BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Secretary Of Transportation

Greater Use Of Value Engineering Has The Potential To Save The Department Of Transportation Millions In Construction Costs

Value engineering is a scientific method of analyzing a product or service so that its function can be provided at the lowest possible overall cost. When applied to Department of Transportation federal-aid construction programs, value engineering identified further potential savings after other cost-reduction techniques had been used. Although the Department does not have a policy requiring that value engineering be used in its construction programs, two of its administrations use value engineering to a limited extent.

The Department believes that value engineering can produce savings, but it has not required its use mainly because the Department believes value engineering may negatively affect other Department objectives, such as providing grantees maximum flexibility to implement construction programs, and because grant management practices vary among Department administrations. GAO believes that a flexible value engineering policy would be consistent with the Department's objectives.

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY,
AND ECONOMIC DEVELOPMENT
DIVISION

B-209932

The Honorable Elizabeth H. Dole
The Secretary of Transportation

Dear Madam Secretary:

This report demonstrates that greater use of value engineering, a cost-control technique, has the potential to save the Department of Transportation millions in construction costs. The report contains recommendations to you on pages 21 and 22.

As you know, 31 U.S.C. §720 requires the head of a federal agency to submit a written statement on actions taken on our recommendations to the Senate Committee on Governmental Affairs and to the House Committee on Government Operations not later than 60 days after the date of the report, and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this report to the committees mentioned above; other interested committees; and to the Director, Office of Management and Budget. Copies are also being sent to your Assistant Secretary for Administration; the Administrators, Federal Aviation Administration, Federal Highway Administration, Federal Railroad Administration, and Urban Mass Transportation Administration; and the Commandant of the United States Coast Guard.

Sincerely yours,

J. Dexter Peach
Director

GENERAL ACCOUNTING OFFICE
REPORT TO THE SECRETARY OF
TRANSPORTATION

GREATER USE OF VALUE ENGINEERING HAS THE POTENTIAL TO SAVE THE DEPARTMENT OF TRANSPORTATION MILLIONS IN CONSTRUCTION COSTS

D I G E S T

Value engineering is a scientific method of analyzing a product or service so that its function can be performed at the lowest possible overall cost without sacrificing quality. Achieving the lowest cost through value engineering may require redesigning or eliminating components by using different, new, or more efficient technology. To be most effective, value engineering should be performed during the early stages of project design. For example, a value engineering study could reveal that wooden, rather than concrete stairs, as proposed in an original project design, are adequate. Generally, value engineering produces a net savings of 3 to 5 percent of total project construction costs, while costing about 0.1 to 0.3 percent of total project costs. (See p. 4.)

The Department of Transportation (DOT) provides billions of dollars annually--over $16 billion in fiscal year 1983 alone--for construction projects for air, highway, maritime, mass transit, and rail transportation. DOT administrations[1] with major construction programs use various methods other than value engineering to reduce construction costs. DOT could potentially identify additional cost reductions by requiring its administrations to use value engineering as part of an overall cost-reduction approach.

In December 1982 GAO issued a report[2] that discussed the feasibility of using value engineering to reduce costs on mass transit construction projects funded by the Urban Mass Tranportation Administration. Because of the

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[1]Federal Aviation Administration (FAA), Federal Highway Administration (FHWA), Coast Guard, Federal Railroad Administration, and Urban Mass Transportation Administration.

[2]Value Engineering Has the Potential to Reduce Mass Transit Construction Costs (GAO/RCED-83-34, Dec. 29, 1982).

potential for savings, GAO expanded its work to other DOT administrations with construction programs.

GAO made this review to determine (1) DOT's policy on using value engineering during the design phase of construction projects, (2) the impact of FHWA's policy of encouraging states to use value engineering, (3) the success of the Coast Guard's value engineering program, and (4) the feasibility of using value engineering on FAA and Federal Railroad Administration projects.

VALUE ENGINEERING USED WIDELY TO REDUCE COSTS

Several American companies and foreign countries use value engineering to reduce costs and improve productivity. Since 1954 several federal agencies have also used value engineering. For example, the Department of Defense and the Environmental Protection Agency require value engineering in their construction programs. (See p. 5.)

In 1982 the President's Private Sector Survey on Cost Control Task Force Report on Federal Construction Management recommended that all federal agencies consistently use value engineering. In addition, several transportation construction associations support and encourage its use. (See p. 5.)

VALUE ENGINEERING IS USED IN SOME DOT ADMINISTRATIONS BUT IS NOT A REQUIREMENT

DOT does not have a policy on the use of value engineering during the design of construction projects; however, two DOT administrations--FHWA and the Coast Guard--use it to some extent. To reduce costs, all DOT administrations with major construction programs do use various other cost-saving methods, such as pavement recyling (a technique of combining new and existing material when resurfacing roads and highways). However, when value engineering was applied after these techniques, it identified additional potential savings.

FHWA's value engineering program

To encourage states to use value engineering on highway and bridge projects, the states and

FHWA have spent about $3 million for value engineering workshops since 1975. The workshops have trained about 2,000 state highway department officials in 43 states, the District of Columbia, and Puerto Rico; 565 federal officials; and 50 consultants. FHWA claims that the training workshops have identified an estimated $600 million in potential savings. As a result of FHWA's promotion of value engineering, 13 states have implemented a value engineering program and have identified over $94 million in potential savings during fiscal and/or calendar year 1982. (See pp. 7 and 8.)

Coast Guard's value engineering program

The Coast Guard requires a value engineering study for construction projects costing more than $200,000. This amount was established because the Coast Guard believed the opportunities for savings were greater than the costs associated with performing value engineering at that level. During fiscal year 1982 the Coast Guard reported gross savings of more than $4 million from its in-house value engineering program. Of this amount, $1.5 million was actually produced by an architectural/engineering firm the Coast Guard hired to value engineer four projects.

GAO's assessment of the Coast Guard's in-house program showed that it had not been fully implemented in accordance with the Coast Guard's criteria. Value engineering officials at Coast Guard headquarters said that value engineering was not fully implemented because of a heavy workload, a lack of training, and a shortage of engineers. The Coast Guard, however, has taken actions that should make the program more effective. These actions include requiring an independent firm or contractor to perform formal value engineering studies on all projects costing over $1.5 million, using a Coast Guard-approved job plan to perform such studies, and documenting value engineering savings. (See pp. 9 to 12.)

FEASIBILITY OF USING VALUE ENGINEERING AT OTHER DOT ADMINISTRATIONS

FAA currently does not require or encourage value engineering in the design of its construction projects. Rather, it uses in-house, grantee, and design consultant reviews to reduce costs. To determine the feasibility of

using value engineering on FAA projects and whether value engineering could identify additional savings after projects had been subjected to other FAA cost-reduction reviews, GAO reviewed the results of two value engineering studies that were performed on FAA projects.

In one study, an architectural/engineering firm value engineered a passenger terminal building for an airport owner. The study identified savings of $7 million in initial costs and $14 million in operating costs. The study cost about $40,000. For the second study, GAO arranged to have an FHWA study team value engineer an air traffic control tower. The study team made recommendations that would reduce the tower's costs by $654,000, or 40 percent. Although an FAA engineer disagreed on the feasibility of implementing most of the recommendations because the tower was already under construction, he believed that, at a minimum, future tower project costs could be reduced by 3 to 5 percent. (See pp. 12 to 15.)

The Federal Railroad Administration did not use value engineering on the design of its only large project--the nearly completed $2.19 billion Northeast Corridor Improvement Project, designed to rehabilitate the rail passenger line between Boston and Washington, D.C. However, the directors of engineering and design for the project agreed that railroad facilities are similar to mass transit facilities and could be value engineered. (See p. 16.)

GAO's 1982 report on the potential of value engineering to reduce costs on mass transit construction projects described a value engineering study on one aspect of a subway station. The study identified $3.1 million, or 18 percent, in potential savings. Implementing the value engineering recommendations was impractical, however, because station designs were 90 percent complete. Another study on a bus maintenance facility identified potential savings of over $900,000, or about 15 percent. The facility owner planned to implement recommendations that would save about $360,000. (See pp. 15 and 16.)

DOT CONCERNS ON REQUIRING VALUE ENGINEERING

In commenting on GAO's 1982 report regarding the potential for value engineering on mass transit projects, DOT provided several reasons for not implementing value engineering, although it agreed that value engineering can reduce construction costs. These reasons were: (1) a value engineering requirement could reduce a grantee's flexibility in administering its grants, (2) differences among DOT administrations' grant management procedures preclude establishing standard value engineering criteria Department-wide, and (3) value engineering is only one of several methods of cost control.

GAO believes, however, that within the constraints of a required value engineering policy for projects, grantees and administrations with major construction programs could be given sufficient flexibility to use value engineering effectively. For example, grantees could determine when, during early design, value engineering should be performed and by whom. After the study is completed, grantees would also determine which value engineering recommendations should be implemented. DOT grantees, particularly for highway and bridge projects, could potentially benefit from a required value engineering policy because states can retain the federal and state share of savings for use on other federal-aid highway projects. Moreover, the fact that value engineering is only one among several methods does not diminish its contribution to cost reduction. (See pp. 17 to 20.)

RECOMMENDATIONS TO THE SECRETARY OF TRANSPORTATION

GAO believes that (1) value engineering has the potential to save millions in project costs if it were required for DOT construction programs and (2) the cost of establishing, implementing, and maintaining a value engineering program would be more than offset by the savings achieved.

Therefore, GAO recommends that the Secretary of Transportation establish and implement a policy to require DOT administrations to supplement their normal cost reduction procedures for construction programs with a value engineering program. The policy should

be flexible enough to recognize and address the operating differences among the administrations. Specific recommendations intended to help establish a value engineering policy are contained on pages 21 and 22.

AGENCY COMMENTS

In commenting on this report, DOT agreed that value engineering can identify areas of potential cost reduction in its direct construction program. DOT plans to examine the value engineering process and its direct construction programs to define a policy that encourages value engineering. Also, DOT agreed that, in general, value engineering could help reduce construction costs in its federal-aid construction programs but believes that the absence of an Office of Management and Budget (OMB) value engineering policy precludes establishing a value engineering requirement. DOT also stated that OMB Circular A-102 appears to prohibit imposing a value engineering requirement upon grantees.

DOT pointed out that in 1976 and 1980 it chaired interagency study groups that asked OMB to include a government-wide policy in Circular A-102 encouraging grantees to use value engineering. The Circular promulgates standards for establishing consistency and uniformity among federal agencies in the administration of grants to state and local governments. However, OMB has not adopted a value engineering policy. DOT pointed out that it is again chairing an interagency study group and will again ask OMB to establish a policy encouraging the use of value engineering on federal-aid construction programs.

In a July 1984 meeting, the OMB Associate Administrator for Policy Development advised GAO that A-102 does not prohibit DOT from establishing a policy that requires its grantees to use value engineering. In fact, the Environmental Protection Agency requires value engineering in its construction programs.

GAO recognizes DOT's efforts to develop both agency and government-wide value engineering policies. However, GAO believes that, given OMB's position and the potential for large savings, DOT already has sufficient flexibility to develop a policy requiring the use of value engineering in its construction programs. (See pp. 22 to 24.)

Contents

ABBREVIATIONS

CG	Coast Guard
DOT	Department of Transportation
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
GAO	General Accounting Office
OMB	Office of Management and Budget
UMTA	Urban Mass Transportation Administration
VE	value engineering

CHAPTER 1

INTRODUCTION

The Department of Transportation (DOT) provides billions of dollars each year for federal aid and/or direct federal construction in highway, air, rail, mass transit, and maritime transportation. This report discusses and demonstrates the potential of value engineering (VE) to reduce costs and the extent that it is currently used in DOT administrations with major construction programs.

In December 1982 we issued a report[1] that discussed the feasibility of using VE to reduce costs on mass transit construction projects funded by the Urban Mass Transportation Administration (UMTA). Because of the potential for savings, we expanded our work to other DOT administrations with construction programs. The administrations included in this review are the Federal Aviation Administration (FAA), the Federal Highway Administration (FHWA), the Federal Railroad Administration (FRA), and the Coast Guard (CG). The Maritime Administration and other DOT administrations were not included in our review because they either do not have construction programs or their programs are small. Our objectives, scope, and methodology are contained in appendix I.

VALUE ENGINEERING: WHAT IT IS AND HOW IT WORKS

Value engineering is a scientific method of analyzing a product or service so that its function can be achieved at the lowest possible overall cost. Achieving the lowest cost may require redesigning or eliminating unnecessary project components by using different, new, or more efficient technology. For example, a VE study could reveal that wooden stairs, rather than concrete stairs as proposed in project designs, are adequate.

VE has its origins with the material shortages that occurred during World War II. These shortages led builders to develop innovative materials and design alternatives. Often, the alternatives functioned as well as or better than the originals and cost less.

VE is best used early in the design stage of a project, when decisions have the greatest impact on costs. In addition, the opportunities for implementing changes are greatest at an early stage, implementation costs are lower, and fewer project delays occur.

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[1] Value Engineering Has the Potential to Reduce Mass Transit Construction Costs (GAO/RCED-83-34, Dec. 29, 1982).

The VE methodology is applied by a multidisciplined team[2] using a VE job plan. The job plan establishes a systematic, documented method of performing a VE study in five sequential phases.

--Information phase: (1) becoming familiar with the design and selecting for further study areas with the greatest potential for significant savings and (2) performing function analysis.

--Speculation phase: developing ways through creative thought to achieve the same basic function of items by different means.

--Analytical phase: screening the ideas generated in the previous phase and selecting the best ones for possible implementation.

--Proposal phase: preparing written recommendations for cost reduction alternatives.

--Report phase: summarizing the results of the study, recommending specific action, and requesting implementation approval from responsible officials.

In contrast to achieving cost reductions by making smaller quantities or using fewer or cheaper materials, VE uses function analysis and a systematic, sequential, documented job plan. VE analyzes a function or method by asking:

--What is it?

--What does it do?

--What must it do?

--What does it cost?

--What other material or method could do the same job?

--What would the other material or method cost?

VE is different from other cost-reduction techniques in that it achieves cost savings by questioning methods, processes, and materials that have been used for years.

VE concepts and techniques are promoted by the Society of American Value Engineers. Founded in 1959, the Society's members include executives, scientists, managers, administrators, architects, engineers, contractors, and purchasing agents organized into 40 chapters throughout the United States. One of the Society's functions is to designate those members who have demonstrated and maintained a high level of competence to be

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[2]A team might be composed of architects, cost estimators, an ›rations manager, and civil engineers.

certified value specialists. The requirements for a certified value specialist are 4 years of college, attendance at a VE workshop, 2 years of full-time VE experience, preparation of a paper on a value topic, and a passing grade on a VE examination.

