others, all appear to have achieved significant results.

A direct comparison among states proved difficult. One reason is that the programs are in different stages of implementation in different states. Another reason is that there is a lack of consistent data on cost savings. The importance of maintaining accurate records of costs and cost savings cannot be overemphasized; these data are essential to program evaluation, decisions, and actions.

Following is a state-by-state summary of current VE programs, efforts, and experiences in several areas of preconstruction operations. To the extent that cost savings data and estimates are available, they are included.

CALIFORNIA DEPARTMENT OF TRANSPORTATION

The California Department of Transportation (Caltrans) has been involved in VE since 1969 and can rightfully be considered a VE pioneer among state transportation agencies. Impetus for initiation of VE came from its considerable publicity in the late 1960s, as well as from enactment of legislation that required inclusion of cost-reduction incentive proposals in construction contracts.

To start the program, Caltrans secured considerable input and assistance from the value engineering officer of the U.S. Army Corps of Engineers in Sacramento. A VE steering committee, composed of high-level managers, was formed. Two Caltrans engineers participated in a Corps of Engineers investigation of a proposed dam. There was a 1-day VE orientation course for top management, and 20 engineers were trained in VE techniques (with the assistance of U.S. Navy personnel). This training included a 6-week investiga-

tion, on a part-time basis, in several areas: sections of the standard plans; sections of the standard specifications; and some elements of four different highway projects (two in each of two districts).

Significant results were obtained from implementing the recommendations derived from the 6-week investigation. After reviewing them, top management authorized a 2-year pilot program. Selected district and headquarters personnel were temporarily assigned full time to two five-man teams working out of the headquarters office. The teams included some nonengineers, and all were trained in VE methodology and techniques. Efforts during the pilot program were largely directed to items of a general nature (e.g., standard plans and specifications), where savings achieved by modification would be applicable on all future projects incorporating them.

The pilot program was reviewed after 2 years, and two determinations were made. First, future VE studies would be mainly district operations, but a small headquarters unit would (a) provide guidance, direction, and expertise to district efforts; (b) coordinate recommendations to ensure implementation; and (c) provide for training. Second, each district would have a high-level VE steering committee and would designate a VE coordinator as the team leader. Selected personnel in each district would be trained in VE techniques to provide a district VE study team.

Since 1974 reductions in work force and redirection of the Caltrans construction program have caused a slowdown of VE efforts. Currently VE is being practiced in the two largest districts and in headquarters. The headquarters VE unit coordinates statewide VE efforts, including training and orientation, and also performs specific studies. In addition, it serves as the staff of a new resource conservation program initiated in 1978.

Despite the slowdown in VE efforts, those directly involved in the program are convinced that VE has great merit and great potential for savings. To date, overall savings have been 8 to 1 over costs. And recurring savings have accumulated to an estimated $16 million annually, mostly from numerous revisions to standards and specifications in such areas as median barriers, fencing, and drainage, and to operations such as pavement surfacing and snow removal.

Following are examples of Caltrans VE applications and the savings achieved.

- Modify concrete drainage inlets. Use lighter grate and frame; use ungalvanized grates for normal installations; eliminate some wall reinforcement; relax finish specifications; allow reusable inner forms; and allow circular pipe inlets and precast inlets along with cast-in-place inlets. Savings of $100 or more per inlet.
- Eliminate concrete median barrier footing: modify reinforcement. Savings of 10 to 15 percent—about $300,000 annually.
- Modify standard headlight glare screen design. Savings of 15 percent—approximately $25,000 per year.
- Install "Domar"-type wooden shelters for sand in lieu of prefab metal buildings. Savings of 25 percent.
- Leave snow poles in place all year where appropriate. Savings of $75,000 annually.
- Eliminate guide markers on tangents; salvage excess: use lighter steel posts; change galvanizing specification; and reduce plate size. Savings of 40 percent—more than $100,000 annually.

Generally VE has not been applied to specific highway projects because of tight schedules and the concern about designers' reactions. It is now being planned for projects over $1 million. The scope of VE application has been based on the premise that 80 percent of the savings potential exists in 20 percent of the design items.

FLORIDA DEPARTMENT OF TRANSPORTATION

Florida's VE unit was created in 1976. The unit is organized to service design, construction, and maintenance through a deputy director of technical services. The emphasis has been on the study of standard designs and specifications to achieve ongoing savings on repetitive items. VE is applied to specific projects on the basis of requests for review or referrals.

The VE program produced relatively small savings during the first 2 years. Much time was devoted to training. Momentum picked up, and by 1978 eight studies of standards and specifications had been completed on median barriers, culvert end treatment, slope stabilization, and bridge barrier rail and fencing. Future plans at that time included studies on inlets, median drains, slope drains, and temporary bridging. The unit also has promoted research in box culvert design, bridge parapet handrails, and sulfur asphalt. Estimated savings resulting from VE efforts: the eight studies achieved savings of $3 million; potential savings recommended in two workshops amounted to $5 million; during the past 1½ years, savings have amounted to $3 million.

Most of the costs to achieve these savings have been for two value engineers. They have conducted training and worked with small VE teams to attack specific problems. An intangible benefit has been the establishment of ongoing teamwork and multidisciplinary communications among VE team members.

Those directly involved in the Florida VE program consider that it has been successful to date and will continue to be so. In their judgment a major ingredient in that success has been the strong interest of top management and its receptiveness to new ideas. Top management has an appreciation of the potential savings from VE and has ensured the availability of needed analysis team resources. It has also given overt support to the VE program, and this has aided greatly in following up on recommended design changes.

IDAHO DEPARTMENT OF TRANSPORTATION

The Idaho DOT's VE program began in 1973 with the appointment of a value engineering officer in the headquarters office. Initially he was virtually the only person with training and knowledge of VE. Although he effectively produced studies, communications problems developed. At the same time, operating personnel were confronted with problems and wanted to apply VE to them but did not have the required training.

As a consequence of these two problems, a VE training

program was developed and 10 VE teams were trained. Six of these are in the districts, and four are in headquarters. Most work only part-time on VE studies.

Management requires that each VE study proposal be reviewed and approved. The process requires about 2 weeks. Generally a VE team is assigned to each problem; the team usually includes both district and headquarters personnel. A considerable number of small special studies, in which only parts of the VE methodology are used, are performed without formal review and approval; that is, they are initiated by supervisors applying VE in their everyday work.

Following are examples of Idaho's VE applications:

- Post-mounted delineators not placed on tangents—savings of approximately $65,000 annually.
- Standardization of concrete barrier delineation with stud-post mounted delineators.
- Elimination of the bottom strand of barbed wire on certain types of fence—a saving of $0.04/ft ($0.13/m).
- Reduction of the number of corner base posts when wood posts are used; use of soil-cement mixture on fence braces and metal corner braces in lieu of concrete; modification to allow 12-ft (3.7-m) fence-post spacing.

MINNESOTA DEPARTMENT OF TRANSPORTATION

The Minnesota DOT initiated in-house VE in 1975, although the value engineering incentive clause (VEIC) for construction contracts had been introduced earlier (1972). The first VE team attended a 4-hr seminar sponsored by the Corps of Engineers. Subsequently two team members attended 40-hr workshops, one conducted by the FHWA and the other by the Corps of Engineers. Two trained persons later guided five others through a VE study of a $525,000 project, which led to recommended changes of $125,000; about $55,000 worth were accepted and implemented. Two standards were revised. In 1977 the FHWA conducted a workshop that was attended by 25 department and 6 FHWA personnel.

At one point the program lost some momentum due to a departmentwide reorganization. Momentum has since been regained, and the program is a viable one. The Minnesota DOT has used training workshops heavily for the review of specific projects ranging from $1 million to $7 million. Following is a summary of results:

- Two workshops have led to $1.2 million in savings, not taking account of savings in subsequent years.
- To 1978 the studies led to changes in two standards: (a) guardrail hardware changed from a special plate washer to a standard round washer—$43,000 in first-year savings; and (b) turning lane width reduced from 13 ft to 12 ft (4.0 m to 3.7 m)—$80,000 in first-year savings.
- Savings resulting from VE team studies on specific projects (to 1978) include (a) elimination of pumping station by use of a tunnel structure—$229,000 in savings; and (b) change of augured pile to H-pile where possible by allowing contractors' option—$223,000 in savings.

The department's VE efforts are directed by one full-time individual located in the headquarters office. Each highway district had been staffed with a methods engineer for some time, and these persons have received VE training. They are responsible for a district VE program, receiving assistance and guidance from the headquarters unit.

Those directly involved in the VE program feel strongly that, even though some standards and specifications have already been reviewed and changed, recent events and conditions offer new design challenges and the need for continuing assessment of standards and specifications as a source for savings.

NEW MEXICO STATE HIGHWAY DEPARTMENT

The New Mexico State Highway Department views VE as a management tool rather than strictly a review technique. The program started in 1977 and applies VE to design standards and specifications, high-cost projects and items, construction contracts, and operations. In other words, the VE program is a comprehensive one designed to allow creative analysis of all major departmental program elements. Although the program is 4 years old, savings have been realized only recently because of the lead time necessary to provide VE training and the need for management to develop appreciation for VE's potential.

A number of formal VE workshops were held. In addition, VE teams were created to conduct specific analyses and were given short VE courses.

Two VE workshops have been conducted for New Mexico by the FHWA. The first (spring 1977) showed few immediate results, but more than $700,000 in savings were subsequently realized through the formation of trained VE teams. The second workshop produced recommendations resulting in approximately $477,000 in initial project savings and an estimated $3.3 million in lifetime savings.

New Mexico's VE program is coordinated by a value engineering coordinator, who provides guidance to VE study teams, particularly through the function analysis, speculation, and evaluation (judicial) phases. The department has established a research program and adopted a research management plan. This is viewed as a welcome addition as VE and research management are considered complementary.

OREGON DEPARTMENT OF TRANSPORTATION

In December 1979 Oregon's state highway engineer created a five-member VE team for a 3-month trial period. The team's assignment was to perform VE studies on preliminary engineering-related items, submit a formal report on the results, and submit recommendations as to a course of action for future VE efforts.

Team members were selected on the basis of their experience and ability to work independently on difficult problems. The team consisted of four department employees and one FHWA employee. All were temporarily relieved from the responsibilities of their existing positions. The team was placed directly under the assistant state highway engineer for technical services and was given freedom to select projects and conduct VE studies on them. As some members were not familiar with VE, a 2-day training session was conducted.

The team evaluated project designs for four projects. The recommendations included:

- Surfacing design and subsurface drainage design changes on an Interstate 3-R project—anticipated savings of $750,000.
- Subsurface drainage design changes on an Interstate gap-closing project—anticipated savings of $1.5 million.
- Pavement reconditioning on a maintenance project—anticipated savings of $150,000.
- Surfacing design changes on a state construction overlay project—anticipated savings of $75,000.

In addition, it was estimated that incorporating the recommendations into future projects would achieve annual savings of $200,000 to $400,000. The estimated benefit-to-cost ratio of these studies was 80 to 1.

The final design engineer and his staff reviewed the proposals, worked with the team to develop a few compromise changes, and then recommended implementation of each to the technical services engineer. The latter subsequently approved each, and project plans were revised.

The team made the following recommendations relative to the future of VE in the Oregon DOT:

- A permanent three-member VE team should be established; the team leader should be a registered engineer with 8 to 10 yr of experience in the division.
- The VE operation should be at the staff level, and the team should report directly to the assistant state highway engineer for technical services. This would ensure independence from other staff level sections and flexibility to perform studies for other branches.
- The VE team should spend about 70 percent of its time performing VE studies, 20 percent of its time training division personnel in VE, and 10 percent of its time in related duties, such as technology transfer.

The annual cost of a permanent team is estimated at $150,000. Initial efforts indicate that the department would realize substantial savings and related benefits from employee training and technology transfer as well as from resource conservation.

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

The Pennsylvania DOT's VE program is, like that of the Oregon DOT, new and growing. Initial efforts in late 1979 centered on the VEIC for construction, but during the last year efforts have been extended into preconstruction. The focus is on study of standards and specifications and on projects over $1 million.

Two engineers in each district were trained through a 40-hr FHWA workshop. Of the 11 districts, 5 have already achieved design savings of more than $16 million. Further savings are anticipated as the program grows and the approaches are refined. The key to achieving such substantial initial results has been top management's enthusiastic support and direction of VE efforts.

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

In 1973 the Virginia Department of Highways and Transportation initiated a VE suggestion program that was a modification of one being used by the Procurement Section of the U.S. Department of Defense. The premise was that VE could be applied beneficially to many areas of operation and that employees would submit suggestions for improvement. This proved to be the case, and a considerable number of good design-related suggestions and standards modifications were made and adopted. One of the early problems was that, with the limited VE staff available to review suggestions, it was not possible to evaluate all suggestions promptly. The result was a decline in morale. Even so, it is currently estimated that savings have been averaging about $100,000 per year.

During the past 2 yr there has been a renewal of interest in the VE program, and future approaches to VE are now under consideration by top management. Thus far approximately 110 of the department's personnel and 8 FHWA engineers have been trained through workshops. Each of the workshops, in which live projects were used, has led to the identification of significant potential savings, and more than $3.6 million of the savings have been realized. Approaches under consideration include an increased emphasis on study of design standards and specifications, using teams composed of those who have been trained in the workshops.

U.S. ARMY CORPS OF ENGINEERS

Most VE programs in highway and transportation agencies are relatively new. To provide some perspective on the characteristics and results of a more mature program, major elements of the program of the U.S. Army Corps of Engineers are described below. Although the activities of the Corps are not strictly transportation-related, the projects administered by the Corps have characteristics similar to those handled by state transportation agencies.

The Corps of Engineers adopted VE in 1964. The program at first was confined to the Office of the Chief of Engineers (OCE). The first two steps were to (a) employ a private consulting firm to conduct a series of VE workshops and (b) include a VEIC in all construction contracts.

Initially field offices received a VE regulation but no guidance in developing their own VE programs. In early 1965 the first full-time VE positions were established, and in less than 5 months more than 4,000 persons were indoctrinated in VE through a crash training program. Regulations required the establishment and maintenance of active programs (in-house and by contractors) that used VE principles and methods.

VE training is the backbone of the efforts of the Corps to apply VE continuously. Basically three types of training are available: 40-hr workshops, short (2- to 4-hr) orientations, and short training sessions for executives. By regulation, all engineers are required to attend the short orientation as soon as possible, and they are sent to a 40-hr workshop at a convenient time. VE officers from the divisions, districts, and OCE teach the 40-hr workshop, which is considered the essential course. It includes training in basic VE fundamentals and hands-on training on actual projects. The Corps adopts

many of the recommendations, and the savings generated by them have more than paid for the training.