CHARACTERISTICS OF A SUCCESSFUL VE PROGRAM

Establishing a VE program does not, in itself, assure an effective approach to cost control. The characteristics of a successful VE program include top management support, a full-time VE coordinator or group, project selection criteria, the use of a multidisciplined team and the VE job plan, and procedures to assure implementation of approved VE recommendations. These characteristics were identified for us by an internationally recognized VE authority, a transportation research board study,[3] and VE officials in Florida, North Carolina, and Pennsylvania--three states we visited with successful VE programs.

Top management support

According to a Transportation Research Board study, the most critical element of assuring a successful VE program is to obtain top management support. This support is needed initially to assure adequate funding for training and for creating positions. The continuing, active involvement of top management creates and maintains the positive, receptive attitude necessary for implementing VE recommendations that management agrees are reasonable.

We discussed with the former director of the General Services Administration's VE program how the lack of top management support impaired the effectiveness of a VE program. From 1972, when the General Services Administration established its VE program, through 1980, its Public Building Service saved $43.4 million, as reported in our 1982 UMTA VE report. According to the former VE program director, the program has produced no savings since 1980, because of the lack of support and a general lack of understanding of VE concepts by Public Building Service top management.

Full-time VE staff

An effective VE program needs not only the support of top management, but also direction and coordination by a VE coordinator or unit with easy access to top management. The coordinator or the unit typically administers the program by establishing VE procedures, maintaining VE statistics, assuring that VE recommendations are implemented, and sometimes performing VE studies.

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[3]An agency of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's purpose is to (1) stimulate research concerning the nature and performance of transportation systems, (2) disseminate information that the research produces, and (3) encourage the application of appropriate research findings.

Project selection criteria

One difficulty in establishing a VE program is selecting projects for study that provide the best opportunity for savings. According to an internationally recognized VE expert and VE officials in the states we visited, cost or project size is generally a good indicator of the potential for VE savings. The basis for establishing a certain dollar amount for selecting projects to be value engineered depends on the type, size, and cost of projects.

Use of multidisciplined team and VE job plan

As discussed previously, VE techniques are applied using a job plan, which establishes a method for performing the study. Adherence to the phases of the plan is essential to obtain the best results. The key features distinguishing the VE job plan from other cost reduction techniques are function analysis, the creativity of a multidisciplined team to develop multiple alternatives, and the principle of maintaining the quality needed by the user. The plan also assures that the various phases of a VE study are performed systematically and sequentially.

Effective implementation procedures

According to the transportation research board study, if a VE program is to maximize cost savings, approved recommendations must be implemented as expeditiously as possible. Implementation is a test of top management's commitment to the VE program and the skills of the VE unit. Implementation procedures also assign accountability for including approved recommendations in project designs.

COSTS, SAVINGS, AND TIME NEEDED TO PERFORM VE

Historically, a VE study costs between 0.1 and 0.3 percent of total project costs yet saves 3 to 5 percent of total project costs. In addition, the savings achieved from using VE on one project can often be applied to similar projects, as discussed on page 9.

The time and cost to perform VE depends on the size and complexity of a project. For example, according to an internationally recognized VE expert, about a week is needed to complete the phases of the VE job plan on a bus maintenance facility and about 2 weeks for a larger project, such as a subway station. However, additional time is required for study before the job plan is initiated. The VE study team members may spend a week reviewing plans, specifications, and cost estimates individually before they initiate the phases of the job plan. After the study is completed, the VE team leader meets with the facility owners to discuss the VE recommendations and to prepare a final report on study results.

VARIOUS PRIVATE AND FEDERAL AGENCIES AND GROUPS USE AND SUPPORT VE

The federal government and the private sector in the United States and several foreign countries, including Japan, West Germany, and India, recognize VE as a useful tool to reduce costs, improve productivity, and increase profits. In addition, several colleges and universities include VE as an elective in their engineering curricula.

Since 1954 at least 14 federal agencies have used VE to reduce costs with varying degrees of success. For example, the Department of Defense established its VE program in fiscal year 1965. Through fiscal year 1982, the Department reported estimated savings in excess of $8.6 billion from its mandated VE program. The Environmental Protection Agency's (EPA's) VE program was established in 1976 for federally subsidized waste water treatment facilities. For fiscal years 1977 through 1982, EPA reported realized savings from VE of $290 million, or a 5.5-percent net reduction in project costs. About $16 was saved for each dollar spent to perform VE. EPA regulations require that facilities costing more than $10 million be value engineered when design plans are 20 to 30 percent complete. According to an EPA headquarters VE official, the $10-million threshold was established when the program was implemented. He said that the threshold is high because, at that time, EPA was not prepared to handle many projects. Facilities under $10 million may be value engineered at the grantee's request. The cost to perform VE and the resulting savings are shared between EPA and the grantees in proportion to their participation in project costs.

A wide variety of groups support VE. The President's Private Sector Survey on Cost Control Task Force 1982 Report on Federal Construction Management concluded that ". . . mandated VE studies are certainly effective." The task force recommended that all federal agencies consistently use VE in all districts and divisions. Nine highway design and transportation construction associations that we randomly contacted also support and encourage the use of VE. For example, the American Institute of Architects sponsors several VE training workshops each year for government and industry officials. In addition, a Joint Committee of the American Association of State Highway and Transportation Officials, the American Road and Transportation Builders Association, and the Associated General Contractors prepared VE guidelines for their constituencies in 1981.

OUR VIEWS ON VE AND OTHER TECHNIQUES

We have a long-standing interest in the use of VE as an effective tool that can reduce government costs. We have issued several reports and studies on the subject (see app. III). We view VE as a management tool that complements rather than replaces other cost reduction or cost control techniques.

CHAPTER 2

TWO DOT AGENCIES USE VALUE ENGINEERING TO SOME EXTENT; BROADENING ITS USE DEPARTMENT-WIDE COULD POTENTIALLY REDUCE DOT CONSTRUCTION COSTS

Because of escalating costs and the ever increasing need to rebuild the nation's transportation system, the size, variety, and scope of DOT's construction programs provide opportunities for using VE. As shown in appendix IV, FHWA, FAA, and UMTA collectively allocated billions of dollars in fiscal year 1983 for grants to states, local governments, and airport and transit authorities. In addition, CG, FAA, FHWA, and FRA have direct funding construction programs.

Despite the opportunities it has for using VE, DOT does not currently require its administrations with construction programs to use VE. However, two DOT administrations, FHWA and CG, use it to some extent. FHWA strongly encourages its grantees to use VE, and CG requires VE on projects exceeding a certain dollar amount. FAA, FRA, and UMTA neither require nor encourage VE, even though VE identified additional savings when VE training workshops and private firms value engineered typical FAA and UMTA construction projects. FRA design and engineering officials believe that VE is also feasible on railroad facilities. As demonstrated in FHWA workshops and other examples that are discussed in this chapter, increased use of VE has the potential to save DOT and its grantees additional millions of dollars annually.

FHWA ENCOURAGES THE USE OF VE

According to the Federal-Aid Highway Program Manual, FHWA's policy is to strongly encourage the states to use VE and other cost-control techniques when designing highways and bridges. To help the states implement VE programs, FHWA has sponsored training workshops for the past 8 years. Between October 1975 and October 1983, the states and FHWA spent about $3 million for 104 VE workshops, but only 13 states had implemented a VE program as of 1982. About 2,000 state highway department officials in 43 states, the District of Columbia, and Puerto Rico; 565 federal officials; and 50 consultants have been trained. FHWA officials believe that this level of training will continue in the future.

During the 40-hour workshops, each VE study team value engineers at least one active project. The VE workshops' overall objective is to familiarize federal, state, and local highway officials with the VE process. After completing the course, each participant should be able to

--understand the differences between VE and other cost reduction techniques,

--apply VE techniques,

--lead a team through a VE study, and

--make positive contributions toward establishing and managing a VE program.

FHWA claims VE workshops save millions

Value engineering has been shown to be cost-effective during the workshops. To demonstrate the effectiveness of VE compared with other cost-reduction methods, the host agency and VE instructors select projects for the workshops that may have gone through states' normal cost-reduction reviews and are proceeding toward construction. FHWA's VE coordinator estimated that the workshops have identified about $600 million in additional potential savings during the past 8 years. Although FHWA encourages the workshop participants to send a copy of the VE study to the appropriate highway officials for possible implementation, no records are available that show the actual amount of savings. The FHWA VE coordinator, however, estimated that about half the recommendations have been implemented.

States with VE programs identify millions in potential savings

To determine the extent that the states use VE during the design of federal-aid highway and bridge projects, we sent a questionnaire to the 50 state highway departments, the District of Columbia, and Puerto Rico. The results are summarized in appendix V. On the basis of 48 responses to the questionnaire, copies of VE studies the states provided, and follow-up discussions with state highway and/or VE officials, we determined that 13 states had implemented a VE program as of 1982. These states value engineered 284 highway and bridge projects, specifications, and standards that identified over $94 million in potential savings in 1982. As shown in the following table, the states reported a wide range of VE activity and potential savings. For example, Pennsylvania value engineered 110 projects, while three states each value engineered only one project. Potential savings ranged from over $29 million in Illinois to $800,000 in South Dakota.

State	Number of VE projects	Potential 1982 savings identified
		(millions)
California	6	$ 1.0
Florida	39	6.0
Idaho	15	9.0
Illinois	15	29.2
Maryland	1[a]	(b)
Minnesota	6	2.4
Montana	1	10.0
Nebraska	23	(b)
New Mexico	9	12.8
North Carolina	32	1.5
Pennsylvania	110	20.3
South Dakota	26	.8
Vermont	1	1.4
Total	284	$94.4

[a]Ongoing study.

[b]No records available.

Source: GAO.

State highway VE officials in the three states we visited indicated that their potential savings are probably understated because (1) accurate records of VE savings are not maintained and (2) savings generated from VE studies on certain projects, such as standards and specifications, are difficult and time-consuming to determine.

Some states indicated that recent improvements to their VE programs have resulted in additional savings, as in the following examples:

--Improvements in Pennsylvania's VE policy and selection criteria increased the number of projects value engineered from 60 in fiscal year 1981 to 129 in fiscal year 1983. Potential savings increased from $12.9 million in fiscal year 1981 to $21.5 million in fiscal year 1983.

--During the first 6 months of 1983, Florida conducted 39 VE studies that identified over $6 million in potential savings. Florida officials indicated that planned VE program improvements, such as establishing new project selection criteria and new implementation procedures to assure that approved VE recommendations are implemented, should increase the program's effectiveness. Florida's goal is to average 10 percent savings in construction costs when the program is functioning routinely.

--In 1982 North Carolina value engineered 13 standards affecting 32 projects that resulted in realized savings of $1.5 million. In 1983, the state realized $6.6 million in VE savings. In addition, North Carolina officials believe that designers are more cost-conscious when they know that a VE study is going to be done.

VE officials in the three states we visited said that the implementation phase of the job plan is the most important. One state requires the VE program manager to assure that all approved VE recommendations are implemented through continuous contact with the district offices and by providing records of statewide program status, implementation, and cost savings to FHWA and state officials. In another state, all VE recommendations are forwarded to a committee that assures that all approved VE recommendations are implemented. Each committee member has follow-up responsibility on specific VE recommendations. In the third state, the VE team meets with the design firm to discuss the VE study recommendations. After they agree on which recommendations are to be implemented, the firm incorporates the changes into the project design.

We also found that in two of the three states we visited, VE officials had established different dollar amounts to select projects for study. One state requires that projects over $500,000 be value engineered; another has a $2-million threshold. Another state also achieved VE savings by reviewing construction standards and processes, because the results can be applied to similar or repetitive projects. For example, North Carolina uses a standard for the width of bridges on secondary roads. As a result of a VE study, the North Carolina VE department determined that the standard width for such bridges was excessive and recommended that the standard be reduced. State highway department management officials agreed with the recommendation, and the new standard was subsequently applied on similar bridges. We believe as evidenced above, that cost should not be the sole determinant.

COAST GUARD REQUIRES VE BUT HAS NOT FULLY IMPLEMENTED ITS VE PROGRAM

The CG Civil Engineering Division established a VE requirement in 1972; however, in the two districts we visited, we found that the program has not been fully implemented according to CG criteria. As a result of our review, CG is making changes to improve its VE program.

According to the Civil Engineering Division manual, VE is applied on all construction projects costing over $200,000, preferably when designs are 30 to 50 percent complete. The division established a $200,000 threshold because the opportunities for savings were greater than the costs associated with performing VE at that level. Under the division criteria, the extent that the various stages of the job plan are completed is related to project size. At a minimum, the information phase of a VE job plan, including the function and cost analyses, must be completed on all projects required to be value engineered.

A field value engineer in each district is responsible for implementing the VE program. In addition to their regular duties, value engineers are responsible for

--establishing and maintaining an active and productive VE program and

--maintaining a VE training program to assure that appropriate personnel are familiar with VE principles and applications.

VE not fully implemented in districts

Each district submits an annual report to the division showing the savings resulting from VE. In fiscal year 1982, only 7 of the 12 district offices realized VE savings. The districts reported $4.4 million in gross savings[1] from in-house VE studies on 165 projects. Of the $4.4 million, we found that $1.5 million in savings reported by the districts was actually produced by an architectural/engineering firm CG hired to value engineer four projects, as discussed on page 11.

To determine the effectiveness of CG's in-house program, we visited the Boston and Seattle district offices because they reported substantial VE savings ($200,000 in Boston and $748,000 in Seattle) and contacted the officials in the Portsmouth, Virginia, and Miami, Florida, districts because they reported little or no VE savings during fiscal year 1982. At the two districts we visited, we found little evidence that the program had been fully implemented in accordance with CG criteria. For example, we reviewed the files on 6 of 9 projects in Boston and 3 of 27 in Seattle that cost more than $200,000 and therefore should have been value engineered. We found no evidence for any of these projects that the VE job plan or the required function analysis had been performed. Rather, the districts we visited considered an undocumented, informal analysis of project alternatives before designs were prepared as VE. As a result, we could not verify the savings the districts reported. CG headquarters VE officials said that a VE program had not been fully implemented in all the districts becuase of (1) an insufficient number of engineers, (2) a lack of VE training, and (3) a heavy workload.

Coast Guard actions to improve in-house VE program

After our review of CG's in-house program, the chief, Civil Engineering Division, and other top-level division VE officials agreed with our assessment of the in-house program, that it was not being implemented as required. Recognizing the problems discussed above, the Division revised its Civil Engineering Manual to clarify existing VE criteria. The clarification

[1]Does not include either the cost of performing the studies or the cost of redesigning project plans and specifications to incorporate approved value engineering recomendations.

--raises the threshold for performing VE from $200,000 to $500,000 because CG realized that $200,000 was too small an amount;

--requires formal VE studies to be performed by an independent firm or contractor for all projects over $1.5 million;

--requires VE studies to be performed with a CG-approved VE job plan; and

--requires documentation of all VE cost savings.

In addition, the division transferred most project design responsibilities from the districts to two new field divisions in June 1983. CG believes that centralizing design activities will improve its VE activities. Initially, architectural/engineering or consulting firms will perform the VE studies on all designs prepared by the field offices. According to headquarters VE officials, because the districts have an insufficient number of engineers and a heavy workload, the division also revised its procurement regulations to make it easier to hire such firms to value engineer projects.

Use of consultants to perform VE is effective on four projects

To improve its VE program, CG, in 1982, hired an architectural/engineering firm, at a cost of $64,000, to value engineer an additional four large projects. The estimated cost of the projects was more than $35 million. The firm identified $3.9 million in potential savings. Subsequently, CG implemented recommendations that resulted in about $1.5 million in gross savings. The savings represent about a 4-percent reduction in estimated project costs, or $23 for each dollar spent to perform the VE studies. The following table shows the results of the VE studies:

Type of facility	Cost	Savings		VE cost
		Recommended	Implemented	
Family housing	$ 3,796,670	$ 456,389	$ 52,050	$14,000
Marine safety office	9,326,601	2,201,370	801,049	16,000
Personnel activity center	12,147,500	724,100	232,600	21,000
Administration center	10,399,538	540,209	381,032	13,000
Total	$35,670,309	$3,922,068	$1,466,731	$64,000

Source: GAO

Our analysis of the four studies shows that they were performed in accordance with generally accepted VE principles established by the Society of American Value Engineers. For example, the firm used a multidisciplined team and the VE job plan and performed the function analysis.

VE FEASIBLE IN OTHER DOT ADMINISTRATIONS

FAA, FRA, and UMTA do not require or encourage the use of VE. However, as demonstrated below, VE identified significant savings on the types of construction projects typically funded by these administrations.

FAA

Two FAA projects, a terminal building and control tower, were value engineered in 1976 and 1983, respectively. In both cases, value engineering identified substantial cost savings.

Terminal building

In 1976 a private firm performed a VE study on the FAA-funded $100-million passenger terminal building and concourses at the William B. Hartsfield International Airport in Atlanta, Georgia (see app. VI). The study was performed because of the owner's and the airlines' desire to control costs. According to the contractor, the study realized about $7 million in initial or capital costs savings and more than $14 million to the grantee in the present value[2] of operation and maintenance cost savings. In addition, the contractor said that the facility uses about 35 percent less energy than comparable facilities in Chicago and Dallas. The total cost of performing the VE study was about $40,000. About $175 in capital savings, which the grantees also share, was realized for each dollar spent to perform VE.

Using the job plan, the VE study teams recommended major changes to the structure and mechanical components of the passenger terminal building. As shown in appendix VI, the 53 recommendations that were implemented included reducing the terminal area and structural spans, modifying the exterior skin and interior closures, reducing the amount of glass, replacing rooftop heating/cooling units with a central system, and changing boiler and air filtering designs.

Control tower

Each year, FAA constructs several air traffic control towers with or without administrative buildings. Between fiscal years 1983 through 1985, FAA plans to construct 35 towers at a cost of $114 million.

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[2]Present value represents the current worth of savings to be achieved in future years.

In June 1983, we arranged to have a medium-sized $1.6-million tower/administrative base building value engineered at an FHWA 40-hour VE workshop. FAA provided a standard set of plans and criteria, a specific set developed for the John Wayne Airport at Santa Ana, California, and cost estimates. The study was to determine if VE has the potential to reduce costs on such projects. Although we discussed the feasibility of the recommendations with FAA, we did not expect that they would be implemented because the facilities were under construction when the VE study was performed. Any changes in project designs would have resulted in costly construction delays. However, because FAA uses standard designs for towers, the recommendations could be applied on future projects.

A six-member VE team first developed current 1983 cost estimates and gathered pertinent information on the project. In completing the VE job plan, the team identified several areas for potential cost savings, as discussed below. On the basis of its analysis of project data, the team determined that designs for FAA towers and base buildings are too standardized. FAA standards, in some instances, call for systems that are overdesigned for a particular region of the country. For example, the footings and foundations are designed for frozen soil conditions, which do not apply in Santa Ana.

The team made the following recommendations:

--Reduce the size of the administrative base building from 4,473 square feet to 2,350 square feet. FAA officials indicated that a maximum of 15 people would occupy the building at any one time. The common allowance is 150 square feet per person, not 264 square feet as designed. One part of this reduction is to relocate the emergency diesel generator outside of the building, which would eliminate a 15' x 19' room. At a cost of $188 per square foot, this would reduce construction costs by $399,124. FAA said that it would need more specific information, such as a building layout showing the revised office and room sizes, to evaluate the feasibility of implementing this recommendation. Time constraints prevented the VE team from developing a detailed building layout.

--Reduce the height of the building by reducing the area above the ceiling from 5 feet to 2.5 feet. The team believes that this 2.5-foot clearance is ample space for the duct system, and is much more common than a 5-foot clearance. Although FAA did not agree with the specifics of this recommendation, it did agree that a building height reduction would reduce the base building cost by 5 percent, or $42,000. FAA officials do not plan to reduce the building height because they believe extensive redesign work would be required.

--Redesign the tower elevator to reduce capacity and speed. As currently designed, the elevator has a

2,500-pound capacity (approximately 14 persons) and a velocity of 350 feet per minute. For a maximum of six people in the tower cab at any one time and a maximum lift of 32 feet, the elevator is clearly overdesigned. The VE team estimated a savings of $35,000 for this change. FAA agreed and plans to specify a slower elevator speed and to review the elevator capacity requirements.

--Eliminate the link building that connects the control tower to the administrative base building because climate conditions in Santa Ana make the building unnecessary. The team estimates cost savings from this change would be $30,000. FAA agreed that the link could be built more cheaply without affecting function, but did not want to eliminate it because of its aesthetic appeal.

--Redesign the heating, ventilation, and air conditioning system. Although FAA has four or five standard designs for systems in various climate zones, the system for this location is still overdesigned. According to Means, 41st edition, which shows standard 1983 construction cost data, this system should cost approximately $24,000. The estimated cost of the system, as designed, is $172,000, or seven times the usual cost. The ventilating/cooling system required for the emergency generator room could be eliminated if the generator room were relocated outdoors. The American Society of Heating, Refrigeration, and Air Conditioning Engineers' standards for Santa Ana should be used for the design of the air conditioning system, rather than the current design, which was developed for buildings in areas with 105-degree temperatures. Redesigning the system could save approximately $148,000. FAA believes it is more economical to use four or five standard designs than it is to pay for the design of a separate system for each location. A VE consultant estimated that, in general, the cost of a site-specific design should be approximately 6 percent of the construction cost--in this case, about $96,000 for a medium-size air traffic control tower.

In summary, the VE team's recommendations would result in a more efficient design and reduce the construction cost of the base building and tower by an estimated $654,000, or 40 percent of the original $1.6 million construction cost.

We also presented the following suggestions to FAA; however, we did not discuss the feasibility of implementing the suggestions because they are not formal VE recommendations and, because of time constraints, the team could not estimate cost savings.

--Eliminate storefront windows on the base building.

--Eliminate windows in the tower that are specified for unused space.

--Eliminate the solar hot water heater.

--Reduce the size of the electrical, telephone, and storage room.

--Redesign the site layout, including the access road, parking lot, landscaping, irrigation, and sidewalks.

An FAA structures branch engineer disagreed that most of the recommendations could be implemented because the tower was already under construction but concluded that VE has the potential to reduce the cost of towers and buildings by a minimum of 3 to 5 percent.

UMTA

In December 1982 we issued a report on VE's potential to reduce mass transit construction costs. During that review, we arranged to have VE studies performed on two typical UMTA-funded construction projects.

To demonstrate that VE could be applied to heavy rail projects and identify greater savings than UMTA's ad hoc review group, the Corps of Engineers value engineered the same aspect of a subway station that the UMTA group had previously examined. The VE study team identified about $3.1 million in potential savings compared with the $334,000 that the UMTA group saved. The transit authority said that it could not implement the VE recommendations because the community where the station is to be located supported the original design and would object to any design changes. We recognized that it would not have been practical to implement the recommendations because, at the time the VE study was performed, the station's design was 90-percent complete.

A second VE study of a $6.2-million bus maintenance facility identified over $900,000, or about 15 percent in potential initial savings, and over $400,000 in operation, maintenance, and replacement cost savings. The transit authority planned to implement three VE recommendations that would produce about $360,000 in initial savings and $100,000 in operation, maintenance, and replacement cost savings. The estimated cost to perform the studies--$53,500 and $40,000, respectively--was small compared with the potential savings.

As a result of our report, the Subcommittee on Transportation, House Committee on Appropriations[3] directed UMTA to take all necessary steps to apply VE techniques to any federally funded transit construction projects currently being designed with a total estimated cost of more than $150 million. Moreover, the Subcommittee expects the fiscal year 1985 UMTA budget

[3]Department of Transportation and Related Agencies Appropriations Bill, 1984, Report No. 98-246.

justification to contain a listing of all projects that have been subjected to VE and an estimate of cost savings.

FRA

FRA, like FAA and UMTA, does not require VE on construction projects. FRA is currently administering one large project--the $2.19-billion Northeast Corridor Improvement Project. The purpose of the project is to rehabilitate and improve rail passenger service between Boston and Washington. Major elements of the project include

--simplifying track configurations,

--modernizing the signal system,

--constructing 4 maintenance facilities,

--rehabilitating 4 equipment workshops, and

--rehabilitating 12 and constructing 3 new railroad stations.

A more detailed listing of the elements of the corridor project are listed on page 37.

At the time of our review, most major components on the corridor project were either designed, under construction, or complete. Therefore, we did not attempt to demonstrate the feasibility of using VE on such facilities. Instead, we provided the FRA Directors of Design and Engineering for the corridor project a copy of our 1982 mass transit VE report. On the basis of their review of the types of UMTA facilities that were used to demonstrate the VE process, the Directors agreed that the design, engineering, and construction processes for FRA facilities, such as railroad stations and maintenance facilities, are similar to UMTA subway stations and bus maintenance facilities. Therefore, the Directors concluded that VE could also be applied to FRA facilities during design.

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In chapter 3, we discuss DOT's concerns about VE; why, in spite of these concerns, we believe VE is needed; and what needs to be done to assure that VE is used.

CHAPTER 3

IMPLEMENTING VALUE ENGINEERING: OVERCOMING DOT'S CONCERNS

DOT agrees that VE can be a valuable tool in reducing construction costs, but it does not favor a policy requiring VE on construction programs mainly because of significant differences in grant management and procurement processes among its various operating administrations. DOT believes that its management strategy of allowing grantees to select cost controls is consistent with the Office of Management and Budget's (OMB's) Circular A-102 and the President's philosophy of according grantees maximum flexibility to administer grants. Further, it views VE as only one of several cost-control techniques that can produce cost-effective designs. Consequently, DOT administrations use several different cost-control techniques in addition to VE, such as alternate designs, in-house and consultant design reviews, and peer reviews.

We believe that DOT could implement a VE policy that is sufficiently flexible to overcome its concerns and considers the differences among DOT's operating administrations. Furthermore, VE has the potential to save DOT and its grantees additional substantial funds if it is applied after their traditional cost-reduction techniques.

DOT VIEWS ON VE

In commenting on our 1982 report regarding the potential for value engineering on mass transit projects, DOT cited several reasons for not requiring VE. DOT believes that the states or grantees should have final authority for approving recommendations on project design and construction. DOT believes this is consistent with OMB Circular A-102 and the President's philosophy of giving grantees maximum flexibility to administer their grants. We believe that a policy requiring VE would not seriously limit grantees' flexibility to manage their projects. For example, grantees would determine at what point during early design VE should be performed, whether the study should be performed by a private firm or in-house, and whether VE recommendations should be implemented. Furthermore, we believe that DOT and its grantees could mutually benefit from the potential of VE. For example, according to the FHWA VE Coordinator, states that have received DOT grants, particularly for highway and bridge projects, could significantly benefit from a required VE program because states can retain the federal and state share of VE savings for use on other federal-aid highway projects. In other DOT administrations, grantees would share VE costs and savings in proportion to their share of project costs.

OMB Circular A-102, Attachment O, addresses procurement requirements. The Attachment prohibits imposing additional procurement requirements or subordinate regulations on grantees. However, in commenting on the UMTA VE report, OMB's Associate Administrator for Policy Development said that

". . . this prohibition does not apply to individual grantee requirements which fall under the exception of paragraph 10 of A-102 or provisions of other Circulars. OMB Circular A-87, Paragraph 3C, 'Capital Expenditures,' states that capital expenditure for equipment or capital assets is allowable when such procurement is specifically approved by the Federal grantor agency. UMTA, therefore, is clearly allowed to authorize and approve the type of capital expenditures and any related requirements it wishes, including value engineering."

Considering OMB's interpretation, we believe that DOT administrations with grant programs, such as FHWA and FAA, could require VE as part of the grant approval process. However, OMB also stated that the administration's philosophy is to lessen the government's intrusion in state and local government affairs. In July 1984 the same OMB official informed us during a meeting that A-102 does not preclude DOT from establishing a policy that requires grantees to use value engineering.

DOT views VE as only one cost-control technique that can produce cost-effective designs. As a result, DOT administrations use a variety of cost controls. For example:

--FHWA's policy is to strongly encourage states to use several cost-control strategies, including pavement recycling (a technique combining new pavement with old when resurfacing roads or highways), alternate designs, and VE.

--The CG Civil Engineering Division as noted earlier requires the use of VE on projects that exceed a certain dollar amount.

--FAA, on the other hand, relies on in-house, sponsor, and designer reviews and the competitive bid process to reduce costs.

--UMTA, in addition to requiring routine regional engineering reviews, established a peer review program in 1979 in an attempt to reduce costs on selected new, primarily heavy rail transit projects.

--FRA, its design firm or contractor, and AMTRAK jointly perform a technical review of Northeast Corridor designs at the 30-, 60-, and 90-percent level of completion.

DOT said that significant differences among the administrations in grant management and procurement processes preclude establishing and applying standard VE criteria Department-wide. While there may be differences, the DOT administrations that we reviewed

--either prepare or approve project designs and specifications and

--review project designs to reduce costs.

Therefore, we believe that DOT could establish a policy that is sufficiently flexible to recognize and address differences among administrations. For example, each administration could establish criteria for selecting projects to be value engineered.

FAA AND FHWA VIEWS ON VE

FHWA believes that states are aware of VE's benefits and that many are initiating VE reviews as part of their highway programs. FHWA also believes that its continuing efforts to promote VE on highway projects will be successful without imposing additional federal requirements. According to FHWA's VE Coordinator and other officials, FHWA considered mandating VE and other cost-reduction strategies in 1975 and 1980 but did not because input from division offices indicated that FHWA's relationship with the states would be adversely affected by imposing additional requirements. FHWA efforts to promote VE have resulted in 13 states implementing a program; however, we believe that a required rather than voluntary VE program would expedite FHWA's VE efforts and produce additional substantial savings for the federal government and the states.