This VE program is comprehensive in its requirement that VE be applied in preconstruction areas in civil contracts, military contracts, and the value engineering contractor proposal program (VECP). Selection criteria and approaches are given in Table 1. The total savings record achieved to 1980 is impressive: in civil work, there have been savings of $419,500,000; in military work, $267,900,000; in VECP, $24,352,137—for total savings of $711,752,137.

The demonstrated success of the VE program has contributed to creation of a positive attitude toward it and toward cost savings. All Corps personnel interviewed emphasized that the success of the program was largely attributable to top management's strong commitment to it. They also emphasized that the inclination to allow operational priorities is recognized and that a key responsibility of VE officers is to pursue implementation strongly.

TABLE 1
SELECTION CRITERIA AND APPROACHES FOR USING VALUE ENGINEERING (U.S. ARMY CORPS OF ENGINEERS)

Project Phase	Selection Criteria	Method of Approach
Standards and specifications	The 80-20 rule [a]	Internal VE team
User criteria	Cost estimates over $300,000	Internal or consultant VE study
Concepts and preliminary engineering	All consultant design	Engineering review reward system [b]
	Internal design and costs over $300,000	Internal VE team
Construction	All projects	VEIC

[a] The 80-20 rule refers to Pareto's curve, or law of distribution. It is described in Chapter 5.

[b] This is an internal system. The Corps of Engineers has published materials that explain it in some detail.

ASSESSMENT OF RESULTS IN PRECONSTRUCTION

Following is a summary assessment of VE in preconstruction in state highway and transportation agencies.

- VE is increasingly being recognized as one means of meeting the challenges that grow out of escalating costs, declining revenues, and mounting needs.
- All programs have produced significant dollar savings. Even initial studies typically produce impressively high savings, and mature programs appear to yield savings in the range of 10:1 to 20:1 over the cost of the program.
- Most programs have also yielded ongoing savings from reduced maintenance, but few agencies track these.

Although VE in preconstruction is receiving increasing recognition as an important management tool, the extent of its use appears to be less than its demonstrated potential warrants. There appear to be three reasons for this. First, emphasis in the past has been on "delivering" the transportation program—"getting the program out." This emphasis has increased with inflation because any time-consuming studies or procedures can delay letting and mean higher costs. Second, many engineers and technicians still have the misconception that VE is just a catchy name for what is already being done as a matter of course by good engineers. Third, some VE programs that have been initiated with a burst of enthusiasm and considerable momentum have lost that momentum because of reorganization, changes in top management, poor follow-up on recommendations, and other reasons. Once lost, it is difficult to regain.

It is the overwhelming consensus of engineers and technicians that the most important factor for the success of a VE program is continuing top management involvement and understanding of VE and overt support for the program. The second most important factor is training—not simply conducting some workshops, but enlisting the continued support of top management and providing time for exposure and attitude change. The third most important factor is a strong follow-up of recommendations. Chapter 5 deals with these and other factors in successful VE program implementation.

The improvement programs of most highway and transportation agencies today are characterized by a steadily increasing number of rehabilitation projects. The examples in this chapter clearly indicate the applicability of VE to such projects.

Although alternative bidding is not normally part of VE, some states have achieved cost reductions through this process. With alternative bidding, an agency will include in the plans and specifications two (or more) materials and/or designs that are considered to provide equal service; for example, asphalt and portland cement concrete pavement or concrete and steel bridge superstructures. Contractors are allowed to submit bids on either of the alternatives. Thus contractors are likely to submit low bids on materials with which they are the most familiar and for which they have the best access to labor and equipment. To a certain extent, this amounts to a VEIC, where the acceptable options are delineated and settled before the contract is awarded.

CHAPTER FOUR

VALUE ENGINEERING IN CONSTRUCTION

The preceding chapter deals with VE in the pre-contract-award phase and focuses on in-house VE programs of the agency responsible for designing the project and awarding and administering the contract. This chapter deals with VE in the post-contract-award phase and focuses on the role of contractors. That role is described in current AASHTO-AGC-ARTBA *Guidelines (4):*

> A useful extension of a state VE program is the "Contractor Incentive Clause" referred to by using agencies as the Value Engineering or Cost Reduction, Incentive Clause. It permits the contractor to propose changes to the contract requirements that will "get the job done" at least as well as the original design, but at a lower cost. Such a clause provides the vehicle for VE applications to carry through contract award and furnishes construction contractors and sub-contractors the opportunity and incentive to actively contribute to cost-effectiveness and the product improvement goals of VE.

VE concepts, principles, and techniques are the same whether they are applied by contractors or by the awarding agency. Thus the description in Chapter 2 is as applicable to VE in construction as to VE in preconstruction.

This chapter describes the generally accepted reasons for and benefits of the value engineering incentive clause (VEIC)—what should be included in the clause and what the key elements in the review process are.

BENEFITS OF THE VEIC

Those who question the use of the VEIC usually reason that the typical state highway or transportation agency employs a considerable number of engineers and technicians whose job it is to work with projects from inception to contract award. They have the responsibility to design projects that are cost-effective; and, after all, the contractor's job is to build the project, not design it.

Although there is logic to this reasoning, to accept it so completely as to exclude VEICs is to overlook the fact that the experience of many government agencies (including a considerable number of state highway and transportation agencies) demonstrates that using VEICs can produce significant cost savings.

There are two main reasons that highway designs do not always yield maximum cost savings. First, there is the time factor. Most state highway and transportation agencies attempt to let projects to contract as quickly as possible in order to make best use of available monies as well as to meet critical needs. Hence, preconstruction schedules typically are quite demanding. During the past decade the preconstruction process has become increasingly complex because of the greater number of reviews, hearings, and approvals required. Project lead times have lengthened, and consequently schedules have become even more demanding and time pressures greater. Most designers agree that, given more time, they could improve on original designs and develop alternatives that are more cost effective.

Second, there is a natural and understandable tendency for designers to continue developing designs in ways that have been successful in the past, particularly if time pressures are great. This is not necessarily wrong, but if the practice prevails over long periods, it is increasingly likely that opportunities for cost savings will be overlooked.

The VEIC represents a low-cost opportunity to use the experience and creative talents of contractors. It is a means of putting them on a post-contract-award design squad to scrutinize the design and search for cost-reduction refinements. In a very real sense, use of the VEIC is a management improvement step because it taps competent resources at small cost and risk. It recognizes that contractors have the advantage of being in constant, direct contact with day-to-day construction problems and can frequently bring fresh approaches to them.

CONTENT OF A TYPICAL VEIC

A considerable number of federal agencies as well as state highway and transportation agencies have developed and included VEICs in standard specifications or special provisions. Although they vary to meet particular conditions, it is generally accepted that they should have certain characteristics in common. Examples of the typical contents of VEICs are presented in the following sections (in italics).

Description and Application

The VEIC should contain a clear description of what it is and how it is to be applied. Following are elements in a typical description.