On the basis of our analysis of (1) the questionnaire we sent to the 50 states, the District of Columbia, and Puerto Rico, (2) VE studies provided by the states, and (3) follow-up telephone calls to the state highway and/or VE officials, we determined that 35[1] of 48 states that responded to the questionnaire did not have a VE program. Seven of the 35 were in the process of establishing a program. Twenty-three[1] of the states with no program provided one or more of the following reasons for not using VE:

Reason	Number of times stated
Prefer present technique (e.g., alternate designs)	16
Do not have trained staff	5
Tried but not successful	6

Twenty-five[1] of the 35 states that did not have a VE program believed that VE could be used at least to some extent on highway projects. In our opinion, these states will not adopt VE as an integral part of their operations until FHWA requires it.

FAA officials believe that certain projects may not be suitable for VE. They believe that (1) the federal share of airport terminal costs, as discussed below, is too small to require VE and (2) in-house and consultant reviews of air traffic control towers, together with the competitive bid process, achieve 90 to 95 percent of the cost reductions that a VE study would achieve. However, we found that FAA funds up to 50 percent of the cost of public use areas for passenger terminals and that such

[1]Includes Washington, D.C.

costs generally make up about 60 percent of the facility's cost. Furthermore, as discussed in chapter 2, the two FAA VE studies demonstrated that VE is not only suitable, but it also produced and identified savings after the projects had been subjected to FAA's normal reviews.

OTHER FACTORS AFFECTING VE USE

Several other factors have limited the use of VE. According to a 1981 Transportation Research Board report, the problems in implementing and managing VE programs are more behavioral and organizational than technical. For example, engineers have widely varying perceptions about what VE really is. Many engineers and designers are not familiar with VE, and they often mistake traditional cost-cutting techniques for VE. Therefore, they assume VE is being performed when in reality generally accepted VE principles have not been implemented. The report also notes that another problem is resistance to change, often causing reviews of VE recommendations to become a defense of the original design rather than a candid appraisal of the recommendations.

CHAPTER 4

CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

VE is a proven cost-control technique that can be used alone or used to complement other techniques. When used, it has historically produced a net reduction of 3 to 5 percent of total project costs. We believe that VE has the potential to save DOT, which has a large construction program (more than $16 billion in fiscal year 1983), and its grantees millions in project costs if it is required for DOT construction programs. The cost of establishing, implementing, and maintaining a VE program would be more than offset by the savings achieved.

To be most effective, VE should be performed early during project design and should incorporate the key characteristics of a successful program: top management support, full-time VE staff, establishment of project-selection criteria and follow-up implementation procedures, adherence to generally accepted VE principles, and supervision of program activities.

RECOMMENDATIONS TO THE SECRETARY OF TRANSPORTATION

We recommend that the Secretary of Transportation establish and implement a policy to require FHWA, FAA, FRA, and UMTA to supplement their normal cost-reduction procedures for construction programs with a VE program. The policy should be flexible enough to recognize and address the operating differences among the administrations. In establishing a policy, the Secretary should require that

--criteria, such as a certain dollar threshold, for selecting projects to be value engineered be established by the FAA, FHWA, and UMTA administrators;

--VE be performed during the early stage of project design;

--VE be performed in accordance with generally accepted VE principles, including use of a multidisciplined team and a VE job plan;

--VE be performed either by qualified administration officials or by private firms;

--follow-up procedures be established to assure that approved VE recommendations are implemented; and

--a full-time VE program staff be appointed at the department level. The VE staff's responsibilities should be to

- help the administrations develop specific VE programs and goals;

- monitor the results of the administrations' VE programs, particularly estimated initial and life-cycle cost savings and implemented recommendations;

- provide a focal point to disseminate information on VE application, techniques, results, and innovative alternative processes and construction methods; and

- develop a VE training program for administration officials.

AGENCY COMMENTS AND OUR EVALUATION

DOT made the following comments on this report:

--It agrees in general with the findings that a broader application of VE could help to reduce construction costs in DOT programs.

--OMB Circular A-102 appears to prohibit the imposition of a VE requirement upon grantees. DOT said that the exceptions permitted under paragraph 10 to Circular A-102, and the agency approvals provided for under paragraph 3C, Capital Expenditures of OMB Circular A-87, do not allow grantors to impose special VE requirements. The exceptions to paragraph 10 apply only to grantees whose performance is substandard and for whom additional requirements are needed. In addition, the special agency approvals permitted in A-87 normally apply to unusual capital expenditures that a grantee wishes to make under an existing grant project. DOT concluded that these approvals in no way permit a federal agency to invoke additional administrative requirements.

--Several times in the past, DOT, as part of an interagency study group, requested that OMB include a policy to encourage VE in Attachment O to OMB Circular A-102. Specifically, DOT had proposed a government-wide policy that would encourage grantees to consider VE during design and to incorporate VE provisions in contracts that are of sufficient size and duration to offer reasonable opportunities for cost reductions. However, VE standards were excluded when Attachment O was revised in 1979 and A-102 reissued in 1981. DOT is currently chairing an interagency review group to review the property and procurement standards of Circular A-102. DOT plans to contact OMB and request that it give special attention to including VE in the revisions to the Attachment O procurement standards. DOT believes this to be a necessary action prior to issuing a Department policy.

--DOT will examine the VE process and its direct construction programs to define a policy that encourages VE to be performed during the early stages of project design using generally accepted VE principles.

--Because the direct construction program is relatively small, performance of VE studies by full-time, in-house staffing is not likely to be feasible. Such an activity is subject to OMB Circular A-76, which requires that the

government rely on the private sector for goods and services it needs whenever it is economical to do so.

--Appointing a full-time VE staff at the Department level would not be warranted to monitor program activities.

In July 1984 the OMB Associate Administrator for Policy Development told us during a meeting that OMB Circulars A-102 and A-87 do not prohibit other DOT administrations from imposing VE requirements on their grantees. He also stated that because this report's recommendations on implementing a VE program are sufficiently broad, OMB does not consider them to be intrusive on state and local governments. In fact, EPA requires value engineering in its construction programs.

We reviewed the documentation prepared by the interagency study group. We found that, in contrast to our recommendation, the study group recommended a government-wide policy to encourage rather than require grantees to use VE for construction activities. However, we endorse DOT's proposal to again discuss the VE policy issue with OMB. We suggest that the interagency review group use our report to demonstrate to OMB that VE has the potential to produce substantial savings on DOT's direct and grant construction programs even after other cost-reduction techniques are used.

After DOT commented on this report, we found that on May 16, 1984, the group submitted additional comments to OMB's review of Circular A-102. The group questioned whether OMB standards should set forth a policy on grantees' use of VE. The group suggested three options: providing no specific guidance on VE (retaining current standards), providing guidance encouraging grantees to use VE, or providing guidance to require grantees to use VE. According to the group chairperson, OMB did not adopt any of the suggestions.

We disagree that DOT should only encourage VE for its direct construction programs. As an example, FHWA's policy for the last 8 years has been to "strongly encourage" states to use VE. Since then, only 13 states have implemented a program. We believe that DOT should have a flexible Department-wide policy for its direct and grant programs. Therefore, we are urging DOT to develop a policy that requires rather than encourages VE. In this regard, the OMB Associate Administrator for Policy Development informed us, in July 1984, that in areas where VE has potential to reduce costs, a mandated VE program is more effective than encouraging VE use.

With regard to the use of the private sector to obtain goods and services when it is economically feasible to do so, we encourage DOT and its grantees to rely on private engineers to perform VE studies when necessary.

We also question DOT's position that a full-time VE staff is not warranted at the Department level. As stated earlier, several states with successful programs identified a full-time VE staff as a key characteristic of a successful program. We also believe

that the magnitude of DOT's construction programs--over $16 billion in fiscal year 1983 alone--and VE's potential to produce substantial savings warrant at least one full-time VE staff member at the Department level. Further, any costs incurred in appointing a staff member would be more than offset by VE savings.

OBJECTIVES, SCOPE, AND METHODOLOGY

In December 1982 we issued a report that demonstrated the feasibility of using VE to reduce costs on mass transit construction projects funded by UMTA. Because of the potential for savings, we expanded our work to other DOT administrations with construction programs. We made this review to determine (1) DOT's policy on the use of VE for the design of construction projects, (2) the impact of FHWA's policy of encouraging the states to use VE, (3) the success of the Coast Guard's VE program, and (4) the feasibility of applying VE on the design of FAA and FRA construction projects.

To accomplish our review objectives, we performed work at DOT and its administrations as described below:

DOT

We met with Office of Policy officials to determine if DOT had a policy on the use of VE when designing construction projects.

FHWA

We identified and discussed with administration officials and FHWA's VE Coordinator the methods that FHWA uses to encourage states to use VE and other cost-reduction techniques. We reviewed FHWA's VE training workshop program to identify the number and cost of VE workshops; the number of federal, state, and local officials that were trained; and the savings resulting from projects that were value engineered during the workshops.

To determine the extent that states use VE and their resulting savings, we sent a questionnaire to 50 states, the District of Columbia, and Puerto Rico in April 1983. The results are summarized in appendix V. To determine the number of states with a VE program, we asked the states to provide a typical VE study when they returned the questionnaire. We reviewed the VE studies to determine if they were completed using generally accepted VE techniques, such as a multidisciplined team and the VE job plan. In those cases in which the states indicated that they used VE, but did not submit a VE study, we made follow-up calls to state highway and/or VE officials to obtain additional information. In addition, reviewing questionnaire results may lead to a different conclusion because some officials were uncertain about what VE really is. Further, some of the states with a program provided updated VE savings after they returned the questionnaire.

After determining the universe of states that had implemented VE, we selected three states with successful programs to visit in order to identify the key elements of their programs. The states were selected on the basis of the amount of savings they identified and/or number of projects that they value engineered. In addition, we wanted a cross section of states that value engineer

projects, as well as a state that value engineers highway and bridge standards rather than individual projects. To assure that the states we selected were representative of states with successful VE programs, we had follow-up discussions with FHWA's VE Coordinator and state VE officials. We discussed VE programs with Florida, North Carolina, and Pennsylvania state highway VE officials and an FHWA division office official in each state. The state VE officials also provided current year VE savings. Because our objective was to identify key elements of a successful VE program, we did not take the time needed to verify the savings.

CG

Our review work was performed at the Civil Engineering Division, the only CG administration with a VE program. At CG headquarters in Washington, D.C., we discussed the division's construction programs and VE criteria and requirements and obtained fiscal year 1982 VE savings reported by 7 of 12 district offices. We visited district offices in Boston, Massachusetts, and Seattle, Washington, to determine if they were performing VE in accordance with division criteria. We selected these districts because of the VE savings they reported to headquarters in fiscal year 1982 and because the Chief, Civil Engineering Division, told us that the Seattle district had the best VE program. At the districts, we discussed the VE program with Civil Engineering Branch officials. Branch chiefs are responsible for establishing procedures to implement VE at the districts. We reviewed fiscal year 1982 VE savings reports and nine project designs at the two districts to determine if VE had been used to reduce costs. We also contacted the technical assistant chief in the Portsmouth, Virginia, district office and the chief of the Civil Engineering Branch in the Miami, Florida, district office to determine why their VE programs had not produced any savings.

We obtained the four VE studies that were performed by a private firm on four large Civil Engineering Division construction projects. We reviewed the studies to determine if they conformed to generally accepted VE principles and to determine implemented recommendations and VE savings. We did not verify the savings. A CG VE headquarters official said that the savings were verified by VE officials in the district where the facilities were constructed.

FAA

To determine if VE could produce savings on FAA projects, we arranged to have a standard, medium-sized air traffic control tower and administrative building value engineered during a VE training workshop. The VE study team was primarily composed of state highway engineers. The instructors conduct training workshops under contract with DOT and FHWA.

To demonstrate that VE could produce savings on passenger terminals, we contracted with Smith, Hinchman, and Grylls Associates, Inc. in Washington, D.C., an architectural/engineering firm,

to summarize the results of its VE study on a passenger terminal at the new Atlanta airport. The summary is presented in appendix VI.

FRA

We examined the potential of applying VE concepts on FRA's only construction activity--the $2.19 billion Northeast Corridor Improvement Project. However, we could not demonstrate the feasibility of using VE to reduce project costs by performing a VE study because most major project components were beyond the stage of development to most effectively use VE. Instead, we discussed similarities between FRA and UMTA facilities and the feasibility of using VE on future FRA construction projects with the FRA Northeast Corridor Project directors of design and engineering.

UMTA

Because we previously demonstrated the potential of VE on UMTA projects during our 1982 UMTA VE report, we did not perform any additional work at UMTA during this review. During the previous review, we arranged to have VE studies performed on two typical UMTA-funded construction projects. We have included a summary of the studies in chapter 2 of this report to demonstrate that VE identified potential savings.

OTHER ORGANIZATIONS

We discussed the feasibility of using VE to reduce transportation construction costs with the American Association of State Highway and Transportation Officials, American Consulting Engineers Council, American Institute of Architects, American Public Works Association, American Road and Transportation Builders Association, American Society of Civil Engineers, Institute of Transportation Engineers, National Academy of Engineers, and the National Society of Professional Engineers in Washington, D.C.

We contacted the General Services Administration's former Director of the Cost Management Division to determine if the Public Building Service's VE program had produced savings since 1980. We also contacted Mr. Alphonse Dell'Isola, an internationally recognized VE authority, to determine the factors that should be used to select projects for VE.

Our review was made in accordance with generally accepted government auditing standards. The time frame of our review was October 1982 through December 1983.

U.S. Department of Transportation

Assistant Secretary
for Administration

400 Seventh St., S.W.
Washington, D.C. 20590

MAY 25

Mr. J. Dexter Peach
Director, Resources, Community
and Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We have enclosed two copies of the Department of Transportation's (DOT) reply to the General Accounting Office (GAO) draft report, "Greater Use of Value Engineering Has the Potential to Save the Department of Transportation Millions In Construction Costs," dated April 12, 1984.

GAO concluded that Value Engineering (VE) is a technique that can reduce costs and improve productivity. When applied to construction programs, it can identify savings after other cost reduction techniques have been used. Although DOT does not have a VE policy for its construction programs, VE is used to a limited degree by DOT's operating administrations as one of a variety of techniques to reduce construction costs. However, GAO believes VE has the potential to save additional costs.

The Department agrees in general with the finding that broader application of VE could help to reduce construction costs in DOT programs. However, contrary to the GAO report, the Office of Management and Budget (OMB) Government-wide standards have not permitted DOT to issue a VE policy on Federal-aid construction. On several occasions, DOT has proposed and submitted to OMB a Government-wide policy on VE; those proposals have not been adopted. Nevertheless, DOT will request that OMB consider a Government-wide VE policy in an interagency effort, initiated by OMB and now underway to streamline OMB Circular A-102, Uniform Requirements for Assistance to State and Local Governments. If OMB adopts our proposal, DOT will develop a VE policy that applies to Federal-aid construction projects.

If we can be of further assistance, please let us know.

Sincerely,

Robert L. Fairman

Enclosure

GAO note: Page references in this appendix have been changed to correspond with page numbers in the final report.