- *The contractor may submit to the chief engineer (or a designated engineer), in writing, a value engineering proposal (VEP) for modifying the plans, specifications, or other requirements of the contract for the purpose of reducing the total cost of construction without reducing design capacity or quality of the finished product.*
- *If accepted by the department, net savings resulting from the VEP will be shared by the department and the contractor on a 50-50 basis.*
- *This special provision applies to all VEPs initiated and developed by the contractor and identified as such by the contractor at the time of submission to the engineer; however, nothing herein shall be construed as requiring the engineer to approve a VEP submitted hereunder.*

In essence, the description and application paragraph should clearly define the basic aims of a VE change proposal:

(a) that it is a proposal to change the contract; (b) that the change is for the purpose of reducing the total cost of construction; (c) that the change will not reduce or impair essential functions, capacity, or quality of the finished product; and (d) that net savings will be shared by the agency and the contractor on a stated basis.

Documentation and Detail Requirements

It is important that the VEIC include all the items of information the contractor is required to develop and submit with each proposal. Following are typical statements concerning documentation.

- *Each VEP shall result in a net savings over the contract cost without impairing essential functions and characteristics of the item(s) or of any other part of the project, including but not limited to service life, reliability, economy of operation, ease of maintenance, desired aesthetics, and safety.*
- *As a minimum, the following information shall be submitted with each VEP: (a) a statement that the proposal is submitted as a VEP; (b) a statement concerning the basis for the VEP and benefits to the department, together with an itemization of the contract items and requirements affected by the VEP; (c) a detailed estimate of the cost under the existing contract and under the VEP; (d) proposed specifications and recommendations as to how such VEP changes are to be accomplished; and (e) a statement as to the time by which a contract work order (change order) adopting the VEP must be issued so as to obtain maximum cost benefit.*

This section also should describe any special procedures or requirements for submittal. Careful adherence to the statements in this section will do much to prevent needless expenditures of time and money by contractors and burdensome and costly reviews by the agency.

Acceptance and Implementation

The section on acceptance and implementation should describe the review, acceptance, and implementation process followed by the agency. In effect, it should communicate to the contractor the actions that the agency will take. Following are typical provisions.

- *The department will process the VEP in the same manner as prescribed for any other proposal that would necessitate issuance of a contract work order (change order).*
- *The department may accept in whole or in part any VEP by issuing a contract work order that will identify the VEP on which it is based.*
- *The department will not be liable to the contractor for failure to accept or act upon any VEP submitted pursuant to this provision, nor for any delays to the work attributable to any such proposal.*
- *Until a proposal is effected by work order, the contractor shall remain obligated to the terms and conditions of the existing contract.*
- *If an executed work order has not been issued by the date upon which the contractor's proposal specifies that a decision thereon should be made, or such other date as the contractor may subsequently have specified in writing, such proposal shall be deemed rejected unless both parties agree to an extension of time for consideration.*

One part of this section generally spells out details related to costs and sharing. Following are typical approaches.

- *The work order effecting the necessary contract modification will establish the net savings agreed upon, will provide for adjustment in the contract prices, and will indicate the net savings to be divided between the contractor and the department.*
- *The contractor shall absorb all costs incurred in preparing a VEP for submission; all reasonably incurred costs of reviewing and administering the VEP will be borne by the department. (An alternative is that development and review costs will be considered in determining net savings.)*
- *The contractor's share of the net savings shall constitute full compensation for effecting all changes pursuant to the agreement.*
- *The department reserves the right to include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the proposal. Acceptance of the work order (supplemental agreement) by the contractor shall constitute acceptance of any supplemental conditions.*
- *Acceptance of the VEP and performance of the work thereunder will not change the contract time limit as a result of the VEP, unless specifically provided for in the work order authorizing the VEP.*

Proprietary Rights

A section should be included to define the proprietary rights of accepted proposals. The following statements are typical.

- *The department expressly reserves the right to adopt a VEP for general use in contracts administered by the department when and if it determines that said proposal is suitable for application to other contracts.*
- *VEPs identical or similar to previously submitted proposals will be eligible for consideration and compensation under these provisions if such proposals were not previously adopted for general application to other contracts administered by the department. When a VEP is adopted for general use, compensation pursuant to this provision will be applied only to those contracts awarded and for which the subject VEP has been submitted prior to the date of adoption of the specific VEP. The department is normally the sole judge of acceptability.*
- *Subject to the provisions contained herein, the department or any other public agency shall have the right to use all or any part of any accepted VEP without obligation or compensation of any kind to the contractor.*

Exclusions

Some states have been concerned that contractors might propose major design changes in VE incentive proposals. Following is a typical provision regarding this.

- *Proposed changes in the basic design of a bridge or pavement type, or which require different right-of-way limits, will not normally be considered as an acceptable VEP.*

The rationale for excluding these items from consideration is that they are such basic features that they generally are subjected to exhaustive analyses before award and the choices can usually be justified and defended. Also, environmental or aesthetic considerations (or other factors) may override cost-effectiveness to some degree in these selections.

SUMMARY OF CURRENT VEIC PROGRAMS

The VEIC, like VE in preconstruction and other areas of operation, has gained increasing acceptance in state highway and transportation agencies during the past decade. FHWA data indicate that a considerable number of states now use it and that others are considering it. The FHWA has recently modified the sharing formula in its standard specifications for direct federal work from the current 50-50 basis for each accepted proposal to provide that the contractor will be paid 100 percent of the first $10,000 saved, 75 percent of the next $40,000 saved, and 50 percent of all savings over $50,000. The objective is to encourage contractors to search for improvements.

Table 2 is a summary of the experiences of nine states using the VEIC. The data were collected by interviews, both in person and by telephone, and from papers presented at meetings. Other states known to use the VEIC include Arizona, Connecticut, Hawaii, Illinois, Iowa, Louisiana, Maine, Maryland, Michigan, Mississippi, Missouri, New Jersey, New York, North Dakota, Puerto Rico, South Dakota, Utah, Washington, and Wyoming. A direct comparison of states was not possible because savings are not always documented in readily available form; some are combined with other contract change orders or with preconstruction VE savings. Also, savings often are understated because probable ongoing savings are not included.

TABLE 2
SUMMARY OF VEIC EXPERIENCE (SELECTED STATES)

State Highway or Transportation Dept. Using VEIC	Years Used	Savings Highlights
Alaska	1 yr	$300,000 in 1st yr.
California	Since 1969	More than $2 million during last 5 yr.
Florida	Since 1976	Roughly $500,000 per year.
Georgia	Since 1977	Not available.
Minnesota	Since 1972	$267,000 through 1978.
New Mexico	Since 1976	Approximately $200,000 in 1st yr.
Oregon	1 yr	Not available.
Pennsylvania	1 yr	Estimate $500,000 per year.
Virginia	2 yr	Approximately $1.1 million in 2 yr.

A wide range of contractor proposals has been submitted and accepted. Figure 3 shows 11 proposals submitted in Virginia. Following is a list of selected proposals accepted by other highway agencies and by the Corps of Engineers.