APPENDIX II

DEPARTMENT OF TRANSPORTATION (DOT) REPLY

TO

GENERAL ACCOUNTING OFFICE (GAO) DRAFT REPORT

OF APRIL 12, 1984

ON

GREATER USE OF VALUE ENGINEERING (VE) HAS

THE POTENTIAL TO SAVE THE DOT MILLIONS

IN CONSTRUCTION COSTS

SUMMARY OF GAO FINDINGS AND RECOMMENDATIONS

Value engineering (VE) is a technique that can reduce costs and improve productivity. When applied to construction programs, it can identify savings after other cost reduction techniques have been used. Although the Department of Transportation (DOT) does not have a VE policy for its construction programs, VE is used to a limited degree, and has produced savings on projects funded by the Federal Highway Administration (FHWA) and the United States Coast Guard (USCG). DOT's operating administrations use a variety of techniques to reduce construction costs, however, the General Accounting Office (GAO) believes VE has the potential to save additional costs. GAO noted that:

- The Procurement Standards in Attachment O to Office of Management and Budget (OMB) Circular A-102, Uniform Requirements for Assistance to State and Local Governments, are the bases for DOT's policy regarding grantee contracting and the operating administrations' implementing guidance. Attachment O prohibits Federal agencies from imposing additional procurement requirements or subordinate regulations on grantees; however, GAO believes that this prohibition does not apply to imposing VE requirements on capital expenditures.

- FHWA has spent about $3 million for workshops since 1975 to train about 2,000 state highway department officials, 565 Federal officials, and 50 consultants to encourage the states to use VE on highway and bridge projects. As a result of FHWA's efforts to promote VE, 13 states have implemented a VE program and have identified over $94 million in potential savings for the current year.

- USCG requires a VE study for construction projects costing more than $200,000. During Fiscal Year 1982, the agency reported gross savings of over $4 million from the in-house value engineering program. During the same period, a consultant value engineered four projects and produced $1.5 million in gross savings. GAO's assessment of the in-house effort

showed that it had not been fully implemented in accordance with the agency's criteria. However, USCG has taken actions that should make the program even more effective.

- The Federal Aviation Administration (FAA) does not require or encourage VE on its construction projects. The agency uses in-house, grantee, and design consultant reviews to reduce costs. GAO arranged for an architectural/engineering firm to value engineer a passenger terminal and an air traffic control tower. The VE effort identified significant potential cost reductions.

- GAO's report of December 29, 1982, on the potential of VE to reduce costs on mass transit construction projects described a VE study on one aspect of a subway station. It identified $3.1 million or 18 percent in potential savings for the Urban Mass Transportation Administration (UMTA) grant project. However, it was impractical to implement any of the VE recommendations because station designs were 90 percent completed. Another study on a bus maintenance facility identified potential savings of over $900,000 or about 15 percent. The facility owner planned to implement recommendations that would reduce costs by about $360,000.

- The Federal Railroad Administration (FRA) did not require VE on its only large project--the nearly completed $2.19 billion Northeast Corridor Improvement Project (NECIP) designed to rehabilitate the rail passenger line between Boston and Washington, D.C. No attempt was made to demonstrate the feasibility of using VE on such facilities because most major components have been designed, are under construction, or are completed.

GAO recommends that the Secretary of Transportation establish and implement a policy to require FHWA, FAA, UMTA and FRA to supplement their normal cost reduction procedures for construction programs with a VE program. The policy should recognize and address the operating differences between the administrations, require VE to be performed in the project design stage in accordance with accepted VE principles, provide for VE to be performed in-house or by private firms, provide for followup procedures to assure proper implementation, and provide for a full-time staff at the Departmental level to assist operating administrations.

SUMMARY OF DEPARTMENT OF TRANSPORTATION POSITION

The Department agrees generally with the findings that VE can identify areas of potential cost reduction in DOT construction programs. VE is already used to some extent in the Department. In the direct construction program, VE has been used in the design and construction phases of projects to cut costs. In the grant construction programs, the effort has been mainly that of education, encouragement and voluntary participation, together with certain cost reduction techniques other than VE. We agree that the application of VE could be broadened and strengthened by a Secretarial policy statement providing certain implementation and monitoring requirements. For direct construction, we will examine the alternatives with the objective of

developing VE policy guidance in the near future. However, contrary to the GAO Report, we believe the OMB Government-wide standards are not clear with regard to the application of a VE policy for grant-funded construction. In fact, the terms of OMB Circular A-102 appear to prohibit the imposition of a VE requirement upon grantees. In addition, several times in the past, we have requested OMB to set forth a Government-wide policy to encourage VE regarding construction under Federal assistance programs, and have submitted draft provisions to be included in OMB Circular A-102. OMB has rejected these proposals. The Department has not established a VE policy because the terms of the Circular and OMB's past practice appear to prohibit such establishment. Once more, we will request OMB to consider establishing a VE policy under a current interagency effort that was initiated by OMB in November 1983, to review and streamline Circular A-102. If OMB adopts our proposal, we will develop a Departmental policy for grant-funded construction.

[GAO COMMENT: See agency comments and our evaluation on page 22 and 24.]

POSITION STATEMENT

- The Department will examine the VE process and its direct construction programs to define a policy which encourages VE to be performed during the early stages of project design using generally accepted VE principles. The type of criteria for selecting projects to be value engineered will be examined so that VE will be used where it is most effective.

  The size of our direct construction program is relatively small; therefore, performance of VE studies by full-time in-house staffing is not likely to be feasible. In addition, such an activity is subject to OMB Circular A-76, Performance of Commercial Activities, which requires that the Government rely on the private sector for the goods and services it needs whenever it is economical to do so. Also, a full-time VE program staff at the Departmental level would not appear to be warranted. However, we agree that monitoring VE results at the Departmental level is necessary to assure that the program is cost effective.

- Based on our experience and dealings with OMB regarding Circulars A-102 and A-87, Cost Principles for State and Local Governments, we disagree strongly with the conclusion on page 17 of the report that grantor agencies can impose VE requirements on grantee construction projects. We believe that the references to the exceptions permitted under paragraph 10 to Circular A-102 and the agency approvals provided for under paragraph 3C, Capital Expenditures, to A-87 do not allow grantor agencies to impose special VE requirements. The exceptions in paragraph 10 permitting additional requirements pertain to problem grantees, and are permitted only when grantee performance is so substandard that additional requirements are needed to ensure proper performance. The special agency approvals permitted in A-87 normally apply to unusual capital expenditures that a grantee wishes to make

under an existing grant project. These approvals in no way permit a Federal agency to invoke added administrative requirements; instead, they allow a Federal agency to approve grantee requests which are outside the general allowable costs. Since 1976, our Department has been requesting that OMB include in Procurement Standards, Attachment O to OMB Circular A-102, a policy on VE. We have been recommending a policy whereby grantees are encouraged to consider VE during design, and to incorporate VE provisions in contracts that are of sufficient size and duration to offer reasonable opportunities for cost reductions. This was first proposed when we chaired the Interagency Study Group to Revise the Attachment O Procurement Standards. The recommendation was made in several draft versions until Attachment O was revised on August 1, 1979. However, OMB elected to exclude VE standards, and no provision was included in the revised Attachment O. We also made a similar recommendation in 1980 when we chaired the Interagency Task Group on Procurement Under Grants for the Uniform Procurement System effort. Circular A-102 was reissued in January 1981, but again OMB issued the Attachment O standards without setting forth a policy on VE. Because grantor agencies are prohibited from imposing additional requirements on grantees, and because of OMB's continuous and frequent reluctance to incorporate a provision encouraging VE, we cannot nor do not presume that it is permissible to develop a DOT policy that would require VE. In fact, the only reasonable interpretation we could make was that OMB did not want us to set forth a VE policy. Because of the OMB actions, the FHWA activity was maintained at a low-key level, and no Departmental policy was established. However, this is an opportune time to again surface the VE policy issue with OMB. At the request of OMB, we are chairing the current Interagency Review Group to Review the Property and Procurement Standards of Circular A-102. We will contact OMB on your recommendation, and request that they give special attention to including a VE policy in the revisions to the Attachment O Procurement Standards. We believe this is a necessary action prior to issuing a Departmental policy.

[GAO COMMENT: See agency comments and our evaluation on page 22 and 24.]

The first paragraph on page v of the draft report includes the following statement: "States receiving DOT grants for highway projects, however, can retain all savings on highway projects as long as the funds are used for other federally-funded projects." This statement is not entirely accurate, and should be corrected by inserting the word "highway" between "federally-funded" and "projects" to clarify that the other projects must be federally-funded highway projects.

[GAO COMMENT: We made the correction in the final report. See pages v and 17.]

In addition, this is somewhat misleading. Many states have unofficially stated that there is little incentive to possibly delay the project to do a VE study when a minimum of 75 percent of the savings are vested in Federal funds, and in some cases 100 percent. There is no real incentive on the state's part to save the Federal Government's money. This is flawed logic because as GAO points out, there is a real benefit to the state. It, nevertheless, is a perceived concern on the part of some states.

[GAO COMMENT: DOT agrees with our position.]

The statement in the first paragraph on page 5 that several colleges and universities include VE in their engineering curricula is misleading because there has not been a universal recognition of the need to provide instructions on VE in a large number of colleges and universities. Some schools offer elective courses on VE, but the courses are more limited than the draft report seems to imply. Therefore, we believe the draft should be changed to reflect a more limited number.

[GAO COMMENT: Changes were made to show that several colleges and universities included VE as an elective in their engineering curriculum. (See p. 5.]

The reference to the "American Road Builders Association" on line six of the third full paragraph on page 5 should be changed to "American Road and Transportation Builders Association."

[GAO COMMENT: We made the above corrections in the final report. See p. 5.]

On the last line of the first paragraph on page 6, GAO states: "In addition, USCG, FAA, and FRA have direct construction programs." FHWA also has a direct construction program which is small in comparison to the Federal-Aid Highway program with the states. However, it approximates the size of the programs cited for USCG, FAA and FRA and, therefore, should be included.

[GAO COMMENT: We have included FHWA's direct program on page 39.]

The reference to the "Federal-Aid Highway Manual" on line one of the last paragraph on page 6 should be changed to "Federal-Aid Highway Program Manual."

[GAO COMMENT: We made the above corrections in the final report. See page 6.]

On page 6, GAO discusses the $3 million expenditure for 102 VE workshops. It should be mentioned that some of that expenditure was by the states to staff the workshops with participants (salaries, travel, overhead, support facilities, etc.). The $3 million should be identified as "state and FHWA investment" in the workshops. Also, the correct number of workshops should be 104 instead of the 102 number that was originally provided to GAO.

[GAO COMMENT: We made the above corections in the final report. See page 6.]

The wording in the last paragraph on page 7, "FHWA selects projects for workshops that have gone through the states' normal cost reduction reviews. . . ", should be changed to ". . . the host agency and instructors select projects for the workshop that may have already gone through the state's normal cost reduction review process, and that are proceeding toward actual construction." In a large number of cases, the states themselves select the projects that the highway agency wants value engineered, and the VE workshop is a convenient vehicle for accomplishing the studies. In most cases, FHWA does not have a large role in selecting the workshop projects.

[GAO COMMENT: We made the above corrections in the report. See page 7.]

In the second paragraph on page 19, GAO states that FHWA "considered mandating VE and other cost reduction strategies in 1980, but did not because input from division offices indicated that the relationship with the states would be adversely affected by imposing additional requirements." GAO believes that a "required" rather that a "voluntary" VE program would expedite FHWA's VE efforts and produce additional substantial cost savings. For the report to be accurate, it should reflect that FHWA considered mandating VE in both 1975 and 1980. Effects on the state-Federal relationship were only part of the reason for rejecting the concept. The previous proposals were too prescriptive in that they required the application of VE to all projects over a stated dollar threshold. (On page 21 of the report, GAO refers to dollar thresholds under the first itemized criterion for establishing a Departmental policy.) High cost projects might seem to show the best potential for savings, but this is not always the case. We have serious reservations about requiring VE reviews for specific categories of projects. This emphasizes the individual administration's need for flexibility in administering any agency VE program.

[GAO COMMENT: We included in the final report that FHWA considered mandating VE in 1975. See p. 19. We also agree with DOT that high cost projects might not always have the best potential for savings. As discussed on pp. 4 and 20 of the report, we recognize that cost is a good indicator but should not be the sole determinant for selecting projects to value engineer. We cited other factors that should be considered, including type and size of projects.

We are unable to evaluate DOT's "serious reservations" about requiring VE reviews for specific categories of projects because DOD did not cite its reservations nor identify those categories of projects.]

- The reference to the "American Association of State Highway Transportation Officials" in line two of the third paragraph on page 27 should be changed to "American Association of State Highway and Transportation Officials."

[GAO COMMENT: We made the above correction in the final report. See page 27.]

The chart on page 37 of the report incorrectly presents air terminal buildings as being eligible for direct Federal funding. Terminal development is only eligible for funding at commercial service airports under FAA's Airport Improvement Program (AIP) and, therefore, should not be included under the direct Federal funding category.

[GAO COMMENT: We made the above correction in the final report. See page 39.]

- The VE study of the terminal building at Atlanta-Hartsfield International Airport that was cited on page 12 of the report presented savings in the initial building costs and in operating costs. The digest at the beginning of the GAO report states that one purpose of the VE study was to determine if VE could identify additional savings after a project has been subjected to FAA cost reduction reviews. Using this example is misleading since FAA records indicate that no FAA grant funds were involved in the construction of the airport terminal building. Because of this, no FAA cost reduction reviews were performed. In addition, two-thirds of the savings claimed are in operating costs, and under the AIP, operating costs are not eligible for Federal participation. Therefore, any projections of funds to be saved should pertain to cost areas eligible for FAA funding.

[GAO COMMENT: We disagree with DOT's contention that the terminal building was not federally funded and not subject to FAA cost-reduction reviews. According to funding data furnished us by the FAA chief, program guidance branch, from FAA's Airport Improvement Program, FAA provided in excess of $25 million for the terminal building as of September 1981. Thus, the $7 million in capital costs savings were in areas funded by the Airport Improvement Program, FAA's grant program. Moreover, an FAA official in Atlanta told us that a cost-reduction technique called "fast tracking" was used on the airport project.

DOT correctly pointed out that "operating costs are not elgible for federal participation," and we revised the report to show that the $14 million in operating savings were to the grantee. (See p. 12.)]

- FAA believes that terminal building construction may be the only area where appreciable benefits of VE analysis can be realized. In Fiscal Year 1983, approximately $37 million of AIP funds were used for terminal projects. Assuming all of these projects were amenable to VE analysis, a net savings of from $1 to $2 million could have resulted, applying GAO's criteria of 3 to 5 percent cost reductions. Although this is a respectable sum, it is far less than GAO's chart on page 37 may imply. If a 5 percent cost reduction factor is applied to the $800 million funding allocation presented on page 37, it appears that a savings of up to $40 million could be obtained (5 percent of $800 M = $40 M). FAA believes that the $1 to $2 million savings projection would be a more realistic estimate. In general, FAA has no objections to encouraging VE analysis or grant-funded construction projects, but the benefits of requiring the process is not as convincing as the GAO draft report portrays.

[GAO COMMENT: We recognize that only $37 million of the $800 million in Airport Improvement Program funds were for terminals, with the balance for constructing runways, taxiways, and fire and crash buildings. Although we did not specifically develop a case to show that VE can be applied to each of these types of projects, an internationally recognized VE expert advised us that VE can produce savings on these types of FAA funded projects.]

- The previous UMTA position on VE as reported to GAO has not changed. UMTA agrees that VE can be a valuable technique in reducing construction costs; however, UMTA believes that VE is only one component of a prudent and responsible program for the cost-effective control of large-scale construction projects. UMTA VE guidelines and training sessions are being developed to fully inform UMTA and grantee management staff of the benefits of VE as a cost reduction technique.

- Page 15 of the report includes a statement that the House Subcommittee on Transportation Appropriations directed UMTA to take necessary steps to apply VE to grant-funded construction projects with estimated costs exceeding $150 million. The report should reflect that UMTA has applied VE to two major new start projects--Los Angeles Wilshire Corridor and San Jose Guadalupe Corridor. Each of the VE reviews under these projects has produced significant cost reductions.

[GAO COMMENT: According to an UMTA headquarters grants management official, VE produced actual savings of $43.4 million on the Los Angeles projects. In addition, VE identified about $25 million in potential savings, with possible additional $4.4 million in savings on the San Jose project. Final decisions have not yet been reached on this project. Although we did not verify the savings or potential for savings, those savings further support our belief that DOT should establish a Department-wide VE policy.]

- Although VE is not required by FRA, the GAO draft report inaccurately reflects that VE is not being used under the NECIP. FRA has and continues to use VE. When GAO interviewed the NECIP's Chief Design Engineer, the auditors were shown a copy of the FRA Design Management Manual. The Manual describes the VE principles to be applied throughout the design of the Northeast Corridor projects. Furthermore, the design engineers and cost estimators work to a "design to cost" edict, whereby, whenever a cost estimate for a project exceeds its budget, the scope of work is reviewed for alteration in order to stay within budget. The GAO auditors acknowledged the high degree of direct involvement in the project by FRA engineers during the interviews. Also, they discussed with FRA the similarity of NECIP to some of UMTA's projects and that, therefore, the VE practices also could be applied on UMTA projects.

APPENDIX II

[GAO COMMENT: We agree that VE was used on the corridor project, but not on a continuing basis. DOT and the project's design firm acknowledged that design and cost engineers work to a "design to cost" edict. Unlike the design-to-cost concept, VE always examines the functions of a project to achieve the lowest overall cost, rather than reducing the scope of work only when costs exceed budget. However, FRA did provide us with three VE studies that were performed during FHWA workshops on three relatively minor aspects of the corridor project, such as reducing the type and size of fences near the tracks. None of the VE recommendations were implemented because the fences and the project elements were eliminated due to funding cutbacks.

DOT also stated that the FRA Design Management Manual describes the VE principles that are to be applied to the design of the Northeast Corridor projects. However, according to our review, the manual describes VE only as a technique that can be used to ensure the effective use of valuable resources.]

To more accurately reflect the scope of the NECIP which is presented on page 16 of the report, we are providing the following list of major elements:

- Modernizing the communications and signals system;
- Constructing four maintenance-of-way facilities;
- Rehabilitating four equipment repair workshops;
- Rehabilitating 12 and constructing three new railroad stations;
- Rehabilitating 200 and replacing 11 bridges, including two moveables;
- Restoring the 110 year old tunnel in Baltimore;
- Eliminating 32 public and 17 private grade crossings;
- Installing concrete tier over 416 track miles, installing 739,000 wood ties, and surfacing 590 track miles for high speed operations;
- Fencing all parkland adjacent to the corridor; and
- Twenty-two civil engineering projects to improve track drainage, reconfigure interlockings, and realign tracks.

PREVIOUS GAO REPORTS ON VALUE ENGINEERING

Value Engineering Should Be Improved As Part of the Defense Department's Approach to Reducing Acquisition Cost (GAO/AFMD-83-78, Sept. 27, 1983).

Water Resource Construction Costs Could Be Reduced If Value Engineering Were Applied to More Designs and Applied Earlier in the Design Process (GAO/RCED-83-127, May 11, 1983).

Value Engineering Has the Potential to Reduce Mass Transit Construction Costs (GAO/RCED-83-34, Dec. 29, 1982).

Potential Exists to Reduce Construction Costs Through More Effective Promotion of the Value Engineering Incentive Program in the Department of the Interior (085636, Dec. 1, 1982).

Letter from the Comptroller General to the Chairman, Senate Committee on the Budget, discussing GAO's position on the value engineering technique (B-165767, Feb. 5, 1979).

Department of Defense Value Engineering Program Needs Top Management Support (PSAD-78-5, Nov. 16, 1977).

Potential of Value Analysis for Reducing Waste Treatment Plant Costs (RED-75-367, May 8, 1975).

Need for Increased Use of Value Engineering, a Proven Cost-Savings Technique in Federal Construction (B-163762, May 6, 1974).

Value Engineering Program Needs to Be Improved and Reinstated (B-118779, May 10, 1972).

Opportunities for Increased Savings by Improving Management of Value Engineering (Design and Manufacture Simplification) Performed by Contractors (B-165757, Aug. 25, 1969).

DOT CONSTRUCTION PROGRAMS AND FISCAL YEAR 1983 ALLOCATIONS

Agency	Program funding	Type of construction	Funding allocation (in millions)
FHWA	Grant	Constructing, reconstructing, and repairing highways, roads, bridges, and rest areas.	$12,000
UMTA	Grant	Constructing subways and extensions, bus stations, garages, and maintenance facilities.	2,900
FAA	Grant	Constructing runways, taxiways, aprons, terminals, and fire and crash buildings.	800
FRA	Direct	Constructing passenger stations, maintenance facilities, bridges, and tracks.	263[a]
FHWA	Direct	Constructing forest highways Indian reservation roads, park roads, and parkways.	195
FAA	Direct	Constructing air traffic control towers and radar approach control buildings.	49
CG	Direct	Constructing administration buildings, family housing, clinics, search and rescue stations, and runways. Repairing and rehabilitating hangers.	37
Total			$16,244

[a]Expenditures.

Source: DOT

U.S. GENERAL ACCOUNTING OFFICE
SURVEY OF STATE HIGHWAY DEPARTMENTS' EFFORTS TO
REDUCE CONSTRUCTION COSTS THROUGH COST-EFFECTIVE DESIGNS

Instructions

The U.S. General Accounting Office (GAO), an agency of the Congress, is studying the use of cost reduction methods such as value engineering, on construction projects funded by the Department of Transportation. The purpose of this questionnaire is to find out how States control construction costs through the design of Federally-funded highway and bridge projects.

Please complete the questionnaire and return it in the pre-addressed envelope within 10 days. Complete your answers by either checking the appropriate box or filling in the indicated blank. The questionnaire should take one to two hours to complete depending on the availability of records. If you should have any questions, please call Messrs. Ralph Tavares, Kenneth Forbes or Joseph Cohen at (617) 223-6536 or 223-7266.

Thank you for your cooperation.

Return the questionnaire to:

Mr. Kenneth Forbes
U.S. GENERAL ACCOUNTING OFFICE
Suite 1907
100 Summer Street
Boston, MA 02110

* * * * * *

*Some questions ask for fiscal year information. Please answer them in terms of your fiscal year.

*All answers should include information on all state operations, i.e., headquarters, district, etc.

*All answers should include information on State-controlled projects only (for example, exclude funds passed through to the local government when the state is not responsible for design).

Name and telephone number of person completing questionnaire:

Title of person completing questionnaire:

1. Approximately what were the total number and estimated highway construction costs of the Federally-funded contracts you were awarded by FHWA in FY 1982?

6,471 (4-6)	$ 6.397 billion (7-15)
(number)	(estimated cost)

2. What percentage of your Federally-funded highway construction projects were designed in-house and/or by consultants in FY 1982?

81 % (16-18)	19 % (19-21)
In-house	Consultants

3. Please describe below procedures used to ensure that designs result in the most cost effective Federally-funded bridges and highways. If necessary, please attach additional sheets or documents.) (22)

	States
Normal Engineering Review	17
Alternate designs, bids, etc.	18
Value engineering	13

The next section deals with value engineering, as defined below, performed during the pre-construction phase.

Value Engineering (VE), is the systematic application of recognized techniques by multi discipline team(s) which identifies the function of a product or service; establishes a worth for that function; generates alternatives through the use of creative thinking; and provides the needed functions and reliability at the lowest overall cost.

APPENDIX V

4. To what extent, if at all, did you use value engineering on any of your projects in FY 1982? (Check one.) (23)

1. [22] To no extent (Go to Q. 12.)
2. [10] To some extent
3. [8] To a moderate extent
4. [4] To a great extent
5. [3] To a very great extent

[1] Did not respond

5. To what extent, if at all, do you use the following criteria to select projects to be value engineered? (Check one box for each row.)

	Very great extent 1	Great extent 2	Moderate extent 3	Some extent 4	Little or no extent 5	
1. Feasibility	6	3	5	6	4	(24)
2. Financial (i.e., above a certain amount)	6	6	6	5	2	(25)
3. Previous experience	3	5	7	8	1	(26)
4. Other (Please specify.)						(27)
uniqueness		1	1	1		
project complexity	1	1	1			
special project			1			
workshop					1	
politics		1				
high cost items	1					

6. For the projects that are value engineered, to what extent, if at all, do you use the following techniques in your planning and design work? (Check one box for each row and also check whether or not documentation is typically available for each.)

	Very great extent 1	2	3	4	Little or no extent 5	Documentation Available? YES	NO	
1. Investigating the basic functions of the project	9	8	8	1	0	13	3	(28,29)
2. Using brainstorming and informal discussions to discover alternatives for performing the functions	9	12	2	3	0	12	6	(30,31)
3. Analyzing the cost and worth of the alternatives	8	13	3	1	1	13	3	(32,33)
4. Developing and refining the alternatives	5	12	7	2	0	14	2	(34,35)
5. Using life cycle costing in selecting alternatives	5	8	5	6	2	11	3	(36,37)
6. Planning and evaluating the best way to present the project to decisionmakers	5	6	5	8	2	8	7	(38,39)
7. Other (Please specify.) _____ _____								(40,41)

APPENDIX V

7. For federally-funded bridge and highway projects that were value engineered during FY 82, approximately what were 1) the total number, 2) estimated construction costs, and 3) estimated savings, if any, of the implemented VE recommendations? (Enter numbers where appropriate.)

	Number	Estimated Costs	Estimated Savings
1. Bridges only	_____ (42-43)	$_____ (51-58)	$_____ (84-90)
2. Highways only	_____ (44-45)	$_____ (59-66)	$_____ (91-97)
3. Both highways and bridges	547 (46-48)	$ 1.168 B (67-75)	$ 71.05 M (98-105)
4. Other (e.g., rest areas and special projects)	_____ (49-50)	$_____ (76-83)	$_____ (106-112)

Please attach a copy of a typical Value Engineering study conducted in FY 82.

8. Of all the FY 82 projects that were value engineered, what percentage were value engineered in-house or by consultants? Dup (1-2) 2(3)

	In-house	Consultants
1. Bridges only	_____% (4-6)	_____% (19-21)
2. Highways only	_____% (7-9)	_____% (22-24)
3. Both bridges and highways	18 states-100% 1 state-90% (10-12)	1 state-100% _____% (25-27) 10%
	1 state-94%	6%
	1 state-20%	80%
	1 state-50%	50%
4. Other (e.g., rest areas and special projects)	_____% (13-15)	_____% (28-30)
	_____% TOTAL (16-18)	+ _____% TOTAL (31-33) = 100 % TOTAL

9. How is your VE effort organized? (Check the most appropriate answer.) (34)

1. [8] An integral part of design staff
2. [5] A full-time separate group
3. [9] Special teams are established as needed
4. [1] Established for workshop training only
5. [1] Other (please specify) various stages during plan development

10. Which of the following organizational units or people are typically represented on your VE teams for highway, bridge or both types of projects? (Check one box for each row, where applicable.)

	Both Highways and Bridges	Highways only	Bridges only	
	1	2	3	
1. Administration/ budget	7			(35)
2. Cost estimator	13			(36)
3. Design	22			(37)
4. Environmentalist	13			(38)
5. FHWA	19			(39)
6. Maintenance	15			(40)
7. Materials	19			(41)
8. Planning	12			(42)
9. Project Manager	11			(43)
10. Right of way agent	9			(44)
11. Safety	10			(45)
12. Specifications	14			(46)
13. Traffic	18			(47)
14. Other (Please specify.)				(48)
Construction	4			
Utilities	1			
Bridge	1			
	6			

APPENDIX V

11. Approximately how many of the highway department's staff have taken the following value engineering training during the last 5 years? (Enter numbers where indicated.)

1. 1,912 (49-51) Workshop--one week or less
2. 45 (52-54) Workshop--over one week but less than two weeks
3. 1 (55-57) Workshop--two weeks or more

12. If you do not use value engineering, please indicate below the reason(s) why you do not use it. (Check all that apply.)

1. [3] Not applicable (we use it frequently) (58)
2. [3] Not cost effective (59)
3. [16] Prefer present or other techniques (60)
4. [5] Don't have trained staff (61)
5. [4] Tried but not successful (62)
6. [0] Not that familiar with VE (63)
7. [0] Not required (64)
8. [3] Other (Please specify.) trial basis (65)

13. To what extent, if at all, do you feel value engineering has a potential to be used in the following areas?

	Very great extent 1	Great extent 2	Moderate extent 3	Some extent 4	Little or no extent 5	
1. Bridge	9	8	11	9	5	(66)
2. Location/ geometrics	8	11	10	9	6	(67)
3. Pavements	7	7	13	11	6	(68)
4. Other (e.g., rest areas)	7	4	9	10	8	(69)

14. During the construction phase, a cost reduction or VE incentive clause permits a contractor to propose changes in the methods of construction or materials to be used. If the proposal is accepted the agency and the contractor share the savings, usually on a predetermined basis. Do you include such an incentive clause in Federally-funded bridge and highway construction contracts? (Check one.) (70)

1. [20] Yes
2. [8] Sometimes
3. [20] No (GO TO Q. 18.)

15. What criteria, listed below, do you use to determine which construction contracts include the cost reduction or VE incentive clause? (Check one.) (71)

1. [18] All contracts
2. [5] Minimum estimated construction cost (Please specify.) $ 2M; $100,000; $1.5M $.5M; 5M
3. [5] Other (Please specify) early stage, no criteria, 2 RR proj. as demonstration, unusual projects

16. What were the total number and estimated construction costs of contracts awarded in which the clause was included during FY 1982?