- Contractor reduced borrow haul by negotiating his own borrow site. Savings of $179,000.
- On the widening of a small bridge, contractor proposed to remove curb and existing rail and install new rail from exterior scaffolding instead of doing it from bridge deck, eliminating need for the temporary rail to protect the work area. Savings of approximately $1,000.
- Contractor discovered room within right-of-way area to dispose of slide removal, eliminating haul and increasing safety. Savings of about $4,700.
- Contractor proposed paying for imported borrow on theoretical in-place volume measurement in lieu of weighing. Savings to state of $32,000.
- Contractor proposed elimination of falsework opening that provided access to private party, paying private party $500 to use other access route. Savings to state of $1,300.
- Contractor proposed that the requirement for tight fit of intermediate stiffeners of a steel girder be eliminated because tight fit did not contribute to structural adequacy. Savings to state of $2,680.
- Contractor proposed that he furnish a special aggregate base in lieu of specified aggregate subbase and aggregate base. Savings to state of $36,000.
- Contractor proposed changes in staging and traffic handling. Savings to state of $4,500.
- Contractor proposed redesign of the superstructure for a bridge, resulting in significant decreases in prestressing steel, superstructure concrete, and bar reinforcing steel. Savings to state of $175,000.
- Contractor proposed to use a long-span corrugated steel culvert in lieu of a concrete bridge over an improved channel (contract was for a cross-post road on a military base). Savings to Corps of Engineers of $16,920.
- Contractor proposed painting with primer the above-water portions of H-piles to 1.5 ft (0.5 m) below low-water datum in lieu of painting the full length of H-piles. Net 1-yr savings to the Corps of Engineers of $6,713.

The list of proposals could be greatly expanded, but even these few examples illustrate the wide range of cost savings opportunities that typically exist in the post-contract-award phase and demonstrate that contractors can and will direct their talents and energies to achieving such savings.

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

SUMMARY OF VALUE ENGINEERING PROPOSALS

FEBRUARY 24, 1981

11 SUBMITTED	TOTAL SUBMITTED	-	$2,405,723.
7 ACCEPTED	TOTAL ACCEPTED	-	$2,233,005.
4 REJECTED	STATES SHARE	-	$1,116,503.

1. Project: 0064-114-103,C503,B605-B609,B611
   FHWA No.: AC-I-64-3(166)237
   Contractor: McLean Construction Company SEE ALSO #3 & #6
   Contract Value: $18,275,535.72
   Item: Elimination of Tremie Concrete Seals
   Projected Total Saving: $70,965.40
   Action: Denied - (Denial Recommended by Committee and Concurred In by Construction Engineer)
   Discussion: Good construction practice would dictate elimination when not needed - can not arbitrarily eliminate all footings on this project.

2. Project: 0603-065-136,C501,B601
   FHWA No.: SOS-065(102)
   Contractor: Sanford Construction Company
   Contract Value: $361,004.50
   Item: Change conventional timber piles and footing to prestressed pile bent design
   Projected Total Saving: $4,461 (Contractor's original submission projected $7,86
   Action: Recommended by Committee - Accepted; Recommended by Construction Engineer - Accepted
   Discussion: Contractor submitted design change - Department was considering change different from Contractor in specifics but same in principal - compromise design worked out with District Bridge Engineer and Contractor.

3. Project: 0064-114-103,C503,B605-B609,B611
   FHWA No.: AC-I-64-3(166)237
   Contractor: McLean Construction Company SEE ALSO #1 & #6
   Contract Value: $18,275,535.72
   Item: Substitution of Steel Sheet Pile
   Projected Total Saving: $120,000 first choice $50,000 second choice
   Action: Recommended by Committee; First choice accepted by Construction Engineer
   Discussion: Original plans required specific sheet pile which has limited availability - plans were prepared by consultant - VEP allowed for different sheet piles.

4. Project: 0095-043-106,G302,B634,B663,B664,D671,D672,D674,D675
   0095-042-106,G310
   FHWA No.: AC-I-95-1(69)76
   Contractor: Lane Construction Corporation
   Contract Value: $14,306,892.30
   Item: Alternate method of constructing Bridge B663 and B664
   Projected Total Saving: $162,550
   Action: Recommended by Committee contingent upon obtaining Corps permit; Accepted by Construction Engineer contingent upon obtaining Corps permit; Corps of Engineer approved amendment to permit
   Discussion: Original Special Provisions limited the Contractor's access to Bridge sites to use of wood, steel, or concrete mats - this VEP provided for rock-fill over Typar - Corps required monitoring of water quality at an estimated cost for monitoring of $12,000 50/50 basis $6,000 each.

5. Project: 0066-000-102,C502,B609,B611,B613,B678,B679,B689,B687,D691,D692,D6
   FHWA No.: I-66-1(105)74
   Contractor: The Lane Construction Corporation
   Contract Value: $39,909,750.80
   Item: Change conventional cast-in-place retaining wall to Reinforced Earth Wall
   Projected Total Saving: $1,717,456
   Action: Recommended by Committee; Accepted by Construction Engineer
   Discussion: This VEP required a redesign of walls - the design was developed by the Contractor and was verified by the Department.

6. Project: 0064-114-103,C503,B605-B609,B611
   FHWA No.: AC-I-64-3(156)237
   Contractor: McLean Construction Company SEE ALSO #1 & #3
   Contract Value: $18,275,535.72
   Item: Substitution of Bar Chart & Narrative plan of operation in lieu of CPM
   Projected Total Saving: $9,800
   Action: Accepted with condition by Committee by Phone Vote; Denied by Construction Engineer
   Discussion: The Contractor advised the Department that a CPM would cost $9,800 to prepare and update - The opinion of the Committee was that this is an administrative decision and appears acceptable if the District concurs and if a CPM will not be actively used; Construction Engineer - This project is of such magnitude as to require CPM - Determined that training of personnel is warranted and steps will be taken to provide training.

7. Project: 0165-122-102,C501
   0165-134-102,C501
   FHWA No.: M-5403(129);M-5403(130)
   Contractor: Ames and Webb, Inc.
   Contract Value: $3,929,663.75
   Item: Stabilization Fabric in lieu of Lime Stabilization
   Projected Total Saving: $89,766.30
   Action: Denial recommended by Committee by Phone Vote; Denied by Construction Engineer
   Discussion: The plans required a pavement structure consisting of 6" of lime stabilized subgrade, 6" subbase-aggregate base material Type II, Size 21A or 22 with liquid bituminous material, 6" bituminous concrete base course Type B-3, and bituminous concrete surface course Type S-5 @ 165 lbs./sq.yd. The Contractor proposed substituting the lime stabilized subgrade with a stabilization fabric: The Materials Division felt that fabric would allow settlement and that this material is still experimental. The general opinion was apprehensive and that future experimentation needs to be performed. This project presented too large an impact area. We are not ready for wide spread acceptance of this procedure.

8. Project: 0095-040-104,G301,B610,B611;G302
   FHWA No.: I-95-1(104)12
   Contractor: Barnhill Construction Company & Subsidiary
   Contract Value: $8,121,743
   Item: Change Pile Bents with full concrete encasement to Pile Bents with A588 steel piles and partial encasement
   Projected Total Saving: $56,669.28
   Action: Construction Engineer, Bridge Engineer and Materials Engineer all had prior knowledge of proposed change and concurred in its acceptance. Committee reviewed submittal and concurred.
   Discussion: This VEP eliminated a considerable quatity of pile encasement and substituted A588 steel piles. Encasement reduced so as to encase piles from 2 feet below ground to 3 feet above ground in lieu of encasing entire exposed length.

9. Project: U000-100-107,C501
   FHWA No.: M-5401(136)
   Contractor: Sperry Corporation, Sperry Systems Management
   Contract Value: $3,149,900
   Item: Substitution of Plastic Junction Boxes for Cast Iron Boxes
   Projected Total Savings: $140,268.72
   Action: Recommended by Committee; Construction Engineer concurred in acceptance except for the 60 day extension which was rejected
   Discussion: Subsequent to this contract award the Department began including Copied Note which allowed substitutions of plastic boxes and does not require a rebate. Apparently, the Contractor was developing this VEP while the Department was developing the Copied Note.