3,491 (number awarded) (72-74) $ 3.04B (estimated costs) (75-82)

17. What were the total number of cost reduction or VE change proposals that were approved and the total actual savings?

91 (number approved) (83-85) $ 2.1M (actual savings) (86-93)

APPENDIX V

18. If you don't use the incentive clause at all, or use it infrequently, why don't you use it? (Check primary reason.) (94)

1. [0] Not applicable (we use it frequently)
2. [0] Not required
3. [5] Causes delays in projects
4. [2] Not cost effective
5. [6] Negative prior experience
6. [1] Contractors don't want responsibility for design changes
7. [9] Other (Please specify.) 3 - considering use 1 - overworked staff and change order process
   1 - overworked staff
   2 - legal conflict w/competitive bid laws
   1 - change order process
   1 - overworked staff and legal problem

19. Please provide any other comments you may have on reducing construction costs through cost-effective designs. (If you need more space, please attach an additional sheet.) (95)

	States
Did not answer	18
More flexibility in federal standards	3
Standard specification	1
VE incentive funds (state share savings)	1
Alternate design	3
Contractor changes	6
Task force	1
Cost effective process	1
Comprehensive survey	1

MMS-4-83

APPENDIX VI

SH&G

September 20, 1983

Mr. Ken Forbes
Auditor
U.S. General Accounting Office
100 Summer Street
Boston, Massachusetts 02110

Dear Ken:

Please find attached a final submittal for our work on the Atlanta Airport Value Engineering. Since we have already forwarded master copies, the attachment contains updated master pages 1, 3 and 4 as well as a copy of the entire document.

It has certainly been a pleasure to be of service to GAO and do not hesitate to call us again in the future.

Very truly yours,

A. J. Dell'Isola, PE, CVS
Vice President & Director
Value Management Division

AJD/kt
Enclosure

Value Management Division 1050 17th Street, N.W. Suite 800 Washington, D.C. 20036 202/296-4090
A Division of Smith, Hinchman & Grylls Associates, Inc.

AJ Dell'Isola, PE Vice President & Director

APPENDIX VI

Final Submittal
9/20/83

VALUE ENGINEERING APPLICATION

AIRPORT TERMINAL FACILITIES

I. INTRODUCTION

This report summarizes and documents the results of a value engineering (VE) study performed on an FAA funded terminal building and concourses at the new William B. Hartsfield International Airport in Atlanta, Georgia (Figure 1). The results of the study produced about $7 million in initial savings and over $14 million in present value of annual operations and maintenance cost savings or $21 million savings in life cycle costs.[1] In addition, the study resulted in the facility using about 35% less energy than comparable facilities in Dallas and Chicago. The initial cost estimate of the entire facility was $281 million of which about $100 million (terminal and concourses) was studied. The post VE estimate was $274.7 million and final bids totalled $274.1 million. The total costs of the VE services was about $40,000.

II. BACKGROUND

VE is a specialized technique which is utilized to augment the traditional approach of designing facilities. It is an organized approach to optimize the total life cycle costs of a facility. Key elements of Value Engineering are:

A. VE is a function oriented approach that utilizes a proven process (VE Job Plan) that allocates time and efforts to achieve its objectives. VE makes total cost optimization happen on purpose rather than by accident. The average return on a VE study is greater than 10 to 1.

B. VE utilizes a multi-discipline team of trained professionals, who are not involved directly in the project, to review and analyze key decisions on a planned basis. The efforts are most effective during early design phase when changes are easier to implement, cost less to change, and potential savings are the greatest.

As an analogy - Medical journals report that some 30% of all operations are unnecessary. As a result, they suggest a second opinion before undergoing surgery. Similarly, every project design contains unnecessary costs - up to 30% is not unusual. VE provides owners with a second opinion whose objective is to optimize the life cycle costs of a facility.

[1]Life cycle cost savings include initial construction cost savings and the present value of all annual cost savings in financing, operations, and maintenance over the life of the facility.

C. The VE approach utilizes proven techniques which help to insure results for the owner. The key technique used in VE are:

1. Modeling

Cost, energy, and life cycle models are used to isolate high cost/poor value areas. These models compare estimated project costs by functional areas with target cost based on previous studies or VE team experience. Where significant differences are indicated, they are subsequently studied for savings.

2. Function Analysis

The team uses two unique techniques to obtain a better understanding of the design and isolate items for study. First, the functions of a design are identified and described using a two word verb-noun phrase. For example, the overall function of a pencil would be to "make marks". Functions of components are also isolated and then classified as either primary or secondary. The component function of the wood in a pencil is to "hold graphite", while the component function of the graphite is to "make marks". The wood function is secondary, while the graphite function is primary. The second technique is to establish worth value for each function. Secondary functions have little worth. The purpose of these techniques are to identify poor value items for further study. The team then focuses on eliminating unnecessary functions, combining functions, or achieving functions at a lower cost.

3. Creativity

A creative (brainstorming) effort is directed toward developing alternate means of accomplishing the required function. The result of this team effort almost invariably achieves better, more cost effective decision making.

4. Life Cycle Costing

A life cycle cost analysis is used rather than the traditional approach of primarily focusing on initial cost estimating to develop alternatives.

5. Non-Economic Evaluation

Prior to recommending the selected alternative, the team reviews each alternative against non-economic design criteria such as aesthetics, environmental, political, safety and reliability. Recommendations are then modified so that optimal-rather than strictly lowest cost-alternatives are selected.

III. CASE STUDY

A. Background

In early 1976, due to the excessive traffic and inability of the old airport to respond, the City of Atlanta, Department of Aviation, authorized the design of a new airport. Because of overall concern to control costs, the owner and airlines decided to use VE.

The design agent for the public facilities (a joint venture including Smith, Hinchman & Grylls) was directed by the Department of Aviation to conduct a formal VE study of the design. The study was conducted from July 27-31, 1976. Some 25 attendees representing: Eastern, Delta, and Piedmont Airlines, the City of Atlanta, and the architect-engineer staff were present during the workshop.

B. Scope of VE Study

The project consisted of a passenger terminal facility of 704,000 square feet, a people mover mall of approximately 403,000 square feet, a mechanical building of 9,000 square feet, and a concourse area totaling some 1,414,000 square feet. The designer proposed a satellite concept with four concourses connected to the terminal by an automated guideway transit system and pedestrian mall. The concourses (A, B, C, D) consisted of a two level structure with a third story ramp leading to the control towers and lounges. The boarding level provided for aircraft gates, support areas, public facilities, and concessions. The lower level housed the airlines' operations areas, baggage equipment, mailroom, employee lounges, cafeterias and an electrical equipment room. Figure 1 is a plan of the layout. All heating, ventilating and air conditioning (HVAC) equipment was located on the roofs.

The upper or ticketing/baggage handling level of the terminal building included concessions and security. The lower level was committed to baggage makeup, plane return, plus the HVAC equipment and primary electrical service.

The estimated cost were $25.9 million for the terminal and $71.3 million for the concourse facilities.

C. Value Engineering Procedures

The following summarizes the scope of the study:

1. Document Collection and Familiarization. Early in July, the VE team collected and reviewed project documents including cost, program, and engineering estimates. Subsequently, the team met at the consultant's offices to discuss the development of required cost models and to collect additional data. The meeting ended with the staff developing cost models to be used for

selecting items to be studied in detail. The team decided to develop separate cost models for the terminal and the concourses (See figure 2). The staff used their expertise to develop the target costs shown in the upper blocks of the figure. These represent the estimated lowest possible cost based on the team's previous VE experiences. The costs shown in the lower blocks are the original estimates provided by the design firm. Subsequently, conferences were held to identify potential areas for in-depth review. Based on the differences between the lowest possible costs and the original estimates, the VE team concluded that the greatest savings potential existed in the following areas:

-- Layout
-- Exterior Closure
-- Superstructure
-- Mechanical

2. Formal VE Review. Under the direction of the firm's VE staff, four teams performed the formal VE studies using the VE job plan. The teams were joined by representatives of the City and the airlines. The full 40-hour project review workshop was held to develop the final listings of VE suggestions and ideas. The job plan consisted of the following five phases.

* Information phase - Study team members became familiar with the design, selected areas with the greatest potential for significant savings, and conducted function analysis.

* Speculation phase - The team developed ways, using creative thought processes, to achieve the same basic function of the items selected for study.

* Analytical phase - The team screened the ideas generated in the previous phase and selected the best for possible implementation.

* Proposal phase - The team prepared final written recommendations for the cost-reduction alternatives.

* Report phase - The team summarized the results of the study, recommended specific action, and requested implementation approval from the responsible officials. In addition, the teams prepared other VE listings of ideas they felt should be reviewed by the owner or designer.

Subsequently, the architect engineer responded with an implementation report with final recommmendations for implementation of the VE suggestions.

D. Following are summaries of VE studies conducted on the layout, exterior closure, and the structural areas, and an example and worksheets from the mechanical team:

Team No. 1 - Layout

The team evaluated the layout of the proposed design concept of the terminal facility and four concourses. The study was divided into two areas, the terminal building and the concourses.

1. Terminal

The team's functional evaluation pinpointed reductions in the horizontal circulation and unassigned areas as potential savings. After evaluating about 39 ideas the team recommended modifying the terminal design to reduce gross area by (1) eliminating and

relocating a concession mezzanine to the lower level, (2) eliminating office space and unassigned space in the baggage claim areas, (3) reducing the length of the terminal by using fewer crossovers and eliminating end crossover space, and (4) eliminating and relocating mechanical equipment space. The team also suggested moving the baggage claim transfer point to reduce the length of the guideway system. In addition, the team suggested reducing the number of parking tunnels from four to two.

Potential Savings:	Initial	$3,400,000
	Operating	$4,479,000

2. Concourse

After analyzing the concourse design, the team recommended reducing corridor widths. They believed that 24 feet rather than the proposed 30 feet wide corridors would be adequate to meet all traffic requirements. Reduction in the corridor widths would also reduce the overal width of the concourse from 90 to 85 feet. The team also questioned the functions of the railings in the holding room.

Potential Savings:	Initial	$4,780,000
	Operating	$5,871,000

Team No. 2 - Exterior Closure

The team's three studies of the terminal building's external wall closure and the upper and lower levels of the concourses resulted in the following recommendations:

1. Terminal Facility - changing proposed exterior design from precast panels to face brick and reducing non-essential window areas.

2. Concourses Upper Level - using carpet for interior walls in lieu of wood paneling.

3. Concourses Lower level - using textured exterior block in lieu of a cavity wall.

Potential Savings:	Initial	$1,867,000
	Operating	$1,491,470

Team No. 3 - Structure

The team conducted an analysis of the concourse structural system. Their analysis indicated that the roof selections of the concourse had the greatest savings potential. As a result, the team recommended: using the existing system less the fill, and obtaining bids for a precast structural system. In addition, the team recommended a further study to evaluate the use of a metal roof versus a built-up roof.

Potential Savings:	Initial	$ 734,000
	Operating	$ 740,000

Team No. 4 - Mechanical

In following the phases of the VE Job Plan (Information, Speculation, Analytical, Proposal), the team developed the following worksheets.

As part of the information phase, cost models were developed and studied (Figure 2). Subsequently, areas selected were broken down into components and each component's cost was estimated, functionally analyzed, and then assigned a target "worth". The graphical function analysis developed is included as Figure 3.

During the Speculation Phase, a listing of potential areas of cost savings was made using brainstorming techniques. The 50 ideas listed during this phase are shown in Figure 4.

During the Analytical Phase, these ideas were investigated and evaluated. From the list, some five ideas were developed for further study. The Analysis Matrix, indicating the ideas selected, criteria used, and weight assigned is shown in Figure 5.

After selecting the best alternative, the team conducted further evaluations, including the development of details and, cost of both initial and operating costs. Life Cycle Cost Analysis indicated significant savings in annual costs resulting in an 18% improvement in total costs of ownership. Figure 6 is the proposal developed for the mechanical area. The team recommended use of a central plant with gas fired dual feed boilers, steam driven chillers, and water cooled towers.

Potential Savings:	Initial	$ 250,000
	Operating	$3,450,000

APPENDIX VI

E. Summary of Savings

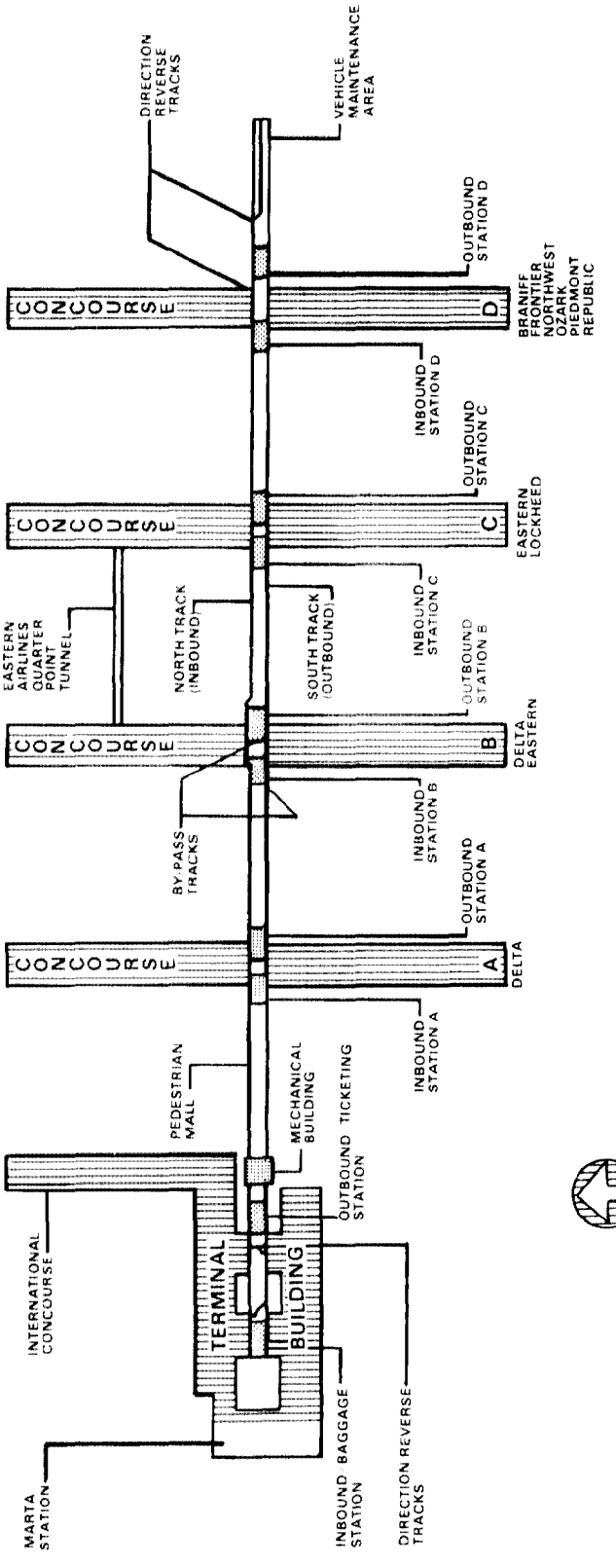
Some 126 proposals representing approximately $11 million in initial cost savings were generated by the VE team and were evaluated by the owner/designer team. Eventually 53 ideas were implemented in the final design, saving about $7 million in initial costs. More importantly, these ideas resulted in operating cost savings which more than doubled the value of initial savings.