10. Project: 0066-000-102,C501
    FHWA No.: I-66-1(104)73
    Contractor: The Lane Construction Company
    Contract Value: $22,808,856
    Item: Elimination of Cement Stabilized Subgrade
    Projected Total Saving: $21,788.50
    Action: VEP Committee questioned the acceptability of this since it dealt strictly with eliminating contract items. Recommendation was to the effect that if accepted it be modified as per W. L. Hayden Memorandum; Denied by Construction Engineer.
    Discussion: This VEP would eliminate cement stabilizing areas where Reinforced Earth Selected Backfill was located. These areas were partially under roadway pavement and this caused some apprehension on the part of the Committee.

11. Project: 0262-007-101,G301,B601,B603
    FHWA No.: F-056-1(103)
    Contractor: Moore Brothers Construction Company
    Contract Value: $3,897,624
    Item: Composite Deck Construction (Stay-in-place Precast Deck Forms)
    Projected Total Saving: $12,000
    Action: Contractor proposed the use of prestressed stay-in-place bridge deck forms in lieu of that specified. Contractor allowed corrugated steel or conventional. Fabricator provided all computations and necessary plans. Savings were provided in the reduced price of deck concrete. Recommended by Committee; Accepted by Construction Engineer
    Discussion: This procedure and substitution has been allowed and provided for on selected projects.

FIGURE 3 Value engineering proposals (Virginia).

ASSESSMENT OF RESULTS OF VEIC USE

In general, states using the VEIC are strongly supportive of it because their experience has borne out the fact that it has the potential for achieving significant savings at minimum cost. That experience has brought to light some potential problems, which should be anticipated and addressed by any state initiating a VEIC program.

Contractor Understanding. It is essential to the success of a VEIC program that contractors have a clear understanding of the VEIC and the requirements for an acceptable proposal. Lack of such understanding can lead to costly, time-consuming, nonproductive efforts by both the contractors and the agency. These can, in turn, lead to the development of negative attitudes toward VEICs by contractors and reduce participation and the number of submittals.

Prompt and Adequate Review of Proposals. One of the first steps an agency must take to ensure success of a VEIC program is to make certain that adequate resources are made available for thorough and prompt review and evaluation of proposals. Rejection of proposals because of lack of time or resources for an adequate review and evaluation will frustrate contractors, cause friction, and reduce participation. On the other hand, acceptance of nonmeritorious proposals will discredit the program.

Criticism of Sharing Savings. It may be expected that some agencies will criticize sharing savings with contractors, finding it difficult to view the savings as taking advantage of an otherwise lost opportunity. Such criticism generally suggests that the agency failed in a design if it overlooked cost-effective alternatives that were subsequently found by the contractor. The criticism also ignores the continuing savings gained from applying a proposal to future contracts, even though the contractor shares in savings only one time.

In summary, the experience of states using the VEIC is that savings have been well in excess of costs. Beyond that, significant ongoing savings have been realized from associated changes in design standards and specifications. The most successful programs have established policies, guidelines, and practices such as the following:

Project Selection. Some departments have achieved greater benefits from VEIC application to selected projects rather than its wholesale application to all projects. Others apply it to all projects.

Orientation of Contractors. Those with experience in the use of VEICs emphasize and reemphasize the necessity for a clear understanding between contractor and agency. Various approaches have been taken to orient contractors, one of the most common being to work closely with contractor associations in training and orientation meetings. Another is to conduct orientations on specific projects at the prebid conferences. Another is to publish results of VEPs.

Timely and Effective Review and Evaluation. VEPs received after the contract is awarded always impose time constraints. It is essential that the agency respond quickly and effectively. Those evaluating VEPs should be well-grounded in VE principles and have experience in it.

There are indications that a VEIC program is likely to be more successful if it is just one part of a comprehensive VE program in the agency. It can be coordinated with other elements of that program in an atmosphere in which there is a general emphasis on improving value/cost performance.

CHAPTER FIVE

CONCLUSIONS AND IMPLEMENTATION GUIDELINES

Foremost among the problems confronting state highway and transportation agencies is that over the past few years financial resources have become increasingly scarce in relation to existing and accruing needs. It is widely believed that this condition will persist through the 1980s and perhaps beyond.

This situation challenges all agencies to aggressively search for and implement ways of achieving more from available financial resources without reducing quality, reliability, or safety. This synthesis has attempted to answer two questions: Do the results of the application of VE in preconstruction and contruction show that it is effective enough to warrant increased use? If the answer to the first question is yes, what general guidelines should be followed in implementing VE programs or systems?

CONCLUSIONS

The study findings led to the conclusion that application of VE concepts, principles, and techniques in both preconstruction and construction has been effective enough to warrant increased use. VE would considerably aid any agency in meeting the continuing challenge to gain more from limited financial resources without sacrificing quality, reliability, or safety. Results achieved in those states that have initiated VE programs warrant the serious consideration of agency management and the pursuit of aggressive efforts to develop, implement, and manage effective VE programs in both preconstruction and construction.

A second conclusion is that the best opportunities for initial application of VE exist in preconstruction, with emphasis on application to standard plans and specifications and on design criteria and guidelines. It can be expected that greater savings will be achieved by a VE program in these areas than through a VEIC program for contractors. Although the data available from states did not allow for precise quantitative comparison, all available data support this conclusion. The conclusion is also consistent with results achieved by the U.S. Army Corps of Engineers, which has aggressively applied VE in both areas since the mid-1960s. From 1965 to 1980 total savings credited to the VE program efforts of the Corps amounted to approximately $712 million, of which about 3.4 percent ($24.4 million) was attributable to contractor change proposals.

The disparity between VE savings in preconstruction and construction should not lead to the conclusion that VEIC programs are valueless. Even though VEIC savings may not be as large as those in preconstruction, available data indicate that they can be expected to be significant. Moreover, VEIC programs generally yield benefits other than immediate savings from individual proposals.

First, the VEIC is a relatively low-cost method for tapping valuable creative resources that would not otherwise be used. Second, VEIC proposals frequently direct an agency's attention to desirable changes in standards and specifications that would yield ongoing savings in return for a one-time payment. Third, a VEIC program tends to stimulate employees' interest in cost savings, particularly if many acceptable proposals relate to items that, by reasonable standards, should have been identified and considered in the early planning stage or the project development stage.

GENERAL IMPLEMENTATION GUIDELINES

During the preparation of this synthesis it became increasingly clear—from interviews, from presentations and group discussions, and from study of experiences—that the success of VE programs depends as much on their planning and implementation as on the technical methodology and procedures of the process itself.

Much of the literature about VE emphasizes the human problems that can be anticipated. The problems have to do with habits, attitudes, beliefs, and perceptions that cause resistance to the program and to recommended changes, and they are commonly referred to as roadblocks to cost-effectiveness. One roadblock mentioned by several interviewees was the tendency for reviews of VE recommendations to be a defense of the reasoning behind the original product rather than a frank appraisal of the proposal to determine if it achieves the objectives at less cost.

The concern about resistance to change is well-founded. The value method is a process designed to generate recommended changes on a continuing basis. It will fail if it does not do so and if changes are not implemented. Thus, it is essential that VE program implementation be planned so that the initial steps create positive, change-receptive attitudes. The planning and implementation guides suggested here will, if followed, do much to create such attitudes.

Top Management Support

The first and most important step in implementing a VE program is to gain the understanding and support of top management. This support is needed initially to ensure adequate funding for training and for creating positions; and more important, it is the most essential element required throughout the life of the program. Continuing, active involvement of top management creates and maintains the positive, change-receptive attitudes that are necessary to implement cost-effective changes.

Ideally, the chief executive of the department (or one or more individuals at the top level) becomes interested in VE and initiates action. Otherwise, one or more persons in the organization must be aggressive and persistent enough to see to it that top management knows (a) what VE is, (b) what its potential benefits are, (c) what will be required by way of

resources and time to implement and carry out a program, and (d) what the proposed plan is.

The first two items can be accomplished through training and orientation. Although it would be useful for the top management group to experience the usual 40-hr (1-week) workshop, it is probably not realistic to expect that this amount of time can be allocated by the whole group. Probably the most realistic approach is to develop and conduct a 1- or 2-day orientation program.

The second two items require that a plan be developed and submitted for top management approval. The pilot study approach taken by the Oregon Department of Transportation (described in Chapter 3) has considerable merit because it demonstrates the potential of the program and provides a basis for developing an implementation plan.

A "go" decision by top management to implement a VE program will not by itself ensure the continuing, active involvement desired. Top management must be brought into the "feedback control loop"; that is, they must review the progress and results of the VE program at regular intervals. Ideally, these reviews should consist of a scheduled, face-to-face discussion with those responsible for directing the VE program and not be just a written report. Such reviews enable top management to make the ongoing supportive decisions needed to maintain momentum.

Middle Management Support

VE programs will succeed only if middle managers—the various division heads and district personnel responsible for design—understand, believe in, and support the program. Middle managers are directly responsible for initiating and carrying out VE studies and implementing recommended actions. Obtaining their support and understanding requires (a) that they are aware that top management understands and supports the program, (b) that they are fully trained in VE methodology and techniques, and (c) that they are convinced that VE can be a powerful tool when used properly.

Whereas a short orientation program may suffice for top management, middle managers should attend a more comprehensive training program (such as the usual 40-hr workshop) so they can fully experience and appreciate VE. A very high percentage of those who attend workshops in which VE is applied to live projects are convinced of the merits of the value method.

Departmentwide Knowledge

Basic to VE program development and management is communicating information about it throughout the organization. Most federal agencies with successful VE programs have assured wide dissemination of information by compiling VE manuals, or similar documents, that spell out in some detail the purposes and objectives of the program and the policies and practices related to it. These documents are updated regularly.

The agency should fully document all savings and circulate the information widely within the organization. Publication externally can be quite useful in creating a positive image of the agency in the minds of the public and the legislature.

Several benefits can be expected from these kinds of efforts. Three of the more important ones are (a) there are clear formal statements by people in top management of their desire that the VE program be carried out and of their support of it; (b) the process of developing cost-conscious attitudes within the agency is continually reinforced, and as these attitudes develop, interest in extending VE application will probably be generated; and (c) external publication of documented results is useful for "crossfeed" purposes and is helpful nationally.

Organization Considerations

An effective program needs not only the support of top and middle managers but also direction and coordination by one individual, commonly called a value engineering coordinator. This person should be a full-time employee; experience has shown that assigning this position on a part-time basis produces poor results.

It is vital that the coordinator avoid creating an organizational unit that alienates middle managers. The danger is that middle managers might adopt the attitude that "VE is the VE department's job, and we will go about our business as usual until they come up with something good." To be effective, the VE coordinator must gain the cooperation and support of middle managers. To do so, this individual should be highly knowledgeable and skilled technically, practical and down to earth, open-minded, skilled in oral and written communication, tactful, self-starting, and tenacious.

The VE unit should be located at the highest level necessary to ensure that the coordinator has easy access to top management. To function well, VE unit personnel should be able to cross organizational lines as necessary to initiate training and implementation activities and work with personnel in any units involved in VE activities.

IMPLEMENTATION GUIDELINES FOR PRECONSTRUCTION

The general implementation guidelines described in the preceding section are applicable to VE programs in any operation, including preconstruction. Following are several implementation guidelines that apply to preconstruction.

Project Selection

The application of VE entails a certain amount of expense, which must be justified by potential cost savings. It follows, therefore, that the process of selecting projects for VE study must recognize the need for change and provide sufficient opportunity for savings to warrant the cost of the study. Promising projects are those in which (a) costs substantially exceed initial estimates; (b) complex items provide costly and unnecessary functions; (c) items use critical or expensive materials; (d) items require very difficult construction or fabrication procedures; (e) items appear too costly to build, maintain, or both; and (f) designs have been revised and have become quite complex.

The earlier VE is applied, the greater the potential for

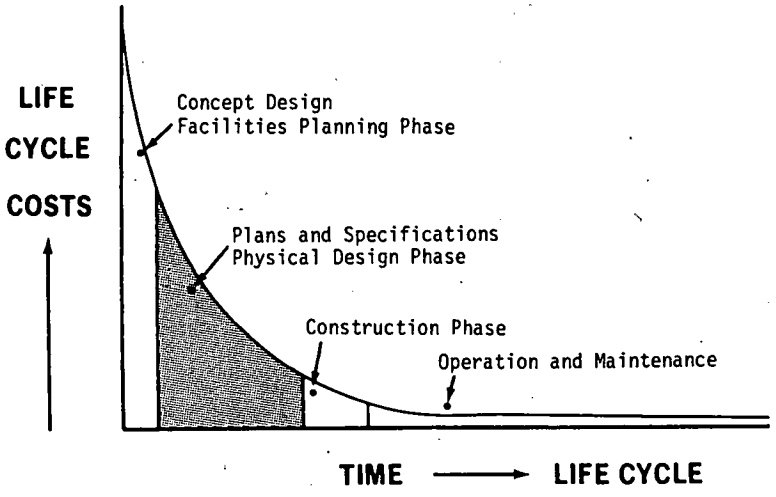

FIGURE 4 Relative influence of project decisions on life-cycle costs.

savings. This principle is illustrated in Figure 4, which shows that decisions made in the early stages of project development have considerably more influence on life-cycle costs than those made in the construction and maintenance phases. The curve illustrates another point: operations and maintenance account for a majority of the life-cycle costs of the typical highway facility, but personnel in these areas generally have the least influence on decisions that influence those costs. Therefore, in addition to design personnel, construction, maintenance, and operations personnel must be involved in the study.

A generally accepted and useful approach for selecting items for VE study is based on Pareto's curve, or law of distribution, which is shown in Figure 5. The curve applies when a significant number of elements are involved. It is based on the principle that a small number of elements—about 20 percent—account for about 80 percent of the costs. It follows that these few elements generally contain the greatest percentage of unnecessary costs. So Pareto's law of distribution (the 80-20 rule) should be applied to identify the element(s) containing the greatest percentage of unnecessary costs.

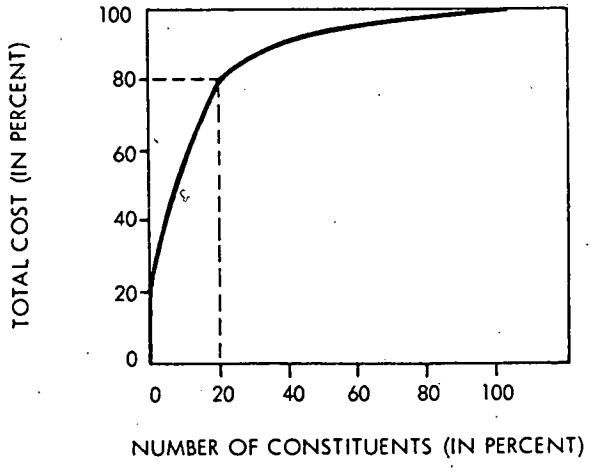

FIGURE 5 Pareto's law of distribution.