The principal items implemented included: a reduction of terminal in both volume and area by relocation of mezzanine, a reduction in structural spans, a modification of exterior skin plus interior finishes, and a reduction in glass area to reduce energy usage. Mechanical changes included: use of a central system versus rooftop units, use of dual fired steam boilers, and steam absorption chillers located in a central plant using water cooled towers, and changes to the air filtering concepts.

In addition, the VE team recommendations to purchase all vertical transportation equipment from one supplier, and use of life cycle costing provisions in procurement of all applicable mechanical/electrical equipment were followed.

APPENDIX VI

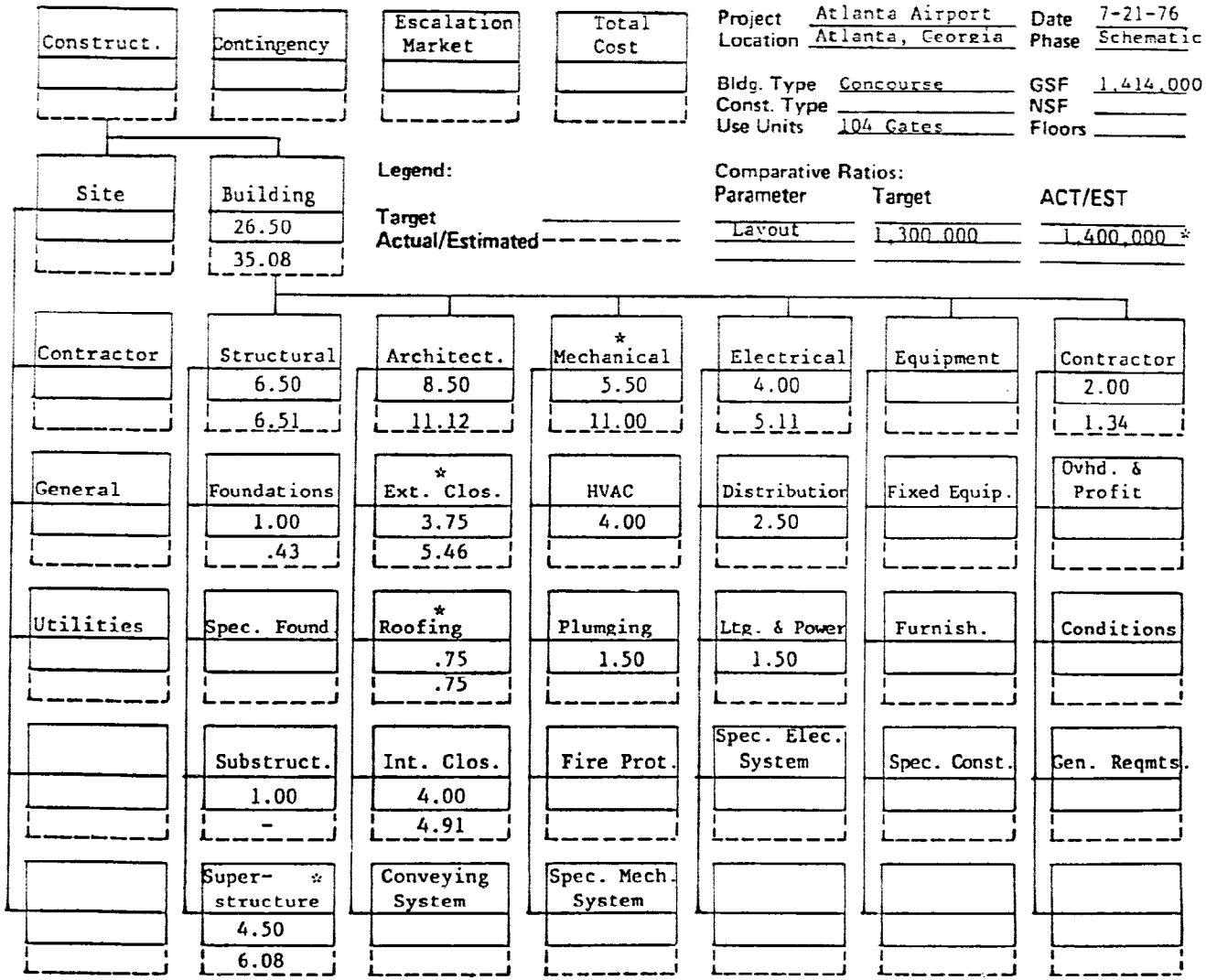
FIGURE 1



PLAN

NOTE: AGT System not included in Study

Cost Model



*Area Selected for in-depth Study.

FIGURE 2

APPENDIX VI

APPENDIX VI

FIGURE 3

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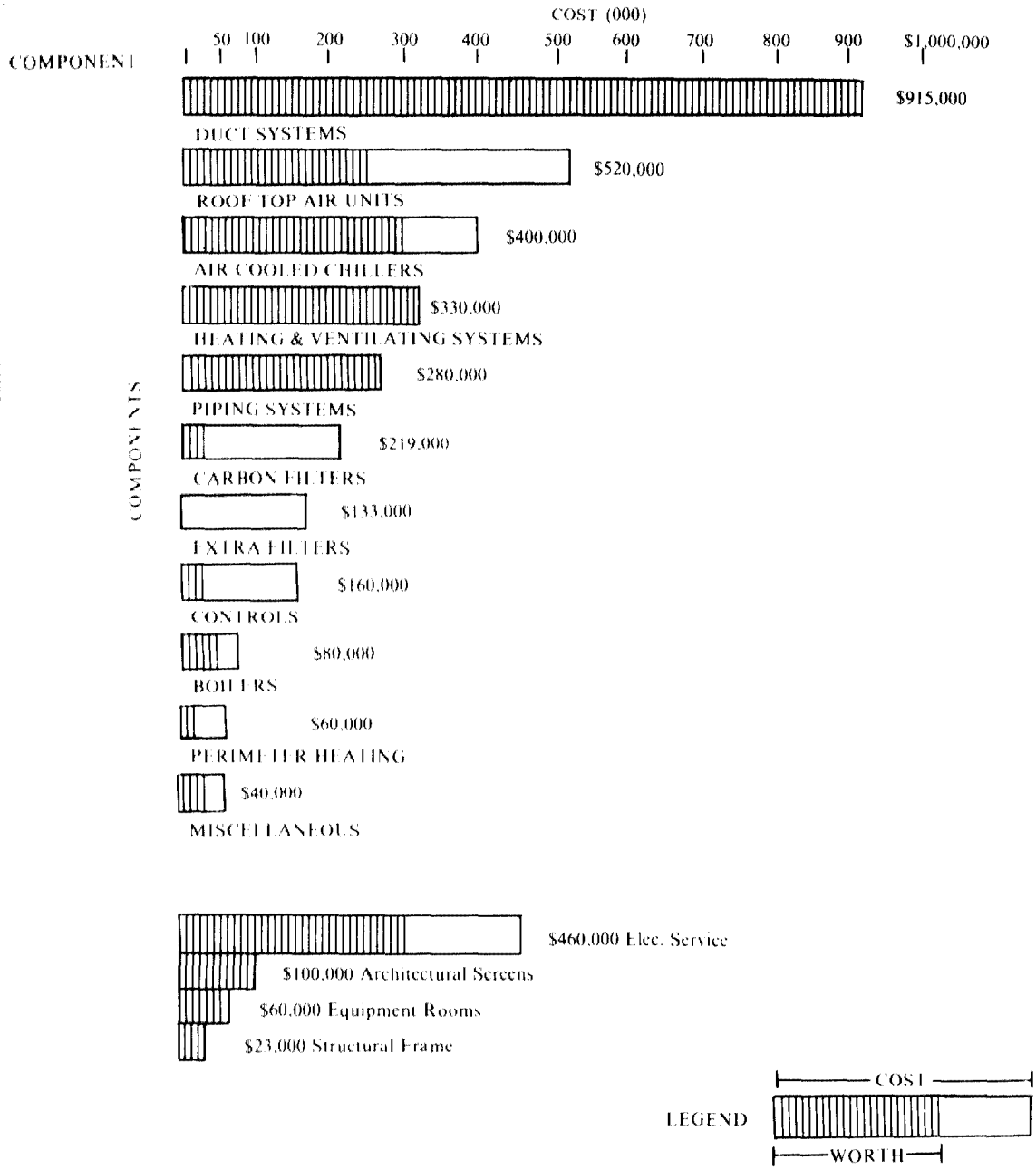
General Work Sheet

Air Conditioning & Heating Systems
Subject

Atlanta Airport 7-28-76
Date

Concourses A, B, C, D

Team No. 4 Mech/Elect.
Drawn By



BASIC FUNCTION

FIGURE 4

Team #4 Mech./Terminal/Concourses, Atlanta, Airport

This is the creative stage of the Value Study. Generate as many ideas, processes or methods to fulfill the basic functions that the item under study must perform. Do not evaluate the ideas during this phase.

* 1.	Consolidate Chillers to One Location/Concourse
* 2.	Consolidate to General Plant Concept for Terminal Complex
* 3.	Investigate Electronic Odor Control Devices & Purafil Ozonation
4.	Re-Evaluate all Design Criteria
5.	Variable Space Temp. -- Swing
6.	Heat Reclaim Troffers - (Heat Reject to Atmosphere)
7.	Electronic Heat & Gas Boilers
8.	Re-Evaluate Construction w/regards to heat transfer
* 9.	Central Computer Control w/Ind Stop - Reset Cap for Complex
*10.	"Four Pipe" or "Double-Bundle" Heat Recovery
11.	Off Peak Ice Plant for Peak Reduction -- Water Storage
12.	Review Space Allow to Duct - Object Better Aspect Ratio
13.	Remove Duct Insulation
14.	Evaluate Noise & Vibration Control Devices to Eliminate or Modify
*15.	Investigate Water Cooled Towers
16.	Enthalpy Control Change-over
17.	Solar Load Compensation on A/C Control System
18.	Variable Volume Dampers on A/C Control System
19.	Reduce Outside Air - Omit
20.	Heat Recovery on Outside Air
21.	Fan Coil Units for Small Areas
22.	Highly Reflective Glass
23.	Less Wide Spread Air Dist. - Fewer Diffusers
24.	Move Air Units Off Roof
25.	Two Speed Tower Fans

List Everything -- Judge Later

* = SELECTED FOR FURTHER EVALUATION

APPENDIX VI

26. Remote Outside A/C Source
27. Tow Aircraft Into & From Position
28. Eliminate Internal Combustion Engines within Buildings
29. Temper Ventilating Air in Baggage Area
* 30. Computerized Control
31. Evap Coolers to Precool O.A.
* 32. Purchase on Life Cycle Cost Basis - Mass Purchasing
33. Purchase Steam
34. Water Softner & Demineralizer for Chilled Water Makeup
35. Ground Water Rejection - Heat Pump
36. Tower with Extended Stack for Regain
37. Charcoal Reactivation Plant
38. Conventional Roof Top A/C Systems
39. Validity of 90-Day Design Period
* 40. Central Cooling Tower with Chillers on Concourses
* 41. Absorption Cooling - Steam Turbines
* 42. "No Plume or Drift from Cooling Towers"
43. Take Outside Air in 12' above Apron. FAA Req'd?
44. Cold Water Cleaning
45. Spring Loaded Faucets
46. Electric Flush Valves
47. Low Volume Water Closets
48. Solar Heat Domestic Water and Space Heat
49. Single Temperature Domestic to Lavatories
50. Group or Localize Plumbing Facilities Top and Bottom
51.
52.
53.
54.
55.
56.

Creativity = Imagination + Inspiration + Illumination

APPENDIX VI

FIGURE 5

Team #4 - Mech./Elect. Concourses
Analytical Phase

Atlanta Airport
Basic Function

List the best ideas from ranking and comparison techniques. Determine which one stacks up the best against the desired criteria.

Desired Criteria	INITIAL COST	OPER. & FUEL COST	MAINTENANCE COST	FLEXIBILITY	AVAIL. OF SPARE PARTS	INTERFACE IMPACT			
Weight of Importance (0-10)	a 9	b 10	c 8.5	d 4	e 4	f 6	g	Total	
1. Present Way AIR COOLED	36 4	20 2	17 2	4 1	12 3	18 3		107	#4
2. CENTRAL PLANT - WATER COOLED - ELECTRIC	18 2	30 3	43 5	16 4	8 2	24 4		139	#2
3. CENTRAL PLANT - WATER COOLED - STEAM	18 2	50 5	34 4	12 3	4 1	30 5		148	#1
4. WATER COOLED - CONCOURSE PLANT	45 5	30 3	17 2	4 1	16 4	12 2		124	#3
5. CONVENTIONAL ROOF TOP UNITS	27 3	10 1	9 1	20 5	20 5	6 1		92	#5
6.									
7.									
8.									
9.									
10.									

Excellent - 5 Very Good - 4 Good - 3 Fair - 2 Poor - 1

Seek The Best - Not Perfection

APPENDIX VI

Atlanta Airport -- Concourses & Terminals — Project
7-31-76 — Date
Team #4 - Mech./Elect. — Item
Project No.

Summary of Change (description)

PROJECT: Comparison of three (3) systems of heating & air conditioning for the concourses & terminals.

1. Air cooled electrical centrifugal refrigeration with boilers in concourse building.
2. Water cooled electrical centrifugal refrigeration located in central plant with boilers in central plant.
3. Proposed Option. Steam generated refrigeration plant located in central plant with boilers in central plant.

EVALUATION: The three (3) systems were studied and evaluated on these factors:

First Cost - Fuel cost - Operation & maintenance - Flexibility - availability of parts & service - impact on arch., elect., & struct. systems.

RECOMMENDATIONS: Estimating data available was pretty rough but the study indicated that the system (3) was the best choice. Based on first cost and annual owning & operating. More refined estimates will be required for definite answers.

NOT EVALUATED IN DOLLARS:
-- Advantages of manning facility (avail. of good manpower).
-- Flexibility to changing fuels.
-- Feasibility of automated central control system coupled with security.

Estimated Cost Summary (see attached cost estimates)	No. of Units	Unit Cost	Total
A. Original (Total Initial).....			18,352,400
B. Proposed (Total Initial).....			18,100,000
C. Initial Savings.....			252,400
D. Life Cycle Costs Annual Savings.....			365,300
E. Present Worth Annual Difference.....			3,450,000
F. Present Worth Annual Difference (Escalated)			
Percent Savings Instant			1.4%
Percent Savings Life Cycle			18.7%
Percent Savings Life Cycle (Escal.)			

(340553)

UNITED STATES
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WASHINGTON, D.C. 20548