VE Study of Standard Plans and Specifications

As already indicated, a number of agencies have focused initial VE efforts on standard plans and specifications and on design criteria and policies. In most instances these efforts have been quite revealing and beneficial in terms of both immediate and ongoing savings. The results warrant the recommendation that, when planning a VE program in preconstruction, an agency should give serious consideration to organizing and initiating a systematic and ongoing team effort to review and analyze all standard plans and specifications currently in use. This recommendation is supported not only by the fact that it has already proved effective but also by the fact that current economic trends make it imperative that every effort be made to reduce minimum standards with adequate regard for quality and safety.

VE Teams

Most organizations with experience in VE have found it most effective when a team approach is used, because the creative phase in the job plan calls for use of techniques that are likely to be most effective when a number of persons with diverse backgrounds and viewpoints work as a team. Size of the teams may vary, but experience shows that a team of four to six persons with diverse backgrounds usually produces the best results. A team of less than four tends to limit the amount and variety of creative input; a team of more than six may be unwieldy. Assignment of one or two persons who are not engineers may well enhance the creativity process.

It is essential that the persons assigned to VE teams be carefully selected. They should, above all, be persons with creative and inquisitive minds who are not inclined to accept the status quo. They should be able to work cooperatively

with others, and they should be willing to face resistance and opposition to change.

VE work is demanding, and the best results are obtained when VE team members are relieved of other responsibilities while performing team assignments, which may vary in length from a month or two to several months.

The team should report to the highest level necessary to ensure that it can operate freely across organizational lines and be objective in formulating and presenting recommendations. The team should have easy access to manufacturers, contractors, and other public agencies.

Teams should be structured so that there is adequate participation of representatives from various functional areas—design, construction, maintenance, support—as appropriate to the assignment. Members should have sufficient experience to feel comfortable with making qualitative decisions, and they should possess sufficient judgment to be able to distinguish important items and not get lost in details.

Implementation of Recommendations

People interviewed in the preparation of this synthesis frequently stated that developing VE recommendations is only half the job and that implementation is the other half. If a VE program is to produce significant cost savings, acceptable recommendations must be implemented as expeditiously as possible. In a real sense, implementation is a test of top management's commitment to the VE program and the skills and abilities of the VE coordinator and the VE teams. Four common barriers to implementation are (a) poor documentation of recommendations and their rationale; (b) imbalance of priorities—if the agency generally gives a much higher priority to "getting out the program" than to implementing VE recommendations, the VE program will suffer; (c) inadequate departmentwide appreciation for VE potential; and (d) resistance to change.

VEIC PROGRAMS

All true VE programs employ the basic value methodology described earlier. And, with the exception of construction, they are typically in-house programs: the VE program is managed by and VE work is performed by agency employees. The success or failure of the program depends largely on the agency itself.

VEIC programs differ from others in that the actual VE work is performed by independent contractors, who can choose to participate or not. This poses some challenges to the agency; its role becomes that of creating and managing a program that will be attractive to contractors, which means the agency must provide adequate incentive for them to participate. It thus should be recognized from the start that a contractor's participation in a VEIC program involves a certain amount of risk: it costs money to search for realistic savings that will be shared by the agency. Realistically the contractor cannot expect that all change proposals will be acceptable. On the other hand, a VEIC program provides the opportunity for contractors to expand their product line by selling an additional service—their technical expertise.

Securing Contractor Participation

The first step in securing adequate participation is to be certain that the VEIC itself encourages, rather than discourages, contractor participation. The contents of a typical acceptable clause are spelled out in some detail in Chapter 4. More general guidelines are (a) the sharing percentage must be equitable to both contractor and agency—a serious imbalance in favor of either party will reduce the attractiveness of the VEIC program and progressively reduce its effectiveness; (b) the VEIC requirements, policies, and procedures should not be so legalistic, stringent, and cumbersome as to discourage contractors from participating; (c) there should be flexibility to meet changing conditions.

Some states have not initiated VEIC programs because of the fear of legal and political complications. Experience in states already using the VEIC has proved these fears to be largely groundless. Nonetheless, it is a fact that state agencies operate in a legal and political environment, and it is therefore important that the clause itself, and its use in VE, be accepted and supported by all concerned. So when initiating a VEIC program, an agency should draw up the clause in its desired form and secure an interpretation (from the attorney general or whatever sources are most appropriate) as to the legality of its provisions. If there appear to be any doubts about the legality of the clause, the agency should take the steps necessary to secure the required legislative amendments.

Past experience indicates that contractors need to be oriented to the VEIC program and educated about VE methodology and procedures. A number of those involved in state VEIC programs expressed their belief that few contractors working in the highway field have made a practice of employing experienced and qualified value engineers and that it could thus be anticipated that many would be unfamiliar with VE methodology and techniques.

It is clearly the responsibility of the agency initiating a VEIC program to do what is necessary to ensure that an effective contractor orientation and education program is developed and conducted. Otherwise many probably will be reluctant to participate and the number of change proposals submitted will be lower than desirable. Following are suggested approaches to contractor orientation and education:

- The agency should work closely, during the whole of the VEIC program planning process, with whatever contractor organizations exist. It is important that contractors have the opportunity to review all elements of the program—and provide input from their point of view—during the planning stages. The payoffs from this kind of a joint effort, in terms of contractor support and participation, can be considerable.
- The agency should encourage contractors to develop and conduct VE training courses. Because it is likely that the agency will be conducting VE training for its own personnel, contractor personnel also could attend these programs. Training benefits will undoubtedly be enhanced by the exchange of diverse viewpoints.
- The contractor orientation, education, and promotion program should be a continuing one. Some continuing efforts could include regular and periodic distribution of VE infor-

mation, regular briefings on VE projects at letting, and discussions of VE during preconstruction conferences.

Most of these suggested approaches are obvious, and certainly many others could be developed to fit particular conditions. What is important to emphasize here is that a well-planned, aggressive, and imaginative contractor VE orientation, education, and promotion program will greatly enhance the probabilities for the success of a VEIC effort. Such a program will do much to ensure contractor understanding, acceptance, and support and will increase the percentage of acceptable change proposals by contractors.

Maintaining Contractor Participation

Even though initial contractor participation is secured through the kinds of efforts described above, the VEIC program will not be successful unless a high level of participation is maintained over a period of time. Three considerations are necessary here. First, the agency must ensure adequate opportunities for participation. Practices vary among states and agencies. Some include a broad incentive clause in their standard specifications. Some set forth a minimum contract size on which the specification will be applicable. Some use the clause only in supplemental specifications of costly or complex projects. Although each agency must make decisions based on perceived conditions, the examples of contractor proposals given in Chapter 4 suggest that broad use can be productive.

Second, contractors must be assured of an objective evaluation of their proposals. This requires that the agency take all reasonable measures to create positive attitudes toward contractor change proposals.

Third, contractors must be assured of expeditious processing of change proposals. To satisfy this requirement, the agency should allocate adequate resources to the program—personnel who are well-grounded in VE methodology and are receptive to well-conceived and well-documented contractor change proposals.

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